GUNS, GERMS, AND STEEL: The Fates of Human Societies
By Jared Diamond, 1997

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SUMMARY

The book asks and attempts to answer the question, once humankind spread throughout the world, why did different populations in different locations have such different histories? The modern world has been shaped by conquest, epidemics, and genocide, the ingredients of which arose first in Eurasia. The book's premise is that those ingredients required the development of agriculture. Agriculture also arose first in Eurasia, not because Eurasians were superior in any way to people of other continents, but because of a unique combination of naturally occurring advantages, including more and more suitable wild crops and animals to domesticate, a larger land mass with fewer barriers to the spread of people, crops, and technology, and an east-west axis which meant that climate was similar across the region. The book is well written and contains not only information about the history of cultures around the world, but excellent descriptions of the scientific methodologies used to study them, from how archeologists study the origin of agriculture to how writing evolved to how linguistics can trace the movements of peoples across huge geographic areas. There are useful examples, maps and charts throughout, which make principles discussed in the body easy to visualize and compare. The appendix includes a chapter by chapter list of further readings on topics discussed.

By the time of the beginning of Europe's worldwide expansion (1500 AD), cultures on different continents showed huge differences in political and technological development. Much of Europe, Asia, and North Africa already had metal-equipped states or empires, some on the verge of industrialization. Aztecs and Incas in America had empires with stone tools. Parts of sub-Saharan Africa had small states or chiefdoms with iron tools. Most other peoples (in Australia, New Guinea, the Pacific Islands, some of sub-Saharan Africa, much of the Americas) lived in tribes using either farming or hunting and gathering technologies. Inequalities in the modern world stem from the same differences in development that occurred between 11,000 BC and 1500 AD. There is no evidence of differences in ability that can be demonstrated when differences in education and experience are taken into account. In fact, an evolutionary argument could be made that "primitive" people in New Guinea must be more intelligent, on average, than "civilized" Western Europeans or Americans. Europeans live in densely populated societies where death not caused by old age most commonly comes from disease, not murder or war. In New Guinea, death is most commonly from murder, warfare, accident, or lack of food, events which are less likely to happen to a more intelligent person. Hence, one could argue that New Guineans are likely to be more intelligent by natural selection.

In any case, the author posits, "History followed different courses for different peoples because of differences among peoples' environments, not because of differences among peoples themselves." He sets out to prove this using information from the following:

- Genetics, molecular biology and biogeography applied to crops and their wild ancestors
- Genetics, molecular biology, biogeography and behavioral ecology applied to domestic animals and their wild ancestors
- Molecular biology of human germs and related germs of animals

- Epidemiology of human diseases
- Human genetics
- Linguistics
- Archaeological studies on all continents and major islands
- History of technology, writing, and political organization

The book is divided into five sections:

- Part I–Relates some of the assumptions of the study, beginning with the evolution and spread of humankind throughout the world, followed by the effects of environment on peoples of the same genetic background using the spread of Polynesians throughout the Pacific islands, and finally introduces the collisions between peoples from different continents by retelling, from eyewitness accounts, the capture of the last Inca Emperor by Pizarro
- Part II–The rise and spread of food production and the reasons for geographical differences in the timing and range of domestication and modification of plants and animals
- Part III–The evolution of germs, writing, technology, government and religion
- Part VI–The specific history of people in five geographic areas in light of the information discussed in Sections II and III
- Part V–An epilogue on human history as science

PART I: FROM EDEN TO CAJAMARCA

CHAPTER 1: UP TO THE STARTING LINE

This section is very similar to The Great Human Diasporas. It discusses the "great leap forward," or the extension of humankind beyond Africa. Did being in some location earlier give those peoples an advantage over later settlers and affect the current state? Africa had an enormous time advantage. However, humans, once they came to a continent, spread and adapted quickly to conditions. Time of settlement by itself does not predict outcomes.

CHAPTER 2: A NATURAL EXPERIMENT IN HISTORY

The Polynesians constitute a small-scale test of how environment determines the path of society. Between 1200 BC and 500 AD, Polynesians scattered over thousands of Pacific islands with great variety of area, isolation, elevation, climate, productivity, and resources. The original Polynesians already had the same elements that were used, when possible, throughout the area: animals (pig, chicken, dog) and plants (taro, yams, sweet potatoes, breadfruit, bananas, coconuts) supplemented by hunting and gathering. They found wildly different environments on the islands they settled. The Chatham Islands, for example, are too cold, being too far south, to support farming of the typical crops. They are small and isolated and could only support a small population (about 2,000) of hunter-gatherers. They had no surplus to support non-hunting craftsmen, armies, or bureaucrats. With nowhere to go, they learned to resolve conflicts peacefully. The Maoris, in contrast, lived on the northern (warmer) island of New Zealand. This is the largest Polynesian island and was suitable for agriculture. In addition, it had supplies of metal. Populations grew dense and chronically engaged in warfare with neighbors. Surpluses supported craft specialist, chiefs, and part-time soldiers. They developed varied tools for agriculture, warfare and art and erected ceremonial buildings and forts.

There are six sets of environmental variables observable in the Polynesian islands.

1. Climate: Varies from tropical to subtropical to temperate to sub Antarctic. Rainfall varies from the highest on earth to an amount too low for agriculture.
2. Geology: Islands can be coral atolls, raised limestone, volcanic, continental, or a mixture. Atolls and raised limestone islands offer no other mineral, thin soil, and flat landscapes. They often have no source of fresh water other than rainfall. New Zealand was part of a continent (Gondwanaland) and has a wide range of minerals. Volcanic islands have different types of stone for tools. Volcanic islands all have rich soils but vary as to height. Those with higher elevations generate rain and streams.
3. Marine Resources: Most of the islands have reefs and shallow waters surrounding them, but some have rocky coasts and steep dropping ocean bottoms that make seafood harder to obtain.
4. Area: Islands vary from 100 acres (Anuta) to 103,000 square miles (New Zealand).
5. Fragmentation: Some are fragmented by steep walled valleys and ridges, while others have gently rolling terrain.
6. Isolation: Some are so far from other islands as to have lost contact once settled. Others remained in more or less regular contact with other islands.

Many islands retained all three of the domestic animals but the more isolated islands often lacked one or more, since they could not be replaced if they died out. So, New Zealand had only the dog; Easter and Tikopia only chickens. On Easter Island there was no coral reef for fishing, and terrestrial birds were eliminated. The people turned to intensive poultry farming. But mainly animals were only occasional meals. Polynesians depended mainly on agriculture with tropical plants. Since this wasn't possible in the sub Antarctic latitudes (The Chathams, New Zealand's South Island), those settlers had to abandon thousands of years of farming legacy and become hunter-gatherers again. On other islands, productivity and the importance of crop types depended on environments. Poor soil and limited fresh water led to decreased population density. Islands with rich soil but lacking height for large permanent streams required intensive, heavy labor to grow dry land crops, often needing to use most of the land area. The most productive crop was taro in irrigated fields. Hawaii had the most productive agriculture. Population density varied from low (5 people/square mile) on Chathams to high (300/square mile) on Hawaii. Anuta, with 60 people on the island's 100 acres, was the densest with 1,100 per square mile.

Political units depend on isolation and terrain. Several nearby islands might be one unit, but one larger island with rugged mountains dividing it might have many. A large island sparsely populated might not become unified at all. Political units vary from a few dozen to 40,000 people.

Population size interacted with density to influence technology and economic, social, and political organization. In general, the larger the size and the higher the density, the more complex and specialized the technology and organization. With high population densities, farmers are devoted to intensive food production, enabling support of non-producers, including chiefs, priests, bureaucrats, and warriors. The biggest political units could muster large labor forces to build irrigation systems and fish ponds, increasing food production even more (Hawaii).

Technological variations also occurred with variations in densities and population. Economies were simple with low density, low numbers, or both. Each household made what it needed and there would be little or no specialization. Specialization increased on larger, more densely populated islands, reaching a peak on Samoa, the Society Islands and especially Tonga and Hawaii. The last two supported hereditary, part-time craft specialists, including canoe builders, navigators, stone masons, bird catchers and tattooers.

Social complexity followed the same pattern. The simplest and most egalitarian societies were on the islands with low population or density. They retained the original Polynesian custom of chiefs, but there was little or no distinction of activity, dress, or living arrangement. Complexity peaked in Hawaii, where people of chiefly descent were divided into eight hierarchically ranked lineages. Chiefly classes were separated from commoners with no intermarriage. All the chiefly lineages, bureaucrats, and some craft specialists were freed from the work of food production.

Likewise, with political organization, where population and/or density was low, chiefs had little authority. Decisions were reached by discussion and consensus. Land ownership rested with the entire community. As population density and/or numbers increased, so did chiefly authority, peaking again in Tonga and Hawaii, where power of chiefs equaled that of kings, including land control. On Tonga and Hawaii the entire archipelago was eventually united under a single chief and constituted an empire. Tonga eventually invaded Fiji. Its conquest of that area was only interrupted by the arrival of Europeans.

Tools and material culture varied with the availability of raw materials. New Zealand was the only area with metals. But people on large volcanic islands, while lacking in granite, flint, or other continental rocks, did grind and polish volcanic stone. Artifacts and architecture grows also with population size and density. Craft specialists created artworks (bird feather capes) and immense stone structures (statues on Easter, tombs of Tongan chiefs, ceremonial platforms of the Marquesas, temples of Hawaii and the Society Islands). All of these differences developed within a relatively short time.

Did the same kind of diversification on continents follow environmentally determined pathways?

CHAPTER 3. COLLISION AT CAJAMARCA

A look at the capture of Atahuallpa, the king of the Incas, by Pizarro on November 16, 1532, illustrates some factors that define the outcome of many similar collisions between native peoples and colonizers. Why did Pizarro come to America and capture Atahuallpa and not the reverse? Among the factors determining this was superiority of equipment; the Spanish had guns, armor, steel swords, horses; the Inca only stone, bronze or wooden weapons and no mounted troops. In fact, the only native Americans able to resist European conquest for any time at all (and then it was for centuries) were those who acquired and mastered the horse and gun (plains Indians of North America, Auraucanian Indians of southern Chile, and the Pampas Indians of Argentina). Superior armaments led to the success of the Europeans against far larger numbers of natives. Later it was guns, but against the Incas, the Spanish had mostly steel swords, lances, daggers, armor and helmets against clubs and cloth armor. Horses allowed them to ride down foot soldiers and outrun sentries and surprise enemies.

But some other factors were equally important. At the time of the capture, the Inca were in the midst of a civil war, which had followed an epidemic of smallpox that had killed the emperor, his heir, and most of his court. Smallpox, brought to the Americas by the Spanish, had spread south from Panama well ahead of Pizarro's troops. Without the epidemic, the Spanish would have faced not only greater numbers, but also a united empire. This is another key historical factor—diseases transmitted to those lacking immunity by invaders with considerable immunity. Smallpox, measles, influenza, typhus, bubonic plague and other endemic European diseases played a decisive role in European conquests. They spread quickly in America, from tribe to tribe, killing an estimated 95% of the population far in advance of the Europeans themselves. In South Africa, Australia, and the Pacific Islands the effect was the same. Tropical diseases (Malaria, Yellow Fever, etc.) were the most important obstacle to European colonization of tropical Africa, India, Southeast Asia, and New Guinea.

Europeans had maritime technology (ships and sailing know-how); the Inca and Aztec did not. So, the Spanish could travel to America, not the reverse. The Spanish also had a political organization that enabled them to finance, build, staff, and equip the ships. They had writing, which allowed for rapid, accurate, and detailed information to be shared. Information about Columbus' voyages, Cortez's conquest of the Aztec and much else was readily available. The Inca had little or no information about the Spaniards. They were ignorant of the previous successful conquest of Central America.

"The immediate reasons for Pizarro's success included military technology based on guns, steel weapons, and horses; infectious diseases endemic to Eurasia; European maritime technology; the centralized political organization of European states; and writing." The fundamental question is why those advantages lay with Europe and not with the New World. The rest of the book deals with this question.

PART II: THE RISE AND SPREAD OF FOOD PRODUCTION

CHAPTER 4: FARMER POWER

Different peoples acquired food production (farming and/or herding) at different times in prehistory. Some never did and remained hunter-gatherers. Some of those who did acquire it did so independently (Chinese); others from neighbors (Egypt). The acquisition of food production is a prerequisite to guns, steel, and germs, as we shall see. Among the wild plants and animals of the world, only a few are worth hunting or gathering. Most are useless—either indigestible (bark), poisonous (monarch butterflies), low in nutrition (jellyfish), tedious to prepare (very small nuts), difficult to gather (larva of most insects), or very dangerous to hunt (rhinoceros). Cultivation increases the amount of calories available per acre. Domestic animals not only provide protein, but also a source of milk and milk products that yield, over the lifetime of the animal, even more calories than from one that is slaughtered. Domestic animals also provide ready fertilizer for fields and, by pulling plows, enable tougher lands to be cultivated.

Increasing the amount of calories available led to increased populations. An indirect consequence of this was fixed abodes. This also increased population, as it shortened the birth interval. Because a hunter-gatherer mother must carry her children with her, children are spaced about four years apart so that the older one is self-mobile and able to keep up before the next one arrives. Farmers do not have this consideration and space their children about two years apart.

Settled life permits the storage of food, which is essential to feeding non-food-producing specialists. This allows for a political elite to gain control of food production by others (through taxation or tribute). Moderately sized agricultural societies tend to be chiefdoms, large ones, kingdoms. A few hunter-gatherer societies in particularly rich environments (coastal Pacific-Northwest of America, coast of Ecuador) did develop sedentary societies with storage of food and chiefdoms, but did not get any larger. Other examples of specialists, besides kings and bureaucrats, are professional soldiers, priests, artisans, and scribes.

Crops and livestock also yielded fibers for clothing, blankets, nets, and rope. Fiber crops include cotton, flax, and hemp. Animals include sheep, goats, llamas, alpacas, and silkworms. Animals also provided bones for artifacts and leather. One of the earliest cultivated plants in America was the bottle gourd used as a container. Large domestic animals are also ridden (horse, donkey, yak, reindeer, camel). Those same five plus the llama were used to bear packs. Cows and horses were hitched to wagons; reindeer and dogs pulled sleds.

Equally important were germs that evolved in societies with domesticated animals. Infectious diseases like smallpox, measles, and flu were mutations from animal infections. Those who had the animals at first fell victim, but then evolved resistance. When partly immune people brought those

germs to those with no previous exposure epidemics resulted in death of up to 99% of the population, playing a decisive role in European conquest of native Americans, Australians, South Africans, and Pacific islanders.

CHAPTER 5: HISTORY'S HAVES AND HAVE-NOTS

The question is not why agriculture and domestic animals did not appear in areas totally unsuitable for it (deserts, high arctic, etc.), but why it didn't or was delayed in some areas which today show themselves to be ideal (California, Pacific states, Argentine pampas, SW and SE Australia, Cape region of South Africa). Surprisingly, some other modern breadbaskets were not early (US, England, much of France, Indonesia, Subequatorial Africa). The earliest sites are currently in dry or even degraded areas (Iraq and Iran, Mexico, Andes, China, Sahel zone of Africa).

Although it was developed independently in a few places, food production was mostly initiated by importing crops and livestock domesticated elsewhere. The timing was very different among those places where it arose independently, thousands of years earlier in Eastern Asia than in Eastern US and never in Eastern Australia, but why? Import times vary greatly also—thousands of years earlier in Southwestern Europe than in Southwestern US. Why, in some areas, did local people adopt crops and/or livestock from neighbors, and in others, invaders replaced the original people and brought the foods with them?

Where and when did food production originate? Plant and animal remains from archeological sites have been analyzed. Most domestic animals and crops differ significantly from wild ones (cattle and sheep are smaller, chickens and apples bigger, etc.), so they can be identified. There are problems with dating methodologies, so they are combined with other methods to determine location and time of domestication. One method is to find the wild progenitor of a domestic crop and combine that with dating methods. Another is to compare dates for each location, assuming that the earliest sign may be the site of initial domestication, especially if the wild ancestor grows there.

The same or similar crops or animals may be domesticated independently at more than one site. Genetic analysis may show when species diverged. For example, genetic analysis of Indian zebu cattle (with hump) and western Eurasian cattle (no hump) shows that their ancestors diverged hundreds of thousands of years ago. Since domestication occurred within the last 10,000 years, this is clearly a case of independent domestication.

Independent food production from local species has been found to have arisen in Southwest Asia (also called the Near East and the Fertile Crescent), China, Mesoamerica, the Andes of South America (including possibly Amazonia), and the Eastern United States. Some or all of these may comprise several independent developments, e.g., North China's Yellow River Valley and South China's Yangtze River Valley. There are also four other possibilities—Africa's Sahel region, tropical West Africa, Ethiopia, and New Guinea—but these are uncertain.

Southwest Asia has the earliest definitive dates—plants around 8500 BC and animals around 8000 BC. Dates for China are nearly as early. Eastern United States was not until 6,000 years later. There are too few early sites securely dated for the other six areas to be sure if or how much they lagged.

The next group domesticated at least a couple of local plants or animals, but production mostly depended on imports that "founded" local food production. The "founder" package from Southwest Asia included wheat, peas, olives, sheep and goats and colonized Western and Central Europe, where poppy seed and probably oats were added, the Indus Valley, and one or two others.

The question of whether local people adopted crops from their neighbors or invaders took over an area has not been settled for many places. Sometimes a marked difference in pottery or other artifacts indicate invasion (Austronesia, Subequatorial Africa). In other areas, the evidence is ambiguous (Europe).

CHAPTER 6: TO FARM OR NOT TO FARM

Why did anyone adopt food production, and why did they do it when they did? Farmers are not necessarily better off than hunter-gatherers. The first farmers were often smaller, less well nourished, had more diseases, and died younger than the hunter-gatherers they replaced. There exist cases of hunter-gatherers who saw and interacted with neighboring farmers or herders and never took it up. Others took a long time to do it.

Food production evolved as a result of decisions made without awareness of the consequences. Not all hunter-gatherers are or were nomadic. Indians of the Pacific Northwest in America, for example, lived in elaborate villages. Their environment was so rich that they did not need to move to find food. Some food producers are and were nomadic. People in New Guinea clear an area of forest and plant banana and papaya, and then go off and live as hunter-gatherers for several months, returning to harvest. Likewise, the Apache in Southwestern North America farmed in the summer at higher elevations, then in the winter moved to lower elevations, where they lived by hunting and gathering. Some hunter-gatherers manage the land as do New Guinea people, who clear away the encroaching vegetation from wild Sago palms, or Australian Aborigines, who burn the landscape to encourage edible plants that sprout after fires and also harvest tubers in a way that encourages regrowth.

Food production evolved step by step over varying amounts of time. Different crops and animals were domesticated at different times. Initially people did both; they farmed and/or herded and they hunted and gathered. The evolution was a result of decisions about how to allocate the finite resources of time and effort. All foragers seek to maximize the return, but they will choose moderate reliability over feast and famine if they can. It is likely that the first planters sought to create reliable reserves for when foraging failed.

Hunters tend to make decisions based on prestige. They will hunt giraffe—even if they only get one once per month—rather than nuts. Cultural preference, lifestyle priorities, and prejudices may also play roles. Hunter-gatherers and farmers traditionally despise one another.

Once some people began farming, others saw the result and could consciously choose to copy or not. Southeast Europe adopted the Southwest Asian cereals, pulses, and livestock all together about 6000 BC. The same “package” moved to Central Europe by 5000 BC. Southwestern Europe, in contrast, adopted it piecemeal starting with sheep. Cereals were later. Movement into Japan was also slow, perhaps because of the productiveness of hunting and gathering. Sometimes people who were farmers reverted to hunting and gathering and then back again, depending on conditions. Food production and hunting/gathering are alternative strategies and existed in mixtures as well as pure forms. But over the last 10,000 years the predominant result has been a shift to food production.

The factors that cause this tipping of the balance to food production are the subject of much questioning and remain unsettled, partly because answers could be different in different areas and cause and effect get tangled. But five reasons seem agreed on, although the relative importance of each continues to be controversial.

1. Decline in the availability of wild food
2. Increase in availability of domesticable wild plants (e.g., climate changes that increased the spread of cereals)

3. Development of technologies used for collecting, processing, and storing food, initially invented for dealing with abundant wild cereal harvests
4. Two-way link between population increase and food production increase. It is unclear which is first; they are probably reciprocal. Population increased as techniques for collecting and storing wild foods improved. With increased density, balance shifts to food production, which increases output, which increases population, etc.
5. Denser population of food producers, which allowed them to displace or kill hunter-gatherers at boundaries between them

The result was that in most areas suitable for food production, hunter-gatherers were either displaced or they adopted food production. The only exceptions were where hunter-gatherers were separated by natural barriers, e.g., deserts (California), climate (the Cape of South Africa), ocean or other water (Australia). The rest of the surviving hunter-gatherers lived in areas unsuited for food production.

CHAPTER 7: HOW TO MAKE AN ALMOND

The conversion of wild to domestic crops seems to have begun when seeds were accidentally sown in latrines and garbage middens. The natural process of gathering would have selected characteristics that later would enhance domestication. Naturally, when the time came, people selected the largest seeds for planting, even if the genetics involved were not understood. But how does a bitter or poisonous wild plant get converted into an edible domestic version? Almonds are a good example. Most wild almonds are bitter and poisonous. But occasionally a tree is a mutation, lacking the gene for the bitter poison. In the wild, these trees had few offspring since animals and humans ate most of them. Lima beans, watermelon, potato, eggplant, and cabbages are among the many plants whose wild ancestors were bitter and/or poisonous. Likewise, plants that normally scattered their seeds or had a heavy seed coat would have been selected for non-scatter or coatless versions. What was gathered would then at first accidentally—and later deliberately—get planted.

There then would be non-deliberate changes caused by the change in conditions that farming (sowing, weeding, watering) brought over wild conditions (dry, unirrigated, competitive environment).

What favors certain plants for domestication over others? (all examples here are from the Fertile Crescent). Some plants were already edible and giving high yields in the wild. Those that could be easily grown by being sown in the ground grew quickly and so could be harvested in a few months after planting, were easily stored, self-pollinating, and needed few mutations to adapt to domestication; these were the first (e.g., wheat, barley, peas), 10,000 years ago. The next group of crops were the first fruits and nuts around 4000 BC (olives, figs, dates, pomegranates, grapes). These all take at least three years to bear and as much as ten to full production. People must have already been settled before planting these. But still, those listed are the easiest of this type to cultivate. The third stage involved fruit trees that required grafting and only came in classical times. This had to have been discovered through conscious experimentation. Another group of plants started as weeds (rye, oats, turnips, radishes, beets, leeks, lettuce) and were discovered to be good to eat and cultivated.

The sequence is similar in other places. First would be fast-growing, high carbohydrate cereals or grains (grass family), and pulses which added protein (legume family). By Roman times almost all of today's leading crops were being cultivated. Potential food sources that were not cultivated are few. Acorns are a prime example. Oak trees take 20 to 30 years to become productive, not a time frame worth the heavy investment of time and effort for domestication.

CHAPTER 8: APPLES OR INDIANS?

Some crops have wild versions in areas where they were not domesticated. The potential of an entire local flora must be assessed for domestication. One or two crops are not enough for hunter-gatherers to change their lifestyle. Compare the Fertile Crescent (site of the earliest food production and domestication of almost all the major animals) with New Guinea and the Eastern United States, neither of which developed the extensive technological and political organization of the Fertile Crescent. What are the advantages of the Fertile Crescent? For most crops grown there, a wild ancestor has been identified and its relationship to the domestic version studied. The approximate time and place of domestication has been identified by following the strata of development down through layers of deposits. Other areas, notably China, also had advantages as early sites of domestication, but the Fertile Crescent is the most thoroughly studied.

Advantages of the Fertile Crescent

1. Mediterranean Climate: Mild, wet winters and long, hot, dry summers, cause natural selection of plants that are able to survive a long dry season and resume growing rapidly when rains returns. This is an ideal type of plant for storage. Many Fertile Crescent plants are annuals, small plants reproducing by seeds with little energy spent on woody or fibrous stems. Many of the big seeds, especially cereals and pulses, are edible. Six of the twelve major crops of the world originated there.
2. Many of the Fertile Crescent crops were already abundant and highly productive, occurring large stands. Huge amounts of these seeds could be collected and stored. Some hunter-gatherers in the Fertile Crescent had already settled into permanent villages before they began cultivation. Fertile Crescent cereals were so productive in the wild that they needed little change under cultivation—only the breakdown of the system of seed dispersal (getting them to hold on to their seeds until collected) and germination inhibition (preventing germination while stored). These changes evolved quickly. Big seeded annuals were among the first plants domesticated in China and the Sahel also.
   In contrast, corn in the New World required drastic changes from any of the suggested ancestors (still being hotly debated). The main candidate, teosinte, is so different that it wouldn't be recognized (it has low productivity, a hard shell on the seeds, and a tiny size). Archeologists are still debating how long (centuries, millennia) it took to change the tiny corn cobs up to the size of a thumb, and how many thousands of years more to reach modern size.
3. A high percentage of Fertile Crescent plants are self-fertilizing. Most plants in the world cross-fertilize (they require pollen from different individual to fertilize their flowers). This is a disadvantage in that any positive changes are easily lost when the new type is fertilized by the original type. Most crops belong to the small percentage of self-fertilizing or vegetative (from roots or runners) reproducers. The first eight crops domesticated in the Fertile Crescent were all self-fertilizers.

There are other locations with Mediterranean climate (California, Chile, Southwestern Australia, South Africa) that never gave rise to indigenous agriculture. What advantages did Western Eurasia have?

1. Size: Western Eurasia is by far the largest Mediterranean zone and as a result has the largest diversity of wild plants and animals.
2. Variation in Climate: Western Eurasia has a great variation of climate, season to season, year to year. Variation favors evolution especially of a high percentage of annuals. A geographer stud-

ied wild grasses and ranked the top 56 by seed size. Virtually all of them are native to Mediterranean zones or other seasonally dry environments. Thirty-two of them are found in the Fertile Crescent. Chile had only 2, California and South Africa 1 each, Southwestern Australia none.

3. Wide range of altitude and topography. This allowed for staggered harvest seasons in the Fertile Crescent.
4. Four species of big mammals: Goats, sheep, pigs, and cattle were all domesticated in the Fertile Crescent. Each lived originally in a different area, but still in close enough proximity that once one was domesticated in one area it was soon adopted in others. In contrast, the other Mediterranean areas had no such animals.
5. Less competition from hunter-gatherers. The Fertile Crescent offers less opportunity for hunter-gatherers than some other areas (even the Western Mediterranean area). It has few large rivers and only a short coast, so there were fewer fishing opportunities than elsewhere. The gazelle was hunted almost to extinction in the area, so food production quickly became superior (by 6000 BC).

There are eight "Founder" crops originating in the Fertile Crescent. These are wild plants that founded agriculture in the region. Because of this availability of a large number of suitable crops and animals, people quickly had a potent and balanced package for intensive food production. They had three cereals for carbohydrates, four pulses with 20-25% protein, four domestic animals as main protein sources, and flax as a source of fiber for cloth and oil. Later the animals also provided milk, wool, plowing, and transportation. This package of animals and plants allowed the Fertile Crescent farmers to meet humanity's basic economic needs for carbohydrates, protein, fat, clothing, traction and transportation.

In contrast, Mesoamerica had only two domestic animals (turkey and dog), both of which have a much lower meat yield. And corn was difficult and slow to develop. Domestication may have been as late as 3500 BC and in settled villages as late as 1500 BC.

Note that nowhere in this discussion is there anything about the advantages of the people themselves. And there is none. A look at Eastern US and New Guinea will quickly show that this is so. Hunter-gatherers know well all the locally available wild species. Ethno-biologists' studies have shown such people to be extremely skilled in knowing names and uses for as many as 1,000 or more plant and animal species. The author's own experience in New Guinea reflects this and, in addition, whenever he took a native New Guinean with him to other parts of the island, they would talk with local people about plants and animals and gathered potentially useful plants to take home. Farmers lose this type of knowledge when it is no longer needed.

When the question is whether ancient hunter-gatherers put such knowledge to good use, archaeology again can give us an answer. A site in Syria called Tell Abu Hurreya was settled from 10,000-9000 BC by hunter-gatherers. Charred plant remains of over 157 species have been identified, all useful in one way or another. Many more plants grew in the area, but they were not useful ones. Another example, from Jordan, shows settled early farmers (9000-8000 BC) grew barley and emmer wheat. There were hundreds of other seed-bearing wild species in the area, but barley and wheat proved best by far. When 23 most palatable and largest seeded grasses were tested, these two were first and second in size. Barley was one of the four most abundant in the wild, with emmer wheat in the middle. Barley evolves quickly for useful changes in seed dispersion and germination. Emmer wheat can be gathered efficiently, as its seeds do not adhere to the head. These farmers selected the two best plants to domesticate. Of course, evolutionary changes were an unforeseen consequence of domestication. But the decision to bring home barley and Emmer wheat would have been conscious.

We can also look at what local farmers in New Guinea and Eastern US did when more productive crops arrived from elsewhere. Results demonstrate that cultural factors did not keep them from

effectively exploiting local wild flora, but that those indigenous crops were not as productive as the imported ones. New Guinea, the second largest island in the world, has been settled for 40,000 years. There are no native land animals larger than 100 lbs. A number of crops are known to have been locally domesticated, but there were severe limitations—for example, no cereals—and staple crops are low in protein. Many centuries ago sweet potatoes were introduced. Compared with older New Guinea root crops, it grows at higher elevations, more quickly, and with higher yields per acre and per hour of labor. This resulted in a population explosion. Similar results occurred when animals (pig, dog, and chicken) were imported from Southeast Asia.

Another example, in the eastern US, is understood even better than New Guinea. Crops and dates and sequences have been identified. Four plants were domesticated between 2500 and 1500 BC. But they were not enough and served only as minor supplements to hunting and gathering. Between 500 and 200 BC, three more seed crops were added. All these seven were high in protein (17-32%), and two were also high in oil. But there were disadvantages: four had tiny seeds in low volume and one was a wind-pollinated relative of ragweed that caused allergies and skin irritations and smelled bad. Mexican crops began to reach eastern US soon after 1 AD. By 1100 AD, the Mexican trinity (corn, beans, squash) had led to greatly intensified farming and densely populated chiefdoms along the Mississippi and its tributaries. By the time Europeans arrived, they had replaced all but two of the original crops.

In both New Guinea and eastern US, limits on indigenous food production were not due to the native people, but instead depended entirely on local biota and the environment. Surveys have shown that areas of the world which never developed indigenous food production probably offered even less in the way of suitable plants and animals than New Guinea or eastern US.

One cannot conclude that those areas that had not developed indigenous food production before they came in contact with crops from other areas never would have done so. It is highly likely that they would have. However, the lack of highly suitable local candidates delayed this process, in some cases until they did come in contact with other groups of plants or were invaded by other people. One also cannot conclude that every society would have adopted food production if it could have. There are too many examples of cultures that have refused to do so. Cultures vary greatly in their openness to innovation. However, it is clear that adopting food production led to increases in population and technology that allowed food producers to take over most arable land that they came in contact with and often to kill or displace hunter-gatherers who had previously occupied it.

So, the question of why apples were domesticated in Eurasia and not in North America is answered by the timing of the adoption of food production. Apples in both places are the same or similar; however, they are also among the most difficult fruit trees to cultivate and among the last major ones to be domesticated in Eurasia because their propagation requires grafting. There is no evidence for their large-scale cultivation in the Fertile Crescent or Europe until classical Greek times, 8,000 years after the rise of food production. Thus, North Americans did not cultivate apples because they were delayed in developing food production; the entire suite of plants and animals available to them was only of modest potential until the arrival of the Mexican crops.

CHAPTER 9: ZEBRAS, UNHAPPY MARRIAGES, AND THE ANNA KARENINA PRINCIPLE

Domesticable animals are all alike; every undomesticable animal is undomesticable in its own way. This is a paraphrase of the first sentence of Anna Karenina ("Happy families are all alike; every unhappy family is unhappy in its own way."). Or to put it another way, success means avoiding the many separate possible causes of failure. This explains why, in the process of animal domestication, so many seemingly suitable big wild mammals (such as zebras and peccaries) have never been domesti-

cated and why the successful domestications were almost exclusively Eurasian. Big mammals were crucial for meat, milk products, fertilizer, land transport, plow traction, wool and germs that killed previously unexposed peoples.

Of course, many small mammals and domestic birds and insects have also been useful. Many birds have been domesticated for meat, eggs, and feathers (Chicken in China, duck and goose in Eurasia, turkey in Mesoamerica, guinea fowl in Africa, muscovy duck in South America). Wolves were domesticated in Eurasia and North America to become dogs used as hunting companions, sentinels, pets, and, in some societies, food. Rodents included rabbit in Europe, guinea pig in the Andes, giant rat in West Africa and, possibly, nutria on Caribbean Islands. Ferrets were used in Europe to hunt rabbits and cats in North Africa to hunt rodent pests. Recently (in the 19th and 20th centuries), foxes, mink, and chinchilla have been farmed for fur and hamsters raised as pets. Insects include the honeybee of Eurasia and the silkworm of China.

Small animals were useful for food, clothing or warmth, but none pulled plows or wagons, bore riders, became war machines, or were as important as food as the big mammals were. If we define "big" as more than 100 pounds, only fourteen species were domesticated before the 20th century. Of these, nine (Arabian camel, Bactrian camel, llama/alpaca, donkey, reindeer, water buffalo, yak, banteng, and gaur) remained in limited geographical areas, and five (cow, sheep, goat, pig, horse) spread around the world. It may seem like there are omissions to this list, for example, the elephant. But elephants were not bred in captivity. All elephants used were born wild, captured and tamed. The definition of a domesticated animal is one that is selectively bred in captivity and thereby modified from wild animals to be more useful. Two forces were at work—first, the human selection of the most useful animals and, second, the natural selection for optimization in the human environment as compared to the wild. This is the same as in our discussion of plants.

The ways that animals evolved in domestication include:

1. Change of size: cows, pigs, and sheep got smaller, while guinea pigs got bigger
2. Increasing amounts of wool and decreasing amounts of hair in sheep and alpaca
3. Increasing milk production in cows
4. Several have smaller brains and less developed sense organs than their wild cousins, reflecting less need.

If you compare all the breeds of dogs to wolves, you'll get an idea of the variety of changes.

Wild ancestors of the fourteen were spread unevenly. South America had only one, which led to the alpaca/llama (these are different breeds of the same animal). North America, Australia, and sub-Saharan Africa had none. Thirteen of the fourteen originated in Eurasia (including North Africa). While no area of Eurasia had all thirteen, in some cases many lived in the same area (e.g., seven in Southwest Asia).

If we define a candidate for domestication as any terrestrial herbivorous or omnivorous mammal (i.e., not predominantly carnivorous) weighing more than 100 pounds, Eurasia had the most candidates (72), sub-Saharan Africa had 51, the Americas had 24, and Australia had 1. So, part of the explanation is that Eurasia/North Africa had the most candidates to start with. However, it looks like relative species of the fourteen existed elsewhere without being domesticated. Why were Eurasia's horses domesticated and not Africa's zebras; why Eurasia's pigs but not Africa's or America's peccaries; why Eurasia's five types of wild cattle, but not Africa's buffalo or America's bison; Asia's sheep but not America's bighorn?

Were there cultural obstacles to domestication (for example, was the abundance of African animals so great that hunting made domestication superfluous)? No, there is the following evidence that this is not the case:

1. Rapid acceptance of Eurasian domesticates by non-Eurasians as soon as they were introduced. In Africa, farmers and herders with cows and sheep overran hunter-gatherers in the rest of sub-Saharan Africa. Horses transformed West African kingdoms with cavalry. European horses were widely in use by native North and South Americans within a generation of their escape from settlements. Within a decade of the introduction of European dogs to Tasmania, the Aboriginals were breeding them and using them in hunting. We can only conclude that the difference lay with the animals, not the people.
2. Universal human penchant for pets. Many more animals are and were regularly tamed all over the world (giraffes, bears, cheetahs, eagles, hawks, and all kinds of birds). This is the first stage leading to domestication, but only a few went the rest of the way.
3. Rapid domestication of the ancient fourteen. Dates confirm that early people quickly domesticated all of the big mammal species suitable between 8000 and 2500 B.C. Sheep were first, around 8000 B.C.; Camels were last, by 2500 B. C.
4. Repeated independent domestication of some. From DNA and mitochondrial evaluation, we know that the humped Indian cattle and the humpless European cattle diverged hundreds of thousands of years ago. So, these must have been domesticated independently. Dogs and pigs were also domesticated in several locations.
5. Limited success in modern efforts at further domestication. In the 19th and 20th centuries, at least six large mammals (eland, elk, moose, musk ox, zebra, and American bison) were subjects of well organized attempts at domestication with very limited success.

To qualify for domestication, an animal must have many characteristics. Lacking even one will disqualify it.

1. Diet. There must be efficiency of conversion of food to consumer biomass of about 10%.
2. Growth rate. They must mature quickly (this eliminates gorillas and elephants).
3. Ease of captive breeding. Some animals are very difficult to breed in captivity (Cheetahs, Andean vicuñas).
4. Pleasant disposition. Zebras become very dangerous as they grow older; they tend to bite and they don't let go, and they cannot be lassoed. Eland and elk are also unpredictable and dangerous.
5. Slow to panic. Useful animals seek their protection in herds, stand their ground and don't run until necessary. Nervous animals are hard to keep in an enclosure. They tend to panic and either die of shock or batter themselves to death trying to escape.
6. Social structure. All domesticated large mammals share three characteristics: they live in herds, have a well developed dominance hierarchy, and have overlapping ranges. Humans replace the dominant herd member. The animals are tolerant of each other and so can be bunched in large groups. Cats and ferrets are the only territorial animals domesticated and the motive for their domestication was not to use them for food, but to keep them as hunters and/or pets. Not all herd animals are candidates. Territorial animals cannot be penned together. Many herd animals are territorial during the breeding season (all the social African antelopes). The males fight for the females. Many herds do not have well defined dominance hierarchies, so they will not imprint to follow or yield to humans.

Eurasian peoples inherited many more large herbivore mammals with all the necessary characteristics for domestication than those of other continents.

CHAPTER 10: SPACIOUS SKIES AND TILTED AXES

Considering a world map, differences seem obvious. North and South America are on a north-south axis, much longer (9,000 miles) than wide (3,000 to less than 40). Africa also is on north-south axis, although not as narrow. In contrast, the major axis of Eurasia is east-west. This difference had enormous consequences in the spread of crops and livestock. Although food production arose in only a few areas, it spread in prehistory to many more. The areas of the main spread of food production were:

- Southwest Asia to Europe; Egypt and North Africa; Ethiopia; Central Asia; and the Indus Valley
- Sahel and West Africa to East and South Africa
- China to tropical Southeast Asia; The Philippines; Indonesia; Polynesia; Korea: and Japan
- Mesoamerica to North America

Rates and ease of spread varied greatly. Germination and growth rates and disease resistance of plants are adapted to variations of season and climate. An east-west axis means that adjoining areas are in similar latitudes and so have similar seasons and climates. Fertile Crescent crops grow well in temperate zones and, because of the east-west orientation, were able to move rapidly east and west. Likewise, crops spread from The Philippines east to Polynesia.

Spread is inhibited by geographic and climactic difficulties. For example, 2,000 miles of tropical conditions south of the Sahara prevented Fertile Crescent crops from reaching the Mediterranean climate of South Africa. Tropical African crops could not survive in the Mediterranean climate of South Africa. Animals were slowed. It took 8,000 years for cattle, sheep, and goats to reach South Africa.

America also had climactic differences north and south. Even though the Mexican highland and the Andes could have supported similar crops, most did not make it because of the intervening hot lowlands of Central America. Most of the American crops are of related species or even of genetically distinct varieties in Mesoamerica, South America, and Eastern North America.

Topographical (height) or ecological (desert, rainforest) barriers can also interfere. Southeastern United States and southwestern United States are divided by the dry area of Texas and the Great Plains. East of the Indus Valley in India the shift from winter rain to summer rain meant that the same crops could not be used. The Central Asian desert, Tibetan plateau, and the Himalayas isolate the temperate areas of China. But this barrier was partly overcome between 1000 and 2000 BC (wheat, Barley, and horses reached China from the west).

Technology had similar difficulty and ease. Southwest Asian technology of the wheel spread within a few hundred years throughout much of Eurasia. Alphabetic writing took about 1,000 years.

PART 3: FROM FOOD TO GUNS, GERMS, AND STEEL

CHAPTER 11: LETHAL GIFT OF LIVESTOCK

Farmers tend to have nastier germs, better weapons and armor, and more powerful technology, and live under centralized governments with literate elites better able to wage wars of conquest. How does food production lead to germs, literacy, technology, and centralized government?

Infectious diseases (smallpox, influenza, tuberculosis, malaria, plague, measles, and cholera) are the major killers of people through most of history. Until WWII, even in war most deaths were from air-borne microbes, not weapons. European conquest of the Americas is the grimmest example of this; 95% of the native population was wiped out by disease, most before they ever saw a white person.

Some microbes are passive and wait for their current host to be eaten to spread (Salmonella, Trichinosis). Or some hitchhike on the saliva of an insect biting the old host and then a new one (mosquitoes, fleas, lice, and tsetse flies spread malaria, plague, typhus, and sleeping sickness). Others can pass from mother to fetus (syphilis, rubella, and AIDS).

For those that spread actively, many symptoms of the disease are actually the ways the microbes have of spreading. Skin lesions (smallpox, venereal disease) directly spread the microbe to the skin or membrane of another victim. Inducing the victim to cough or sneeze releases a cloud of microbes to a new host (influenza, the common cold, whooping cough). Diarrhea puts bacteria into the water supply (cholera). Rabies induces a frenzy of biting to spread itself from the saliva of a host to another. Worms (hookworms, schistosomes) burrow into new victims' skin from water or soil, into which larva have been excreted in feces. Killing the victim is an unintended byproduct of such strategies of reproduction of the microbe. Our bodies attempt to survive by killing the microbe. One response is fever to bake them. We also mobilize the immune system, which includes cells that seek out and kill foreign microbes. We gradually develop specific antibodies for the particular microbe infecting us, which means that we are less likely to be reinfected. Sometimes this immunity is temporary (colds); in other cases it is permanent (measles, mumps, rubella, whooping cough, and smallpox). This is the principle of vaccination. Some microbes evolve quickly into slightly different forms, fooling the immune system (influenza, malaria, sleeping sickness, AIDS).

The slowest defense is natural selection. But for almost any disease, some people are more resistant. In an epidemic, these people are more likely to survive and reproduce. Over time, as a population is repeatedly exposed to particular pathogens, it will consist of a higher proportion of those resistant to the disease. Some such defenses come at a price—the sickle cell gene for malaria, Tay-Sachs for tuberculosis, and cystic fibrosis for bacterial diarrhea.

Consider the forms of this war between microbes and humanity. Is it blitzkrieg or guerrilla? If the number of cases of a disease in a particular geographic area are counted and watched, we see that the pattern for diseases varies. For some (malaria, hookworm), new cases appear at any time. For epidemic diseases, the pattern is different. There will be no new cases for a long time, then a large number, then none again for a while (influenza, cholera). The greatest single epidemic in history was the Influenza epidemic at the end of WWI, which killed 21 million people. Bubonic plague (the Black Death) killed one fourth of the European population between 1346 and 1352. In 1880's Saskatchewan, tuberculosis killed nine percent of the population per year.

The characteristics of epidemic disease are:

1. Spreads quickly
2. Acute illness—one either dies or recovers in a short period.
3. Those who recover develop antibodies, which leave them immune for a long time, possibly life.

4. It is restricted to humans. The microbes tend not to live in the soil or other animals.

This is how it works: When exposure comes, everyone is quickly infected and either recovers and is immune or dies. Once everyone left alive is immune, the disease dies out, until a new generation of children without the immunity is born and a new infected person arrives.

Research shows that epidemic (crowd) diseases tend to die out permanently in any population less than 500,000. In larger populations, disease shifts from one area to another, returning when enough new non-immune children are born for it to strike again. Hunter-gatherers and other small population groups can't sustain such diseases, so no one has immunity. Therefore, when those diseases are introduced from outside, they have a devastating effect. The diseases that small groups have are chronic and take a long time to kill—so infected people are always available to infect others (leprosy, yaws) and possibly wild animals too (yellow fever)—or they live in soil or water (parasites).

Crowd diseases arose after the buildup of large, dense populations, i.e., after the rise of agriculture. Frequent camp changes by hunter-gatherers meant that they left behind the sources of passing infection through feces and contaminated water. Sedentary farmers lived near their own sewage. It is a short path from sewage to drinking water to another person. Also, some farming populations use their own feces and urine as fertilizer in their fields, where people work. Irrigation and fish farming created environments for water borne parasites.

Cities were even more densely packed with even worse sanitation. Until the 20th century, urban areas needed a constant influx from the countryside to keep populations steady because of losses to crowd diseases. Another bonanza for microbes was world trade routes joining the populations of Europe, Asia, and North Africa into one giant breeding ground. Today, the spread is even more rapid.

Since these diseases need large concentrated populations, they evolved from animals that also congregate in large, dense populations—our own domesticated social animals, such as cows and pigs. Measles virus, for example, is closely related to rinderpest, a disease of cattle, smallpox to cowpox, etc.

The stages of evolution of a specialized human disease from its animal precursor are as follows:

1. Diseases that we occasionally get from animals but don't spread to each other, such as cat scratch fever (from cats), leptospirosis (dogs), psittacosis (chickens, parrots), brucellosis (cattle), and tularemia (rabbits)
2. Diseases that do get transmitted directly between people and cause epidemics, but quickly die out for any of several reasons—they are cured by medicine, everyone has already been infected and ether has died or is immune, (e.g., O'nyong-nyong fever in East Africa in 1959, which probably started with monkeys and was spread by mosquitoes. Patients recovered quickly and became immune. Another example is Kuru, which was spread by cannibalism in New Guinea's Foré tribe and died out when cannibalism was stopped). History tells of diseases that appeared and disappeared, such as "English sweating sickness" in Europe from 1485-1552, and "Picardy sweats" in 18th- and 19th-century France.
3. Diseases that are established in humans and have not (not yet?) died out and may or may not still be major killers, such as Lassa fever (from rodents) in Nigeria, Lyme disease in the US, and AIDS.
4. Major, long-established epidemic diseases, confined to humans. The transformation often means that the microbe finds a new vector to transfer itself more conveniently from victim to victim. Typhus was first transmitted by rat fleas, then by human lice, and, now that Americans have de-loused themselves, it has found a new route via flying squirrels in the attic.

Microbial evolution can be studied by using myxomatosis in Australian rabbits. This lethal virus was introduced in Australia in hopes of eradicating the rabbits infesting the country. In the first year, it killed 99.8% of the infected rabbits. But in ensuing years mortality rates dropped to less than 25%. The virus evolved—to serve its own purposes—into a less virulent form, killing fewer and allowing the dying to live longer, so more viruses could spread. Syphilis apparently mitigated itself from a rapid (2-3 months) killer to a disease taking many years, thus spreading to more victims.

The importance of lethal microbes is well illustrated by the European conquest and depopulation of the New World. Far more Native Americans died from disease than on the battlefield. In less than 100 years, smallpox reduced Mexico's indigenous population from 20 million to 1.6 million. In the United States, the large indigenous farming population in the Mississippi valley was wiped out long before the Europeans themselves arrived in that area. Perhaps as much as 95% of the population was killed.

Smallpox, measles, influenza, and typhus compete for top killer. Diphtheria, malaria, mumps, pertussis (whooping cough), plague, tuberculosis, and yellow fever are in the second tier. The only major killer to possibly be transferred from America to Europe was syphilis and there is controversy about it.

The Americas lacked domesticated herd animals of the type to easily spread diseases. The turkey in Mexico and Southwestern United States, and Muscovy duck in Amazonia were not kept in large flocks or indoors. Guinea pigs (Andes) may have contributed, but it is uncertain. Llamas and alpacas were not kept indoors or in large herds and people did not drink their milk.

Eurasian germs played a key role in decimating native people all over the world, including Pacific Islanders, Aboriginal Australians, Khoisan people of South Africa (Hottentots and Bushmen) in addition to Native Americans. Cumulative mortalities ranged from 50-100%. Hispaniola (the island of Haiti and the Dominican Republic) had eight million people when Columbus arrived in 1492 AD. By 1535 the native population was exterminated. When measles hit Fiji in 1875, it killed one fourth of those still alive after previous epidemics. Between 1779, when Cook first visited Hawaii, and the 1850s, when smallpox killed 10,000, the Hawaiian population went from 500,000 to 74,000 or less.

Germs were not only an advantage for Europeans. Although the New World did not have native epidemic diseases, tropical Africa, Asia, Indonesia, and New Guinea did. Malaria, cholera, yellow fever were and still are notorious tropical killers in various areas. Malaria and yellow fever were transported to tropical America, impeding colonization there. However, in the temperate zones Eurasian diseases played a huge role. A sinister gift, they evolved from Eurasians' long intimacy with domestic animals.

CHAPTER 12: BLUEPRINTS AND BORROWED LETTERS

Writing went together with weapons, microbes and centralized government as a modern agent of conquest. Commands of those organizing fleets were conveyed in writing. Conquerors set courses with maps and written directions from previous expeditions. Written accounts of earlier expeditions motivated later ones by describing wealth and fertile lands. They also told what to expect when they got there and administered the resulting empire. All these types of communication went on in preliterate societies, but writing made it easier, more detailed, more accurate, and more persuasive. Until the expansion of Islam and the European colonization it was absent from Australia, the Pacific islands, subequatorial Africa and most of the Americas. Some peoples (Incas) managed to administer an empire without writing. And those with writing didn't always defeat those without it (Romans were defeated by the Huns). But this is atypical.

Why did some people develop writing and others did not? How many times did it evolve and under what circumstances? Why earlier with some than others? The diffusion of writing raises ques-

tions we could ask about the rise and spread of other aspects of culture, such as technology, religion, and food production. Why did it spread from the Fertile Crescent to Ethiopia and Arabia, but not from Mexico to the Andes? Did it spread by being copied or did it inspire neighboring people to invent their own? How is a writing system that works well for one language revised for another? The advantage of looking at these questions for writing is that the answers are in the written record.

There are 3 basic strategies determining the size of the speech unit denoted by one written sign.

1. Alphabets, one sign = one sound (phoneme), are the most common today. Since there are usually more phonemes than there are letters, some letters denote more than one sound and some sounds take more than one letter ("th" and "sh" in English are separate letters in Russian and Greek alphabets).
2. Logograms, one sign = one word, are used for Chinese and Kanji (Japanese) today, but also for Egyptian hieroglyphs, Mayan glyphs, and Sumerian cuneiform.
3. Syllabaries, one sign = one syllable, are today found in Japan's Kana, which is used for telegrams, bank statements, etc. It was common in ancient times (Linear B of Mycenaean Greece).

No writing system uses one strategy exclusively. For example, English uses many logograms ($, %, @, &, etc.). Syllabic Linear B had many logograms and logographic Egyptian hieroglyphs included many syllabic signs as well as a virtual alphabet of individual letters for each consonant. Chinese today is not purely logographic.

The first scribes had to settle on the basic principles, now taken for granted, for how to decompose continuous utterance into speech units. No matter what strategy they used, they had to learn to recognize the same sound or speech unit through all the normal variations of volume, pitch, speed, emphasis, phrase grouping and idiosyncrasies of pronunciation and, ignoring that, had to devise symbols to represent the sounds. The difficulty is evident in that on only a few occasions in history have people invented writing on their own. Two indisputable occasions are the Sumerians (Mesopotamia) somewhat before 3000 BC and the Mexicans before 600 BC. Egyptian writing (3000 BC) and Chinese writing (before 1300 BC) may have arisen independently. Probably all the others have borrowed, adapted, or at least been inspired by existing system or systems.

We have the greatest detail about the oldest form, Sumerian cuneiform. For thousands of years before it developed into actual writing, people used clay tokens with simple shapes for accounting purposes. Just before 3000 BC, they developed, within the accounting format, signs and technology that rapidly led to writing. They began to use flat clay tablets as a writing surface. Initially they scratched marks on it, but then began to use a reed stylus to make precise marks. Conventions were gradually adopted and marks were organized into ruled rows or columns (horizontal rows in Sumer) and marks were made in a constant direction of read (left to right, top to bottom in Sumer).

But the crucial change was the devising agreed upon visible marks that represent actual spoken sounds rather than ideas or words independent of sound. First were accounting reports—numerals and a pictograph noun for an object. There were no grammatical elements. Then, gradually, with the use of the stylus, signs became more abstract. New signs were created by combining old ones—e.g., the sign for "head" plus that for "bread" became "eat."

Perhaps the most important step was the introduction of phonetic representation—initially by writing an abstract noun by means of a sign for a depictable noun with the same phonetic pronunciation—e.g., "arrow" and "life" were pronounced the same in Sumeria (Ti), so an arrow was used for "life." Ambiguity was resolved with a small sign called a determinative. Once this principle was discovered, it was used for more than just abstract nouns (syllables and grammatical endings). Sumerian

writing came to be a complex mix of several types of signs: logograms were used for a whole word or name; phonetic signs were used for syllables, letters, and grammatical elements or parts of words; and determinatives, which were not pronounced, were used to resolve ambiguities. Still, Sumerian was not a complete syllabary or alphabet. Some syllables lacked any written signs. The same sign could be pronounced in different ways and the same sign could be read as a word, a syllable, and a letter.

The other independent writing arose in Mesoamerica. There are several related scripts, the earliest from the Zapotec area of southern Mexico. The best understood is Mayan (although not yet completely translated), where the oldest date is 292 AD. The forms are quite different from Sumerian or any other Old World writing, but the principles are similar. They used both logograms and phonetic signs. Logograms for abstract words often used the rebus principle. Like Japanese Kana and Mycenaean Greek Linear B, most signs are for syllables of one consonant and one vowel. Like the early Semitic alphabet, a sign is often derived from a pictogram of a word starting with the same syllable. These similarities attest to the universality of human creativity. The languages may have no special relationship, but writing raised similar basic issues. The solutions invented by Sumerians before 3000 BC were also invented by Mesoamericans before 600 BC. With the possible exceptions of Egyptian, Chinese, and Easter Island writing, all other writing appears to be either descendants of or inspired by Sumerian or early Mesoamerican.

While other early societies evolved the features needed to find writing useful, the rapid spread of the already invented Sumerian or Mesoamerican system precluded developing it again. Writing and other technology and ideas spread by either direct copying, called "blueprint copying," where an existing system is modified for use, or by "idea diffusion," where the basic idea of it is imported but people invent their own details.

Today, when linguists design a writing system for an unwritten language they use blueprint copying with modifications. We know who invented some current systems—e.g. Cyrillic (Russian) was an adaptation of Greek and Hebrew letters by St Cyril, a Greek missionary in 9th century AD; the first Germanic texts were in the Gothic alphabet created by Bishop Ulfilas, a missionary to the Visigoths in the 4th century AD, with borrowed letters from Greek and Roman and a few invented ones. But usually we don't know. However, comparisons of newly emerged alphabets with previously existing ones allow us to deduce the models—e.g., Linear B of Mycenaean Greek was adapted from Linear A of Minoan Crete about 1400 BC.

Blueprint copying almost always needs adaptation, as the new language would not often the same sounds used in the old. Unused letters might dropped or used for a different sound. New sounds might use a combination of letters (like English "th"); add a distinguishing mark (like Spanish tilde ñ or German umlaut ü); co-opt needed letters to a new sound (Czech uses "c" of Roman alphabet for the sound "ts"); or invent a new letter (j, u, w in English).

The alphabet apparently arose only once, among speakers of Semitic languages in the area from modern Syria to Sinai during the 2nd Millennium BC. All of the hundreds of alphabets, past and present, were ultimately derived from that ancestral Semitic alphabet. In a few cases (e.g., Irish Ogham) this was by idea diffusion, but mostly it was by copying and modification. The Semites used alphabetic writing exclusively. This was the first step. The second step was to help remembering the alphabet by putting names to the letters. The Semites used familiar words that began with the letter (Aleph = ox, Beth = house, Gimel = camel, Daleth = door, etc). The third step was to provide vowels. Early they used small signs, but the Greeks in the 8th century BC were first to use the same kind of letter for a vowel as for a consonant, co-opting five letters used in Phoenician for consonants lacking in Greek. We can follow a line of development from Phoenician to Aramaic to modern Arabic, Hebrew, Indian, and Southeast Asian. There is another line from Phoenician to Greek to Etruscan to Roman.

The best-documented instance of idea diffusion is Sequoyah's syllabary for Cherokee from the 1820s. He received writing materials and the idea of a writing system, the idea of using separate marks

and even the form of some of the marks, however, since he could neither read nor write English, he did not acquire the details or principles from the existing script. This has happened a number of times (Han'gul in Korea, Celtic Ogham alphabet).

As for the three other debated scripts, Easter Island probably got the idea from Spanish. Chinese was probably independent, around 1300 BC, possibly with a precursor, as at that time there was no other writing nearer than 2,600 miles south (Indus Valley). Egyptian hieroglyphs appeared suddenly and in nearly complete form around 3000 BC. However, they are only 800 miles west of Sumer.

Why did writing arise in and spread to some societies, but not to many others? We begin with the limited capabilities of uses and users of early writing systems. Early scripts were incomplete, ambiguous, complex, or all three of these. For example, the oldest, Sumerian, was telegraphic shorthand restricted to names, numerals, units of measures, words for objects counted and a few adjectives … i.e., one could say "John 27 fat sheep," not "We order John to deliver the 27 fat sheep he owes to the government." Later Sumerian cuneiform added a messy mix of logograms, phonetic signs, and unpronounced determinatives to become capable of rendering prose. But it was still confusing, using the same sign for several related consonants. It was as if our language spelled "rap," "lap," "lab," and "laugh," identically.

Another limitation was that the early scripts were confined to professional scribes in the employ of kings or temples. Linear B in Mycenaean Greece was used by such small cadres of palace bureaucrats that individual scribes can still be distinguished by their handwriting. Writing was restricted to uses where ambiguity was countered by context to make meaning clear. Cuneiform and Linear B were used for accounting; early Egyptian for religious and state propaganda and bureaucratic accounts; Mayan for propaganda, births and accessions, victories of kings, and astronomical observations of priests; and Chinese for religious divination. Early users wanted writing restricted to professional scribes to record tax information and not to be used by the masses to "write poetry and hatch plots." Personal use came much later, when systems became simpler and more expressive. Linear B, for example, disappeared when Mycenaean civilization fell and Greece returned to preliteracy until the 8th century BC, when uses and users were quite different. At that time, writing was a borrowed alphabet (Phoenician) to which the Greeks added vowels. Instead of lists of goods that could only be read by palace scribes, Greek alphabetic writing was from its appearance used for poetry and humor. The sequence of uses for alphabetic writing was the reverse of that for earlier systems of logograms and syllabaries.

All of the likely or possible independent inventions of writing (Sumer, Mexico, China, Egypt) and all of the early adaptations (e.g., Crete, Iran, Turkey, Indus Valley, Maya) involved socially stratified societies with complex centralized political institutions. Writing served the needs of the political institutions (record keeping, royal propaganda, etc.). Users were full-time bureaucrats nourished by food surpluses grown by peasants. Writing was never developed or adopted by hunter-gatherers, who lacked both the institutional uses and food surpluses required to feed scribes.

Food production was a necessary condition; it was not a cause. There were some food-producing societies with complex political organization that did not develop writing (Inca, Tonga, Hawaii, all the states and chiefdoms of subequatorial Africa and Sub-Saharan West Africa, and the largest native North American society in the Mississippi valley). Most of these societies developed food production later than Sumer, Mexico, and China so, given enough time, they might have developed writing as well. Had they been able to be in contact with societies with writing they might have acquired it.

CHAPTER 13: NECESSITY'S MOTHER

Technology of weapons and transportation are the direct means by which certain peoples have expanded their realms and conquered others. Why were Eurasians, not Native Americans or Sub-Saharan Africans, the inventors of firearms, oceangoing ships, and steel equipment? This difference extends to most other significant technological advances (printing presses, glass, steam engines). Why were they all Eurasian? Why were New Guineans and Native Australians still using stone tools in 1800 AD, despite rich deposits of gold and iron?

This is why so many assume Eurasians are superior in inventiveness and intelligence. But no such difference in neurobiology exists to explain it. Another theory is the "solitary genius" by accident born Eurasian. Another view holds that it is receptiveness of society to innovation that counts, some being hostile to change. The central issue of this book is why technology evolved at such different rates on different continents.

"Necessity is the mother of invention" seems a truism, and many modern examples bear it out (e.g., the Atom bomb and the steam engine). But it is deceptive. Many, or even most, inventions were developed by people out of curiosity or love of tinkering. They would then have to find an application for it or even create a need. Often an invention for one purpose finds most of its use in other unanticipated ways. Inventions for which we know a use had to be found include the internal combustion engine, electric light bulb, airplane, automobile, phonograph, and transistor. "Invention is often the mother of necessity." Take the phonograph, for example. Edison mostly thought its use would be as an office dictating machine. He even objected to jukeboxes as debasing his invention. It took him 20 years to concede the main use was to record and play music. When the automobile was invented, people were using horses and steam locomotives. There was no shortage of horses or dissatisfaction with railroads. The first engine (1866) was too heavy, weak, and large (7 feet tall) for much use. Even 50 years later, autos were still expensive, unreliable toys for the rich. WWI created the need for trucks. Most inventions initially work rather poorly or are too large, heavy, or expensive to be of much use. It often takes years of tinkering for them to be productive.

Likewise, the "heroic" view of inventing is encouraged by modern patent law. In fact, most inventions have many precursors and most are improvements on previous designs. For example, the steam engine invented by James Watt in 1769 was an improvement on that of Thomas Newcomen in 1712, which followed Thomas Savery's in 1698, which was preceded by Denis Papin's of 1680, which came from ideas of Christiaan Huygens and others. The other factor is timing—an invention or improvement must coincide with a time when society can use it. How many inventions failed because society couldn't exploit them?

Our conclusions are:

1. Technology develops cumulatively.
2. Technology finds most of its uses after it is invented rather than being invented to meet a need.

Although we can't go back and get the actual stages of development for early pottery or glass, by observing technologically "primitive" people today we see that they constantly pick up and tinker with things, especially when in a new environment or when finding objects abandoned by others, seeing if it might be useful for something. The author uses examples from his own experiences in New Guinea. Natural materials were the raw substances available to ancient people—stone, wood, bone, skins, fiber, clay, sand, limestone, and minerals in great variety. People gradually learned to work certain types of stone, wood, and bone into tools; to convert clay into pottery; to work mixtures of sand,

limestone, etc., into glass; and to work pure soft metals (copper, gold). They later learned to extract metals from ores and, finally, to work hard metals (bronze, iron).

Combustible natural products make themselves noticed (e.g., resinous logs explode in a fire). By 2000 BC Mesopotamians were extracting petroleum from rock asphalt. Ancient Greeks used various mixtures of petroleum, pitch, resins, sulfur, and quicklime for incendiary weapons. Islamic alchemists distilled petroleum into fractions to create powerful incendiaries used to defeat the Crusaders. The Chinese made gunpowder. An Islamic book of 1100 AD describes seven recipes for gunpowder, and another from 1280 AD has over 70. Nineteenth-century chemists found a distillate fraction of petroleum useful for fuel oil for lamps. Gasoline was a waste product until the internal combustion engine. Gasoline started out as an invention lacking a use.

Once a use for a new technology is found, society must be persuaded to adopt it. Being better than what came before is no guarantee (the history of the typewriter keyboard attests to that). Many factors have been put forward as promoting acceptance of or resistance to technological innovation. While all these are plausible, none has any necessary association with geography. In actuality, everywhere there are some societies highly receptive to innovation and change and others that aren't. When we observe recent history in places like New Guinea, Africa, North America, or Australia, we see that when Europeans brought technology, some societies adapted and adopted it and some didn't. And often those that did came to dominate those that didn't. The same variations exist in the same society over time. Medieval Islam was technologically advanced and open to innovation. Many major advances in areas like windmills, trigonometry, maritime technology, metallurgy, engineering, irrigation moved into Europe from Islamic areas. Now many of the same societies are conservative and suspicious of technology. China shows a similar pattern. This unpredictability means that societal variation is a random factor. Over a large enough area (a continent) at any particular time, some societies are likely to be innovative and some will not.

Most innovations are borrowed. The relative importance of local invention and borrowing will depend on the ease of inventing the particular technology and the proximity of other societies. Some inventions grew easily from handling natural raw materials and arose in many places (plant domestication, pottery). More difficult ones (writing) were mostly borrowed (water wheel, magnetic compass, toothed gearing, windmills). Some spread more rapidly than they could be invented (wheel). The spread happens in two ways, either because one society sees it and adopts it from another, or because the ones with the invention move in and absorb or displace those without it. Diffusion may happen in many contexts, peaceful trade (transistors from USA to Japan in 1954 AD), espionage (silkworms smuggled from SE Asia to the Middle East in 552 AD), emigration (French glass and clothing manufacturing throughout Europe with the expulsion of the Huguenots from France in 1685 AD) and war (papermaking when the Arabs defeated the Chinese in 75 AD—they captured some papermakers and brought them to Samarkand to set up paper manufacturing). The same principles apply to all technology as to writing.

Geographic location does determine how readily a society can adopt technology from others. Most accessible are those embedded in major continents, not on the fringes (Australia, New Guinea). For example, Medieval Islam was centrally located in Eurasia and acquired inventions from India and China, as well as inheriting ancient Greek learning.

Sometimes a society will acquire a technology and then abandon it, as the Japanese did with guns in the 17th century. But again, they need isolation to do this. No central European country could afford to do it because they would have been overrun by their neighbors. The Japanese quickly resumed gun manufacture after the US Fleet visited them in 1853. Other examples from both modern and prehistoric times tell us the importance of geography and diffusion. Without diffusion, fewer technologies are acquired and more are lost.

Technology begets more technology, so the importance of diffusion potentially exceeds the importance of original invention. The history of technology exemplifies this "autocatalytic" process. The speed of change increases with time because the process catalyzes itself. There have been many explosions of technology, the most recent following the Industrial Revolution of the 18th century. But the Medieval period, the Bronze Age and the Upper Paleolithic were others.

Technology catalyzes itself because advances depend on previous mastery of simpler problems. Iron was not the first metal worked because it required high-temperature furnaces. It grew out of thousands of years of human experience working with metal, starting with naturally occurring pure soft metals (copper and gold) and developing simple furnaces to make pottery. Gradually, metals requiring higher and higher smelting temperatures came into use. Bronze, for example, was produced for about 2,000 years in China and the Fertile Crescent before iron objects were made. New World societies were just beginning to make bronze when the Europeans arrived.

New technologies and materials generate still other new technologies by recombination. For example, printing spread explosively in Medieval Europe because of six technical advances. Paper and moveable type came from China. Gutenberg typecast metal dies to overcome the problem of non-uniform type sizes. His press derived from wine and oil and his ink was an oil based improvement. Alphabetic scripts used in Europe meant only a few dozen letter forms (instead of the thousands required in China).

Human technology developed from the first stone tools 2 ½ million years ago to today, but initially hundreds of thousands of years passed with no discernible change. Now change is reported almost daily. There were, however, two especially significant jumps. The first occurred between 100,000 and 50,000 years ago, probably due to genetic changes allowing modern speech and/or modern brain function, and led to bone tools, single-purpose stone tools, and compound tools. The second jump resulted from the adoption of settled lifestyles, as early as 13,000 years ago in some parts of the world. This change is linked to food production and allowed accumulation of non-portable possessions (pots, looms, etc.). Food production also allowed the development of economically specialized non-food-producers.

Local technology depends not only on local development, but also on diffusion of technology from other locations. So, it develops most rapidly on continents with few geographic and ecological barriers to diffusion either within the continent or from other continents.

Finally, societies vary greatly in innovativeness for many reasons. So, all things being equal, technology develops fastest in large productive regions with large human populations, many potential inventors and many competing societies. Variation in these three factors (time of onset of food productions, barriers to diffusion, and human populations size) lead to observed intercontinental differences in the development of technology.

Eurasia and North Africa occupy the largest landmass with the largest number of competing societies and are where food production first began. The east-west axis permitted many inventions to spread relatively quickly to societies in similar latitudes and climates. It is broad along its north-south axis as well and lacks severe ecological barriers like those along the major axes of America and Africa. Eurasia was the continent where technology started earliest and spread most widely and, therefore, had the greatest local accumulations.

North and South America, when considered together, compose the second largest land mass, significantly smaller than Eurasia. They are also fragmented by geography and ecology. The Northern Mexican desert separated the advanced Mesoamerican societies from North America and the narrow Isthmus of Panama and the Central American rainforest separated them from South America. Also, the main axis is north-south, forcing diffusion to go against latitude and climate. For example, wheels were invented in Mesoamerica and llamas were domesticated in the Andes. But after 5,000 years, they had

not met up with each other, even though they were only 1,200 miles apart. Contrast this with 6,000 miles between China and Europe separating the wheel and horse.

Sub-Saharan Africa is the third largest continent but is much smaller than North and South America. Although it is more accessible to Eurasia than the Americas, the Sahara was a major ecological barrier. The north-south axis also was an obstacle, both to diffusion from Eurasia and North Africa and within Sub-Saharan Africa itself. For example, pottery and iron metallurgy arose in or reached the Sub-Saharan Sahel zone at least as early as it reached Europe, but pottery didn't reach the southern tip of Africa until 1 AD, and metallurgy hadn't reached there by the time the Europeans did.

Australia is the smallest continent. It has very low rainfall and productivity throughout most of it. This makes it even smaller in its capacity to support a human population. It is the most isolated continent. Food production never arose there, nor did metallurgy.

Not surprisingly, population sizes compare in the same way as land mass. Eurasia/North Africa had many more people than North and South America, which had more than Sub-Saharan Africa, etc. More people means more inventors and more competing societies. Differences become exaggerated because technology catalyzes itself. The initial advantage of Eurasia was huge by 1492 by reason of geography—not intellect.

CHAPTER 14: FROM EGALITARIANISM TO KLEPTOCRACY

Today previously uncontacted hunter-gatherer societies in New Guinea and Amazonia are most often first brought to the modern world by missionaries. After them come teachers and doctors, bureaucrats and soldiers. The spread of governments and religions are linked throughout history, whether peaceful or not. When it is done by force, government organizes and religion justifies. The trend over 13,000 years has been for nomads and tribes people to lose. In 1500 AD, less than 20% of the world's land area was marked by boundaries into states run by bureaucrats and government by laws. Today all land, except Antarctica, is so divided and marked. The descendents of those societies that achieved centralized government and organized religion earliest have ended up dominating the modern world. The combination of government and religion functioned (together with germs, writing, and technology) as one of the four main agents leading to history's broadest pattern.

How did government and religion arise? Societies differ in the presence or absence of professional police forces, cities, money, distinctions between rich and poor and many of the political, economic, and social institutions. Did those institutions all arise together or not? We can infer an answer by comparing modern societies at different levels of organization by examining written accounts and archeological evidence and observing the changes in a given society's institutions over time.

Attempts by cultural anthropologists to define evolutionary or developmental stages for societies are always imprecise. Each stage grows out of the one before and lines of demarcation are arbitrary. Developmental sequences are not uniform; examples labeled for a given stage are always diverse. Nevertheless, arbitrarily delineated stages provide a useful shorthand. Using a simple classification, societies can be listed as band, tribe, chiefdom or state.

	Band	Tribe	Chiefdom	State
Membership				
Number of people	Dozens	Hundreds	Thousands	Over 50,000
Settlement pattern	Nomadic	Fixed: 1 village	Fixed: 1 or more villages	Fixed: many villages & cities
Relationships basis	Kin	Kin based clans	Class & residence	Class & residence
Ethnicities & Language	1	1	1	1 or more
Government				
Decision making, leadership	"Egalitarian"	"Egalitarian" or big man	Centralized, hereditary	Centralized
Bureaucracy	None	None	None or 1 or 2 levels	Many levels
Monopoly of force & information	No	No	Yes	Yes
Conflict resolution	Informal	Informal	Centralized	Laws, judges
Hierarchy of settlement	No	No	No → paramount village	Capital
Religion				
Justifies kleptocracy?	No	No	Yes	Yes → no
Economy				
Food production	No	No → yes	Yes → intensive	Intensive
Division of labor	Age & sex only	Age & sex only	No → yes	Yes
Exchanges	Reciprocal	Reciprocal	Redistributive ("tribute")	Redistributive ("taxes")
Control of land	Band	Clan	Chief	Various
Society				
Stratified	No	No	Yes, by kin	Yes, not by kin
Slavery	No	No	Small-scale	Large-scale
Luxury goods for the elite	No	No	Yes	Yes
Public architecture	No	No	No → yes	Yes
Indigenous literacy	No	No	No	Often

A band is the smallest society. Today autonomous bands only exist in the remotest parts of New Guinea or Amazonia. Many have recently been assimilated, exterminated or come under state control. All are or were hunter-gatherers. Probably all humans lived in bands until at least 40,000 years ago and most did until 11,000 years ago. Bands are egalitarian, but that does not mean that all members are equal in prestige or contribute equally to decisions. It means there is no formalized class structure, no formalized or hereditary leadership, and no formal monopoly of decisions. Leadership is acquired through qualities such as personality strength, intelligence or fighting skills. Where bands still exist, it is because that region lacks local concentration of resources (until brought from the outside) necessary for larger groups to form. Humanity's closest relatives (gorillas, chimpanzees, bonobos) all live in bands. Our development beyond it all took place in the last 10,000 years.

A tribe will usually have fixed settlements, although some are herders and do move seasonally. The political definition is often much smaller than the group sharing language and culture. Evidence suggests that tribal organization began to emerge about 13,000 years ago in the Fertile Crescent. A prerequisite for living in settlements is either food production or a very productive environment where

resources can be hunted or gathered within a small area. This is why Fertile Crescent settlements began at the time when climate change and improved technology allowed abundant harvests of wild cereals.

A few hundred is the upper limit of a group size compatible with everyone knowing everyone else. One reason why the political organization of a group must change when the size grows to over a few hundred is the difficulty of conflict resolution between strangers. This leads to Chiefdom structure. The division, band to tribe to chiefdom is a continuum. The largest tribes may have some of the attributes of a chiefdom—for example, the local "Big Man" (a non-hereditary position) may be responsible for dividing meat slaughtered for feasts. Fully independent chiefdoms had disappeared by the 20th Century because they tended to occupy prime territory. But prior to 1492 they were widespread over the eastern United States, productive areas of South America and much of Sub-Saharan Africa, and all of Polynesia. Chiefdoms arose around 5500 BC in the Fertile Crescent and around 1000 BC in Mesoamerica and the Andes.

Chiefs differed from tribal "Big Men" in that they dressed differently than everyone else and held much more power. Bureaucrats under a chief were usually generalized. Only a few chiefdoms existed without food production, notably in the Pacific Northwest of North America, where the Kwakiutl, Nootka, Tlingit, and others lived under chiefs in villages without agriculture or domestic animals because of the richness of the ocean and rivers in fish. But in all chiefdoms, food surpluses supported chiefs, their families, bureaucrats, and craft specialists. Most luxury goods, whether produced or obtained by trade, were reserved for chiefs, for example: Hawaiian chiefs had feather cloaks made with tens of thousands of feathers and requiring many generations of artisans to make. Archeologists can recognize chiefdoms because of some graves being much richer than others. Again, chiefdoms varied in size and complexity, from those looking much like tribes except having a hereditary "big man" and a few other attributes of chiefdoms, to large, complex societies with multiple classes, large public works, and massive amounts of tribute, even many villages with one chief village and slaves.

Chiefdoms introduced the dilemma common to all centrally governed non-egalitarian societies. At best, the government does good by providing expensive services impossible to accomplish on an individual basis. At worst, it becomes a kleptocracy, transferring wealth from commoners to upper classes. The difference between a kleptocrat and a wise statesman, a robber baron and a public benefactor is a matter of degree—how large a percent of the tribute is retained by the elite, and how much commoners like the public uses to which the redistributed tribute is put.

Why do commoners tolerate the transfer of wealth to kleptocrats? This is a question raised by political theorists from Plato to Marx and by voters in every modern election. Kleptocrats with little public support risk being overthrown either by commoners or by upstart kleptocrats with better promises. To maintain public support while still enjoying a better lifestyle than commoners, kleptocrats throughout history have used a mix of four solutions.

1. Disarm the populace and arm the elite. This is easier in these days of high-tech weapons than in the days of clubs and spears.
2. Make masses happy by redistributing much of the tribute in popular ways.
3. Use the monopoly of force to promote happiness by maintaining public order and curbing violence, (an often under-appreciated benefit. In the past, anthropologists tended to idealize band and tribal societies as gentle and nonviolent, whereas, after long study, it is clear that murder is a leading cause of death in these societies).
4. Construct an ideology or religion justifying kleptocracy. While bands and tribes had supernatural beliefs, they did not serve to justify a central authority, the transfer of wealth or maintain the peace between unrelated individuals. When supernatural beliefs gained those functions they became institutionally transformed into what we term a religion.

A chiefdom characteristically has an ideology, a precursor to an institutionalized religion, buttressing the chief's authority. The chief will either be both the political leader and priest or support a separate group of priests who provide ideological justification for the chief. This is the reason why so much tribute goes to constructing temples and other public works as centers of an official religion and visible signs of the chief's power.

Institutionalized religion has two additional benefits for a centralized society. First, it solves the problem of how unrelated people can live together without killing one another by providing a bond not based on kinship. And second, it gives the people a motive for self-sacrifice on the behalf of others. At the cost of the society members who die in battle as soldiers, the whole society becomes more effective at conquering others and/or resisting attack.

States now rule all the land area of the globe, except for Antarctica. Many early and modern states have literate elites. Many have literate masses as well. Vanished states tended to leave visible archeological evidence of standardized design, such as ruins, four or more levels of settlement sizes and pottery styles, covering thousands of square miles. We thereby can tell that states arose in Mesopotamia around 3700 BC, in Mesoamerica around 300 BC, in the Andes, China, and Southeast Asia around 1 BC and in West Africa around 1000 AD. We also have repeatedly observed the conversion of chiefdoms to states. Thus, we have more information about past states than past chiefdoms, tribes, and bands. Again, change is incremental as population and territory increase.

Cities differ from villages in monumental public works, palaces of rulers, accumulation of capital from tributes or taxes, and the concentration of people other than food producers. Early states had a hereditary leader with a title equivalent to king, like a super chief with even greater monopoly on information, decision making and power. Even in today's democracies, crucial information is available only to a few, who control its flow and, therefore, the decisions. Central control and economic redistribution (taxes) are more extensive. Economic specialization is more extreme (even today's farmers are not self-sufficient). Hence, when state government collapses the effect on society is catastrophic. Most, if not all, early states had mass production and public works that made wider use of slave labor. A larger scale of warfare provided them with more captives.

Levels of administration within government grows much more complex—not only vertically, with more levels, but also horizontally with increased specialization. Internal conflict resolution is increasingly formalized with laws, judiciary, and police. No early chiefdom developed writing. Early states had state religions and standardized temples. Many early kings were considered divine and given special treatment. For example, Japanese has a special form of the pronoun "you" for use only when addressing the emperor. Early kings often were head of a state religion.

The ways that states diverge from chiefdoms in new directions include:

1. They are organized on political and territorial lines, not kinship.
2. They are regularly multiethnic and multilingual.
3. Bureaucrats are professionals selected, at least partly, on ability and training, not only on heredity and kinship.
4. In later states, leadership is not hereditary, and many abandon the entire system of formal hereditary classes.

Over the past 13,000 years the predominant trend has been toward larger and more complex units. But this is an average, long-term trend with innumerable shifts each way. Large units regularly break up into smaller ones (most recently, the USSR, Yugoslavia, and Czechoslovakia). Sometimes large, complex units are overrun by smaller, simpler ones (both Rome and China at times). But the trend is the other way.

States triumph over simpler entities because they usually have the advantage in weapons, technology and numbers. But chiefdoms and states also have centralized decision makers to concentrate troops and supplies and they have official religions and patriotic fervor which make troops willing to fight suicidally. This latter willingness is so strongly programmed into citizens of modern states by schools, churches and governments that we forget what a radical break it is with previous history. Every state has its slogan "for King and country," etc. Such sentiments are unthinkable in bands and tribes. New Guinean accounts of tribal warfare have no hint of patriotism, of suicidal charges or any other military action carrying an accepted risk of being killed. Raids are initiated by ambush or by superior force to minimize the risk of death. This attitude limits its options compared with states. What makes patriotic and religious fanatics such dangerous opponents is their willingness to accept the deaths of some of their number in order to crush their enemy. Fanaticism in war, which drove Christian and Islamic conquest, was probably unknown until chiefdoms and especially states emerged.

States arose independently prehistorically on every continent but Australia. They arose multiple times in many areas. Chiefdoms arose even more often. There have been many attempts to explain this evolution. Some of the unsatisfactory ones include: 1) Aristotle's proposal that this was the natural state for mankind (he knew of no other); 2) Rousseau thought it was a rational decision entered into voluntarily (there exists no evidence of any kind for this, actually quite the opposite—smaller units only abandon sovereignty under duress or by conquest); 3) Systems of irrigation require centralized bureaucracies to maintain and construct them (the problem is that irrigation systems are one of the end results of states, not the cause; this theory says nothing about the evolution from band to tribe to chiefdom; and small irrigation systems already existed before the rise of states—in fact, in some states they remained small).

The correlation between societal organization and population size means that we need to use this to trace the chain of cause and effect toward complex societies. Large or dense populations only arise where food production exists or at least within an exceptionally productive environment for hunting and gathering. However, no hunter-gatherer society ever became a state. Intensified food production and societal complexity stimulate each other, i.e., population growth leads to increased complexity, which leads to intensified food production, which leads to population growth. Complex centralized societies are uniquely able to organize public works (including irrigation), long distance trade (including the importation of metals with which to make better agricultural tools), and activities of economic specializations.

Food production also contributes to some special features of complex societies. Seasonally pulsed inputs of labor mean that when the harvest is stored farmers are available for other projects. Food production can lead to stored food surpluses permitting economic specialization and social stratification. Food production permits or requires sedentary living, a prerequisite for acquiring substantial possessions. Increased population size also makes many features of complex society possible, but that does not prove that food production and large populations make complex societies inevitable.

There are four obvious reasons why all existing large societies are complex centralized organizations.

1. The problem of conflict between unrelated strangers. Relationships within a band of 20 yield 190 possible 2-person interactions (20x19/2). A band of 2,000 would have 1,999,000 such dyads. Dyads can explode into murderous argument. Each murder in bands and tribes usually leads to an attempted revenge murder, starting an unending cycle of murder/counter-murder that destabilizes society. In a band, everyone is related and relatives step in to mediate the quarrel. In a tribe, everyone knows everyone and mutual friends and relatives mediate. Once a group is large enough to contain strangers, bystanders are likely to know only one or neither member of the quarreling dyad and are likely to have little ability to prevent its escalation into a

brawl. Hence, large societies must have centralized authority to monopolize force and resolve conflict, or they blow up.
2. Communal decision making becomes logistically impossible.
3. Transfer of goods between members in a small society can be done reciprocally. But a large society must have a redistributive economy so that goods can get to those with a deficit, who are usually unknown to the people with the excess.
4. Large societies have not only more people but greater population density. As density increases, more of the necessities must be obtained from outside the individual's physical area—e.g., Holland's 16,000 square miles and 16 million people couldn't be divided into 800,000 self-sufficient territories of 13 acres and 20 people. They couldn't produce enough for their needs. It requires a complex structure to support such dense populations.

What drives the amalgamation of people into such large groups? Societies in the same category are infinitely diverse. Among tribes, some "big men" are more charismatic, powerful, and skilled in decision making than others. Their tribes will tend to have greater centralization and will have the advantage over others. Tribes that resolve conflict poorly tend to blow apart into bands. Ill-governed chiefdoms blow apart into smaller chiefdoms or tribes. Societies with effective conflict resolution, sound decision making, and harmonious economic redistribution can develop better technology, concentrate military power, seize larger and more productive territories, and crush autonomous smaller societies.

Competition among societies at one level leads to societies on the next level, if conditions permit. Large societies will have an advantage over smaller units if they can solve the problems that come with larger size, such as upstart claimants to leadership, commoner resentment of kleptocracy, and increased difficulty with economic integration. Amalgamation has often been documented, both archeologically and historically, and never has it been a process of unthreatened little societies deciding to merge. Leaders of small societies like big ones and are jealous of their independence. Amalgamation occurs either by merger under threat of external force or by conquest. Numerous examples of each are available. War or threat of war leads to amalgamations when population density is high enough. If the density is very low, survivors of a defeated group can just move farther away from enemies, as tends to happen with wars between nomadic bands. In moderate density, as with food producing tribes, there is usually no large vacant area for survivors to flee to. The victors will have no need of slaves and the defeated won't produce enough for tribute, so the only use for survivors is to take the women in marriage. So, most of the defeated tend to be killed and the territory occupied. With high density, there is still nowhere to go, but the victors can exploit the losers while leaving them alive, as slaves, or leave them in place, deprived of political autonomy, and extract tribute in food or goods. This will eventually lead to their amalgamation into the victorious state or chiefdom.

PART 4: AROUND THE WORLD IN FIVE CHAPTERS

This section applies the principles described in the rest of the book to five distinct areas of the world.

CHAPTER 15: YALI'S PEOPLE

Australia is the sole continent where, in modern times, all native peoples lived without any of the hallmarks of "civilization"—without farming, herding, metal, bows and arrows, substantial buildings, settled villages, writing, chiefdoms, or states. Australian Aborigines were nomadic or semi-nomadic hunter-gatherers, organized into bands, living in temporary shelters or huts and still using stone tools. During the last 13,000 years, Australia has had less cultural change than any other conti-

nent. Yet as of 40,000 years ago, Australia was ahead of Europe and other continents. People there developed some of the earliest stone tools with ground edges, the earliest stone tools mounted on handles, and the earliest watercraft. Some of the world's oldest known rock paintings are in Australia. Modern humans may have settled Australia before Europe.

During the Pleistocene ice ages, when ocean levels were low because water was trapped in ice sheets, Australia and New Guinea were one continent. They were separated after the ice melted, 12,000-8,000 years ago. On New Guinea, the society was opposite that of Australia. Most people were farmers or herdsmen and lived in settled villages. They were politically organized into tribes, not bands. All had bows and arrows and many used pottery. They had more substantial dwellings and more seaworthy boats and more numerous and varied utensils. They had a higher population density with several times the number of people living in 1/10 the area as Australia. The Torres Strait between New Guinea and Australia is 90 miles wide, but is dotted with islands where the people culturally resemble New Guineans. The largest island is 10 miles from Australia and its islanders traded with both Australia and New Guinea.

Why the difference? And why, even on more "advanced" New Guinea, had society not developed further? Both were colonized from Asia via land bridges and a short ocean voyage beginning before 40,000 years ago and reaching the highest and farthest areas by 30,000 years ago. People crossed at least 8 channels up to 50 miles wide to get from the nearest Asian land mass of the Ice Age, modern Borneo or Bali, to Pleistocene Greater Australia, possibly on bamboo rafts. There was no further contact until a few thousand years ago, evidenced by the arrival of the Asian pig in New Guinea and the Asian dog in Australia. The societies, however, developed in isolation from Asia as shown by the fact that the languages show no clear relationships to modern Asian languages. Australian Aborigines and New Guinea Highlanders are genetically and physically somewhat more similar to modern Asians than to people of other continents, but there is no close relationship. This may be because they had a long time of development with limited genetic exchanges with Asians, but also because the original populations of Southeast Asia were largely replaced by other Asians expanding out of China.

Aboriginal Australians and New Guineans also diverged physically and linguistically from each other. For example, blood group B is present in New Guinea but absent in Australia; New Guineans have tightly coiled hair, while Australians' is wavy or straight. The languages are mostly unrelated. The conclusion is that they developed in isolation since the rise of the seas separated them 10,000 years ago. The chart below shows the differences in climate, terrain, and ecology.

NEW GUINEA	AUSTRALIA
Mountainous & rugged	Low and flat
One of wettest areas on Earth (>100" rain annually)	One of driest (<20" rain annually)
Equatorial climate with little variation	Highly seasonal climate with highest variation year to year of any on Earth
Many large permanent rivers	The only permanent rivers are in the east, and even the largest has ceased in long droughts
Mostly dense rain forest	Mostly desert and dry woodland
Young fertile soil from volcanic and glacial activity	Oldest, most infertile, most nutrient-leached soils of any continent with no volcanic or glacial activity to refresh it
Many mammal and bird species	Few mammal and bird species

All of these characteristics influenced the cultural history of each area.

The earliest and most intensive food production with the densest population was in the highlands of New Guinea between 4,000 and 9,000 feet. Drainage ditches from 9,000 years ago have been found. By 6,000 years ago, extensive agriculture with terraces in drier areas and ditch systems to drain wet areas existed. Many are still used. Many crops used to be assumed to have been imported from Southeast Asia, but now are known to have arisen indigenously and developed from native species. In addition, three imports were present at the time of first European contacts: chickens and pigs from Southeast Asia and sweet potatoes from South America by way of the Philippines. The lowlands of New Guinea do not support intensive agriculture because of the steep terrain, persistent cloud cover, malaria, and risk of drought below 4,000 feet. Lowland populations on the sea coast and rivers depend on fish. In drier areas, they use slash and burn agriculture to raise bananas and yams, supplemented by hunting and gathering. Swamp dwellers are hunter-gatherers and depend on starchy pith of the sago palm, which is very productive and yields three times more calories per hour of work than gardening, a clear example of people remaining hunter-gatherers because, in their environment, farming can't compete. Despite developing the most advanced technology, social and political organization, and art of greater Australia, New Guineans still did not progress beyond stone tools, and tribes remained nonliterate. This is because of several biological and geological strikes against them. First, their indigenous food products are low in protein and they lacked large animals to assist in agriculture. Second, the limits on available area limited population. There are only a few broad valleys in the highlands capable of supporting dense populations. Third, only that zone, between 4,000 and 9,000 feet, is suitable for intensive food production. This meant that no large-scale economic exchange of foods developed which could lead to a more balanced diet.

Until European colonial government brought western medicine and an end to tribal warfare, the population never exceeded one million. This is not enough to develop technology, writing, or complex political systems. The rugged terrain fragmented the population even more, with different languages (more than 1,000 of them), culture, and intermittent warfare. Geographical isolation restricted the inflow of ideas and technology from elsewhere. The nearest neighbors were less developed than the New Guineans until about 1600 BC and the Austronesian expansion, when New Guinea received pottery, chickens, dogs, and pigs. That expansion was interrupted by the Europeans.

Australia developed neither herding nor farming because soon after it was colonized by humans no large animals remained. The only domesticable animal (the dog) arrived about 1500 BC. Native Australians kept captive dingoes, as the dogs became, for companions, watchdogs, and even as living blankets (the phrase "5 dog night" describes a very cold night) but not for food or as hunting companions. They did not develop agriculture because this is the driest continent with the most infertile soil and a climate that is mostly under a non-annual cycle known as the El Niño Southern Oscillation (ENSO). Severe droughts, lasting years, are punctuated by unpredictable torrential rains and floods. Even today, with Eurasian crops and motorized equipment, food production is risky. Herds built up in good years die off in drought. Also, there are almost no domesticable native plants. Even modern plant geneticists have only developed macadamia nuts from them. A nomadic hunter-gatherer lifestyle based on a great variety of wild foods makes sense in such a climate. A small mobile population could easily move to a more clement area if conditions deteriorated. The Aborigines did engage in "firestick farming" to increase the production of edible plants. This involved intentionally burning an area to drive out animals to kill and eat; to convert dense thickets into open parkland, which could be more easily traveled and was an ideal habitat for kangaroo; and to stimulate new grass (for kangaroos to eat) and new ferns (for people to eat).

The population varied with rainfall and abundance of aquatic foods in the sea, rivers, and lakes. The highest density was in the wettest, most productive regions, which also came to support the densest populations of European settlers. Aborigines were, of course, killed or driven out of all but the least desirable areas, which is why, today, we think of them as desert people. Prior to European invasion,

Aborigines had intensified food-gathering methods in some regions which increased population densities, including methods to remove poison from abundant and nutritious cycad seeds, building fish farms and elaborate canal systems for eels. They also built elaborate eel weirs and traps, which adapted to changing levels of water. In these areas, settled villages developed. Eastern and Northern Aborigines had begun harvesting a wild millet. They had stone tools to harvest and to grind the millet, skin and wooden storage vessels. Tools were similar to those developed in the Fertile Crescent for the same activities. Because they remained hunter-gatherers, they did not develop metal, writing, or politically complex societies. They remained hunter-gatherers because of their environment. Productive areas were like islands separated by a sea of very sparsely populated desert. Even in the relatively moist productive eastern end, there are 1,900 miles between the tropical rainforest in the northeast to the temperate rain forest in the south, a geographical and ecological distance as great as that from Alaska to Los Angeles. Tasmania, an island separated from Australia 10,000 years ago, had the simplest material culture in the world, lacking many of the technologies and artifacts widespread on the mainland. Both Tasmania and Australia suggest the effects that isolation and limited population size have on development, including loss of technology as well as the failure to invent it. This implies that size matters and explains some of the differences in development rates for the largest (Eurasia) and smaller continents (Africa, North America, South America).

From the time of initial colonization 40,000 years ago to the Austronesian expansion (1500 BC) there is no evidence of contact with outside peoples. Austonesians certainly reached Northwest Australia (the dingo is evidence) and annual visits by Macassans from Indonesia were made from at least 1000 AD until 1907 (when Australia stopped them) to gather sea cucumbers. There was trade between New Guinea and Australia island-hopping across the strait between them. But the culture on the islands is only an attenuated version of New Guinean culture. Some New Guinean features did come into Australia, e.g., some language, shell fishhooks, and outrigger canoes. But again, the great environmental difference between Northwestern Australia (low, dry) and New Guinea (wet, mountainous) prevented much useful exchange.

Because of malaria, the number of European settlers remained small in New Guinea, despite European superiority in ships, compasses, writing, printing, guns, and administration. It remains a barrier today. New Guinea was not infected on a massive scale by European infectious diseases because there were no permanent European settlements until the 1880s, by which time Europeans understood how to control those diseases, and the long exposure to Asian mainland diseases (via Indonesia), which increased New Guinean resistance. Although the highlands offer the only New Guinea climate where Europeans do not suffer from health problems, the rugged terrain prevented their reaching this area until the 1930s. There was already a dense population there and governments were no longer willing to open an area for European settlement by killing or displacing the native population. In addition, European crops and livestock do poorly everywhere in New Guinea. Some South American tropical crops (coffee, squash, corn, tomatoes) are grown. But New Guineans seem to have already perfected crops for their climate and terrain.

Australia was colonized by Europeans for all the same reasons that New Guinea wasn't. Today 20 million non-Aborigines populate and govern Australia, mostly of white European descent (non-whites have only been allowed to immigrate since 1973). The Aborigine population has declined 80% since the Europeans arrived. The Aborigines fared worse than the New Guineans because of the suitability of Australia for European food production combined with European guns, germs, and steel, which cleared the Aborigines out of the way. Agriculture in the Australian temperate zone is dominated by Eurasian crops (wheat, barley, oats, apples, and grapes) with some from the Sahel (sorghum and cotton), Andes (potatoes), and tropical areas—sugar cane (New Guinea), bananas and citrus (Southeast Asia), and peanuts (South America). Livestock includes Eurasian sheep in more arid areas and Eurasian cattle in the wetter ones. None are of native origin. Europeans removed the Aborigines

from the desirable areas by shooting them (still acceptable in the 19th century) but also by epidemics of Eurasian diseases.

English colonists did not create a literate, food-producing, industrialized democracy in Australia. They brought it with them. Without their inherited technology, European settlers could not have survived in Australia. Aboriginal Australians did create a society in Australia—they adapted to the harsh environment and were prevented by that environment from further development.

CHAPTER 16: HOW CHINA BECAME CHINESE

All but one of the six most populous nations in the world are melting pots that have achieved political unification only recently (USA, Russia, India, Indonesia, Brazil). The exception is China, which was unified by 221 BC. China has had only one writing system. Of 1.2 billion people, 800 million speak Mandarin and the other 300 million speak seven other similar languages. The unity of China is astonishing. Genetically the Chinese vary more than Swedes and Italians. North Chinese are taller, heavier, paler, with more pointed noses and smaller eyes with more "slant." The North Chinese are similar to Tibetans and Nepalese. South Chinese are similar to Vietnamese and Filipinos. The genetic differences imply a long history of moderate isolation. So how did they end up with similar or the same language and culture? New Guinea with less than 1/10th the land area has one thousand languages from dozens of groups. Europe has about forty, China only eight. North and South differ in environment and climate as well. North China is drier and colder than the South.

Humans have inhabited China for over 500,000 years. Because China became politically unified much earlier than other regions, it homogenized a huge region and repopulated tropical Southeast Asia and influenced Japan, Korea, and perhaps India. A linguistic map shows a huge area of Mandarin and its seven close relatives (a sub-family of the Sino-Tibetan language family) covering from Manchuria in the north to Myanmar (Burma) in the south. Three other linguistic families are fragmented, like islands, in Southeast Asia. They are the Miao-Yao family (including Hmong of Vietnam), Austro-Asiatic (including Vietnamese and Cambodian), and Tai-Kudai (including Thai and Lao). Speakers of Thai, Lao, and Burmese all moved from South China to their present locations in historical times, inundating descendants of previous migrations and replacing or converting them. Chinese speakers in the Zhou dynasty (1100-221 BC) conquered and absorbed most of China's non-Chinese speaking population.

Linguistic tracing of history is based on three types of reasoning:

1. Known linguistic expansions in recent millennia can be analyzed in reverse, showing the movement of language into an area.
2. Modern areas with a single language group testify to recent geographic expansion because over time a single language will differentiate into many.
3. Conversely, an area with a high diversity of languages within the same linguistic family has spoken the language longer and is therefore closer to the original location of that language.

Linguists have concluded that North China is the origin of Chinese and other Sino-Tibetan languages. South China is the origin of the other three Asian languages. Austronesian (spoken in the Philippines and Polynesia) may have originated on the Chinese mainland, but has vanished from there.

By looking at the process of domination by European languages of English and Spanish in the Americas and Australia, we see how language replacement occurs. Native speakers are initially killed or pushed out. Later they are pressured into adopting the dominant language because of the advantages

of its speakers in technology and politics. When we look at the archeology of China to see if Chinese had a similar superiority, we find that evidence of food production appears in China by 7500 BC, possibly independently in the north and the south. Earliest sites show two types of millet grown in the north and rice in the south. They also show domesticated pigs, dogs and chickens, followed by water buffalo, silkworms, ducks, and geese. Later crops included soy beans, hemp, citrus, tea, apricots, peaches, and pears. Eurasia's east-west axis permitted exchanges with the west, adding wheat, barley, cows, horses, sheep, and goats. Bronze metallurgy occurred by the 3rd Millennium BC, iron by 500 BC, followed by 1500 years of technological inventions including paper, compass, wheelbarrow, and gunpowder. Fortified towns and class differential existed by 3rd millennium BC. Written accounts go back to the Xia Dynasty around 2000 BC. While the north-south axis of China retarded the diffusion of some crops, it is a shorter distance and without the barriers found in Africa and the Americas. Differences in altitude are gentle east to west and are transversed by large long rivers (Yellow in the north and Yangtze in the south). These were easily connected by canals that facilitated north-south communication. Western Europe is much more rugged and without unifying rivers. Some development spread south to north in China (notably iron smelting and rice), but the predominant spread was north to south. Writing, bronze technology, the Sino-Tibetan language, and state formation all developed in the north.

By the 1st Millennium BC, writings refer to all non-ethnic Chinese as barbarians and show a tendency to view China as superior. Unification under the Qin Dynasty came in 221 BC. Although all East and Southeast Asian culture did not come from China, its role is disproportionate. The original people of Southeast Asia were so thoroughly replaced that only three tiny pockets survived (although these are also probably the people who colonized New Guinea and Australia). Japan still uses Chinese writing despite problems in representing Japanese speech.

CHAPTER 17: SPEEDBOAT TO POLYNESIA

Three prehistorical waves of people moved from Asia east into the Pacific. New Guinea has them all. Highland New Guineans are descended from the earliest wave, which colonized New Guinea and Australia 40,000 years ago. A second wave moved from the South China coast starting about 6,000 years ago, through Indonesia and Java, reaching New Guinea around 3,600 years ago The third was the movement of North Chinese South and then East into all parts of Asia. The middle wave was the Austronesian Expansion and was among the biggest population movements of the past 6,000 years. Austronesian languages are spoken as the native language over half of the globe, from Madagascar in the east to Easter Island in the west. They populated Java and western and central Indonesia, the Philippines, Malaysia, and all of Polynesia. Austronesian languages are still spoken in pockets of Malaysia, Vietnam, and Cambodia.

Languages give us clues to the route of the expansion. There are 959 Austronesian languages in 4 sub-families. One sub-family, Malayo-Polynesian, with 945 languages, covers almost all of the geographical area. This suggests the Malayo-Polynesian was a recent differentiation and spread from the Austronesian homeland. The other three sub-families differ considerably from each other and from Malayo-Polynesian. They are spoken by tiny groups of people, all of which are Aborigines of Taiwan. This suggests Taiwan as the original home of Austronesian. Archeological evidence also supports this conclusion, showing earliest evidence of agriculture and technological advance among the Austronesian people. There is also evidence of agriculture, deep-sea fishing, and regular sea traffic and exchanges with the mainland showing development of the maritime skills, which later allowed the expansion over the Pacific.

Certain artifacts, like a stone bark beater, link early Taiwan to later Pacific Island culture. Once people spread beyond access to wool-bearing animals and fiber plant crops they became dependant on pounded bark cloth for clothing. The spread of the Austronesian culture took about 1,000 years. There is evidence of a cultural package (pottery, stone tools, crops and animals) around 3000 BC in the Philippines, 2500 in Indonesian Celebes and North Borneo and Timor, 2000 BC in Java and Sumatra, and 1600 BC in New Guinea. From there it spread eastward to all uninhabited islands of the Pacific and Westward to Madagascar by 500 AD.

Linguistically, all the Austronesian languages have words from their shared culture, such as dog and pig. And they share roots for outrigger canoe and other maritime words. However, tropical crop words, such as *taro*, *breadfruit*, *banana*, *yams*, and *coconuts*, which are present in proto-Malay-Polynesian, are not present in the three Taiwanese proto-Austronesian languages. This suggests they were added after migration, which agrees with archeological evidence.

The reasons Austronesians replaced hunter-gatherers in the Philippines and Indonesia resemble why Europeans replaced native Australians. They were farmers with denser populations, superior tools and weapons, more developed watercraft and maritime skills and epidemic diseases. In some areas they were blocked by preexisting Austro-Asiatic speakers. In New Guinea, they were only able to colonize about 15% of the island. Most of New Guinea speaks one of the many Papuan languages and they were already farmers and toolmakers and had same resistance to diseases as the Austronesians. However, both the Austronesian and Papuan languages show evidence of long contact and borrowing. Sometimes a language moves although people don't. Most of the people on Bismarck and the Solomon Islands speak Austronesian languages, although genetically they are mostly Austro-Asiatic. The Austronesian Expansion's successes and failures show the importance of food production in human population movements. Where people were still hunter-gatherers, the Austronesians displaced them. Where the people were already settled farmers, they did not.

Studying Southeast Asian peoples, including the Austronesians, shows how culture is influenced by environment. The South Chinese people developed food production and technology and received still more (including writing) from North China. They then went on to colonize tropical Southeast Asia and Taiwan, largely replacing indigenous hunter-gatherers. Within Southeast Asia descendents had a wide range of culture. Some were forced to revert to hunting-gathering, while others progressed to complex empires with elaborate metal work and magnificent monuments. Austronesians show the same variety. Europeans were only able to colonize in significant numbers the largest and most remote islands nearest the temperate zones (New Zealand, New Caledonia, and Hawaii). The rest remain occupied by East Asian and Pacific peoples.

CHAPTER 18: HEMISPHERES COLLIDING

The largest population replacement of the last 13,000 years was the result of the collision between the Old World and the New World. The examination of food production suggests that Eurasian agriculture yielded more calories per person than that of the Americas. Eurasia had thirteen big domestic mammals and the Americas had one, the llama/alpaca, which was confined to a small area of the Andes and Peruvian coast. It was used for meat, wool, hides and to transport goods. Its uses did not include milk, transportation of humans, drawing of plows, provision of power for machinery, or usage in war, all of which were functions served by Old World mammals. The disparity was not as great with plant production as with big mammals. Agriculture was widespread in both areas, but in the Americas, hunter-gatherers occupied a much larger fraction. Most of North America, and all of southern South America were still occupied by hunter-gatherers. Many areas, which today are very productive, were not farmed because of lack of domesticable native plants and ecological and geographic barriers to ar-

rival of crops and animals from other parts of the continent. Some of these areas became productive for native peoples with the introduction of Eurasian crops and animals.

The parts of the Americas with food production had five disadvantages vis-à-vis the Europeans: 1) widespread dependence on protein-poor corn instead of Europe's diverse and protein rich cereals; 2) hand planting of individual seeds (vs. broadcast planting) limits the amount of crops; 3) hand tilling (vs. plowing with animals) limits the area and type of land that can be used; 4) Lack of animal manure to enrich the soil; 5) only human power (vs. animal power) for tasks such as threshing, grinding, and irrigation.

Such differences constituted major ultimate causes of disparities. Resulting proximate factors included differences in germs, technology, political organization, and writing. Germs are most directly linked to differences in food production. All of history's most lethal killers regularly visited crowded Eurasian societies. This is a result of both domesticated animals and population density. Settled villages arose thousands of years later in the Americas and the three regions supporting them (southeastern United States, Mesoamerica, and the Andes) never connected in the high-speed trade which transmits disease. Even the tropical diseases that inhibited Eurasian colonization of tropical America (yellow fever and malaria) were not native, but brought from Africa by Eurasians.

The much longer history of settlements and the high populations of Eurasians were responsible for differences in technology. Iron was in use in Europe; bone, stone, and wood were primary materials in the Americas, with the occasional use of copper. Gold and silver and most of the copper were used in ornaments only. Military technology of Europe included steel armor, helmets, swords, lances, daggers, small firearms and artillery. In the Americas, there were clubs and axes of stone or wood (some copper), slings, bows and arrows, quilted cloth armor. The Europeans utilized many sources of power, including animals, wind and water. The Americans used mostly human power.

Likewise, the European population density led to organized states made up of polyglot amalgamations formed by the conquest of other states. These, in turn, led to empires. Many had official religions that increased cohesion, legitimized rulers, and sanctioned war against others. The Americas had two empires (Aztec and Inca) and Europe had seven, which went on to acquire American colonies (Spain, Portugal, England, France, Holland, Sweden, and Denmark). The Americas had many chiefdoms in tropical South America, Mesoamerica (beyond the Aztec area), and southeastern United States; the rest were at the tribal or band level of organization.

Most Eurasian states had literate bureaucracies and in some a significant proportion of the population was also literate. Writing facilitated political administration and economic exchange, motivated and guided exploration and conquest. In the Americas, only the elite in a small area of Mesoamerica were literate. The Incas had an accounting system and a mnemonic device based on knots.

The above 1492 snapshot shows the out come of the 5,000-year head start in Eurasia in food production. Even allowing for some controversy over exact dates, most agree that Eurasia started a long time before the Americas. Every other development is equally later in the Americas. Humans have occupied Eurasia as much as 1 million years longer than the Americas where humans arrived about 12,000 BC. This difference in development has been given four possible reasons: later settlement, more limited suite of wild animals and plants to choose from, greater barriers to diffusion, and possible smaller or more isolated areas of dense human populations. Examining these possibilities in more detail leads to varying conclusions.

The rate of the spread of humans in the Americas was probably very rapid. If only 100 people crossed from Siberia and the population increased by only 1% per year and spread by 1 mile per month, the Americas would be saturated with hunter-gatherers in only 1,000 years or less. Using an analogy to New Guineans and Polynesians occupying previously unfamiliar environments within historical times (e.g. the Maori in new Zealand or the Tudawhe in New Guinea), it can be shown that it probably took less than 100 years to discover the best rock sources and to distinguish useful from poi-

sonous plants. The first Americans arrived from Siberia with tools and technology suitable for the Tundra. As they moved south into the Americas, they had to develop new technology suitable for each new environment. People who were living in the Fertile Crescent were in the same environment for thousands of years, refining their equipment to it.

The most obvious explanation concerns the animals and plants available for domestication (see Chapter 6). Early American people remained hunter-gatherers because of the lack of domesticable wild animals and the nature of the domesticable plants. The main domesticable plant (corn) required a long time to evolve from its wild ancestor to a productive domesticated version. Fertile Crescent plants required little change. Consequently, when farming did develop in the Americas, it remained part time for a long time, supplemented by hunting and gathering.

Diffusion was also easier in Eurasia, so the numbers of plants and animals available to farmers and herders grew quickly. The Americas are fragmented by deserts, mountains, and rain forests, areas not suited for food production or dense human populations. Likewise, other features of human society (political, technological, linguistic) were blocked and not shared. For example, looking at language, in Eurasia there are 10 large language families that spread over large geographic areas. In the Americas, linguists agree on only 2 such large families covering large geographic areas (Eskimo- Aleut of the Arctic area and Na-Dene language, found in Alaska, Northwest Canada and Southwest United States). Other languages seem to be unrelated, isolated and restricted to small areas.

The fourth factor is speculative, as it involves the puzzling lack of inventions in the Americas. Writing and the wheel were not invented in the Andes. The wheel was used only for toys in Mesoamerica. The wheelbarrow did not appear. Perhaps the island experience is more relevant as populations in the Americas were isolated from each other as with true islands. The lack of competitive pressure and cross-fertilization of ideas may have slowed or stopped inventions.

The first contacts with Europe were from the Norse, who settled Iceland in 874 AD, Greenland in 986 AD, and reached Newfoundland in 1000 AD. But Norway was small and poor, Iceland was more so and Greenland was even more marginal, and with the start of the Little Ice Age in the 13th century, settlements there were insupportable. The technology and numbers were too low to continue and the area too far north for efficient food production. The second invasion of the Americas was successful because the source, target, latitude, and time allowed European advantages to be used effectively. Spain was rich and populous enough to support exploration and colonies. Landfalls in the Americas were in the subtropics in areas highly suitable for food production, at first with native plants but quickly with European animals (cattle and horses). 1492 was at the end of a century of rapid development of European ocean-going technology, incorporating advances in navigation and ship and sail design from Islam, China and Indonesia.

Colonization began in the West Indies, which, prior to European invasion, had a population of about 1,000,000. These were rapidly exterminated by disease, dispossession, enslavement, warfare and murder. Around 1508 came the first mainland colony in Panama, and by 1533, both Aztecs and Incas had been conquered, due in major part to epidemics of European diseases followed by military conquest. Conquest of the large societies of North America was accomplished by disease alone. Even where large native populations did survive (Andes, Central America) culture and language were extensively replaced with European ones. The total population of the Americas is now ten times what is was in 1492 because of immigration (voluntary and not) from Europe, Asia, and Africa.

CHAPTER 19: HOW AFRICA BECAME BLACK

Even though we tend to equate African with black (excepting European colonials), very different people may have occupied much of modern black Africa until a few thousand years ago, and the

so-called black Africans are heterogeneous as well. Even before white colonization, Africa already had five of the world's six major divisions of humankind (three of the six are confined to natives of Africa). It is the most diverse continent, the result of geography and a long prehistory. It is the only continent to extend from the northern temperate zone to the southern temperate zone. It also has some of the largest deserts, largest tropical rainforests, and highest equatorial mountains in the world. The remote ancestors of humans originated in Africa approximately seven million years ago and Homo Sapiens may also have originated there. It had two of the most dramatic population movements in the past 5,000 years, the Bantu expansion and the Indonesian colonization of Madagascar. The details of who arrived where before whom are shaping Africa today. The five groups found in prehistoric Africa are (loosely) blacks, whites, African pygmies, Khoisans, and Asians. Blacks and whites in Africa were mostly farmers or herders or both, whites in the north, blacks in the south. Pygmies were hunter-gatherers scattered through the central African rainforest. The Khoisans were formerly distributed over much of southern Africa and were both hunter-gatherers and herders. The northern whites were similar to people of adjacent areas of the Near East and Europe, reflecting the movements of people back and forth throughout that area for all of recorded history. This chapter looks at the area south of the Sahara and how blacks came to dominate it.

The 1500 languages of Africa fall into five linguistic families.

1. Afro-Asiatic- (North African, Semitic languages form one branch).
2. Niger-Congo languages (including Bantu)
3. Nilo-Saharan
4. Khoisan
5. Austronesian

Of the five groups, only the Pygmies lack a distinct language. Each modern group of Pygmies uses the same language as the black farmers nearby. But analysis shows some distinctive characteristics that suggest that in former times, when Pygmy groups were more widespread and isolated from other groups, they would have had their own language. This suggests that their homeland was engulfed by invading black farmers, and the fragmented groups that survived adopted the languages of their dominant neighbors, retaining only traces of their own. Nilo-Saharan language distribution is also fragmented, suggesting that those speakers also were engulfed by Afro-Asiatic or Niger-Congo speakers.

Khoisan distribution also suggests dramatic engulfing. Khoisan language is distinct in its use of click sounds as consonants. All the extant versions are confined to the Southern Africa two, both of which are stranded in Tanzania, 1,000 miles from the nearest Khoisan in Southern Africa. Also, Xhosa and a few other Niger-Congo languages of Southern Africa are full of clicks, as are two Afroasiatic languages of Kenya. These are even farther from the current areas of Khoisan languages than Tanzania. This suggests that Khoisan formerly extended far north of its present situation.

Niger-Congo languages are currently distributed all over West Africa and most of Subequatorial Africa. Of the 1,032 Niger-Congo languages, nearly half are of the Bantu subgroup. The Bantu languages are so similar that they are sometimes called 500 dialects rather than distinct languages. All the non-Bantu Niger-Congo languages are crammed into West Africa. The most distinctive Bantu language and the non-Bantu Niger-Congo language most closely related to Bantu are packed into a tiny area of Cameroon and adjacent Eastern Nigeria. This is evidence that Niger-Congo languages arose in West Africa with Bantu at the eastern end of the range (Cameroon and Nigeria) and that Bantu spread out from there, long enough ago that ancestral Bantu had time to split into 500 daughter languages, but recently enough that the daughter languages are still very similar.

Here there is a digression to explain how linguistics is used to explain migrations of people, using English as an example. By far the largest number of English speakers in the modern world are in North America, with others scattered in Britain, Australia and elsewhere. Each country has a dialect. One might guess from the numbers that English arose in North America. But it is actually a subgroup of the Germanic family of languages. Other subgroups (Scandinavian, German Dutch) are in Northwestern Europe. Frisian, the most closely related Germanic language to English, is spoken in a tiny coastal area of Holland and Western Germany. The linguist correctly deduces that English originated there and spread, which we can confirm from history.

This reasoning leads to the conclusion that in Africa, Bantu moved into the rest of tropical and subtropical Africa from Cameroon and Nigeria, displacing Khoisans and Pygmies. What advantages allowed the Bantu to displace these other peoples?

Even if the Mediterranean crops of North Africa could cross the desert, they couldn't grow in the Sahel south of the Sahara. Instead, sets of African crops whose wild ancestors were adapted to summer rains and less seasonal variations in length of day were domesticated. These included some from the Sahel region, some from the highlands of Ethiopia, some from West Africa, and some from tropical Asia, even though the only Asian people are on the island of Madagascar. All the crops originated north of the equator, as did the Niger-Congo people. Again we see the failure of people (in this case Pygmies and Khoisans) to develop agriculture due to lack of suitable candidates and later to being restricted to unsuitable areas by the invasion of the Bantu people. Animals give a similar story. The only domesticated native animal is the guinea fowl. None of the large native mammals of sub-Saharan Africa was suitable for domestication.

We can compare words for domestic plants and animals. For example, words for West African yams, oil palm, and kola nuts are very similar in all the Niger-Congo languages. These plants are believed to have originated in West Africa. Names for Southeast Asian crops like bananas and Asian yams are inconsistent. This is evidence that they reached Africa only after the languages began to break up into subgroups, that is, after the migrations. Some crop names are not even consistent within language subgroups, but instead follow trade routes. This is especially true of New World crops such as corn and peanuts. These often have foreign names.

Comparative linguistics (glottochronology) can even estimate dates. There is both direct and indirect evidence that the people who domesticated the Sahel crops spoke the ancestor to modern Nilo-Saharan languages. The people who domesticated the West African crops spoke the ancestor of the Niger-Congo languages. And speakers of the ancestral Afro-Asiatic languages may have domesticated the crops of Ethiopia and certainly introduced the crops of the Fertile Crescent to North Africa.

How Austronesians came to Madagascar (between 300 and 800 AD) is unclear. Already by 100 AD trade between Egypt and India was thriving, as well as between India and Indonesia. This may have a connection. But there is little evidence of the Austronesians on the mainland other than their crops.

The Bantu expansion from inland savannahs of West Africa south into coastal forests may have begun as early as 3000 BC. Soon after 1000 BC, they moved into the East African Rift Valley and the area of the great lakes. The smelting of metal probably arose independently with them, as their techniques were very different from those of North Africa. They were making steel 2,000 years before Europe and the Americas. Iron tools and agriculture created an unstoppable military-industrial package for the Bantu. Within a few centuries, the Bantu had reached Natal on the eastern coast of South Africa. Because the Khoisan already had cattle and sheep, the initial Bantu colonization was only in the wet areas suitable for West African crops, leaving the drier areas to the Khoisan. However, gradually the Bantu multiplied and incorporated cattle and dry climate crops. There was also intermarriage with the Khoisan people. The Bantu expansion only stopped when it reached the Fish River in South Africa. From there the climate turns Mediterranean with winter rains, and their crops do not do well. When

Whites arrived in South Africa, they easily displaced the remaining Khoisan in the Mediterranean areas, but when they tried to move east they encountered a dense population of steel-equipped Bantu farmers. It took 9 wars and 175 years for the Boers to subdue the Bantus of the region.

Whites colonized Sub-Saharan Africa because of superior technology (guns), widespread literacy, and political organization to support the effort. Food production was delayed in Sub-Saharan Africa by the lack of domesticable native animals and plants. Also, it has a smaller area than Eurasia and a north-south axis, which also retarded the spread of food production and inventions. The large mammals of the region have occasionally been tamed (elephants) but cannot be domesticated, i.e. bred selectively in captivity and genetically modified to increase usefulness. The north-south axis gives greater variations in climate, habitat, day length, diseases, and rainfall, meaning that crops suitable for one part would have difficulty growing in other parts. Both Mediterranean and Asian crops did not reach suitable climates until they were brought by sea. Technology was similarly slow to reach down the north-south axis. Pottery, recorded in Sudan and the Sahara around 8000 BC, did not reach the Cape until 1 AD. Writing developed in Egypt by 3000 BC and spread south into Nubian kingdom of Meroe and into Ethiopia. But writing did not reach the rest of Africa until it was brought by Europeans and Arabs.

EPILOGUE: THE FUTURE OF HUMAN HISTORY AS A SCIENCE.

Unresolved issues:

Further quantification: Why Europe took the lead in technology and became politically and economically dominant rather than the Fertile Crescent or China or India, especially since Europe began as the most backward area. Part of the answer has been documented. If we look at the Fertile Crescent today, we would not describe it so. It is mostly desert, semi-desert and steppe or heavily eroded or salinized. Forests that covered the area were cut down in ancient times to increase farmland, for use in construction, or to burn for fuel. Low rainfall inhibited regrowth, as did overgrazing by goats. Loss of trees and grass led to erosion. Irrigation in a low rainfall area leads to salt accumulation (salinization). All these processes began in the Neolithic era and continued into modern times. Thus, societies of the Fertile Crescent and the Eastern Mediterranean arose in a fragile environment and committed ecological suicide by destroying their own resource base. Power shifted gradually westward. Northern and Western Europe has a more robust environment with more rainfall, so vegetation regrows more quickly.

China enjoyed advantages at first in early food production, ecological diversity, a large population and a robust environment. Medieval China led the world in technology. It also led in political power, navigation and control of the seas. Because China was politically unified, one decision to stop ocean going and destroy shipyards stopped it throughout the region. The same is true with technology; China's periodic steps back from technological development (most recently in the "cultural revolution" of the 1960s and 1970s) affect the entire area. Unlike China, Europe has many scattered areas, none big enough to dominate the others for long.

Maps show part of the cause of European disunity and Chinese unity. Europe has a highly indented coastline with five large peninsulas (Italy, Greece, Iberia, Denmark, and Norway/Sweden). All evolved independent languages and ethnic groups and governments. China's coastline is smoother, with only one large peninsula (Korea) to break it up. Europe also has two islands (Britain and Ireland) large enough to assert linguistic and political and ethnic independence, but close enough to interact with the mainland area. Japan was too isolated from the mainland to be much of a force. Europe is carved up by mountains (Alps, Pyrenees, Carpathians, and the Norwegian border mountains). China's mountains east of Tibet are much less of a barrier. China's heartland is bound by two long navigable

east-west river systems in rich alluvial valleys. Europe's two largest rivers (Rhine and Danube) are smaller and connect much less of Europe.

Once China was unified in 221 BC, no other independent state ever had a chance of arising or persisting for long. So, the connectedness and unity of China gave it an initial advantage, but later that unity became a disadvantage because of the lack of competition. One despot could, and often did, turn off innovation and/or destroy an industry, and there was no competition to force it open again.

Other differences were in the Fertile Crescent, China, and Europe's exposure to barbarian invasion. The Fertile Crescent was the most exposed of the three; China the least.

Even today, when information travels rapidly and an invention in one place can create a thriving industry elsewhere, the old rules still seem to apply. Places that had the early advantage in food production or areas settled by those people still have the advantage of a long history of literacy, metal machinery, and centralized government. They are equipped to adapt new technology to use.

Another area for further exploration is that of cultural idiosyncrasies. A minor cultural feature may arise for trivial, temporary, or local reasons and become fixed and then predispose a society toward more important cultural choices. Examples range from the QWERTY keyboard on modern western typewriters and computers to the base for counting systems. Sumerians used a base 12 system, which led to our 60-minute hour, 24-hour day, 12-month year, and 360-degree circle. Mesoamericans used a base 20 system. Chinese children learn to write more rapidly using alphabetic transcription of Chinese sounds (Pinyin) rather than the thousands of signs of traditional Chinese. However, the large number of homophones (words that sound the same) in Chinese suggests a reason for the traditional method. That method may have had a large impact on literacy in China, although it is unlikely that anything in the environment influenced the development of a language rich in homophones.

Did linguistic or cultural factors prevent the Andean culture from developing writing? Was anything in India's environment predisposing for the development of rigid socioeconomic castes that had serious consequences for the development of technology? Was there anything about the Chinese environment that predisposed the dominance of the culturally conservative Confucian philosophy? Or did anything in Europe and West Asia predispose toward proselytizing religions (Christianity and Islam) and the dynamic of conquest?

Another large area for exploration is the effect of individual people on social development. An example would be if and how the modern world would be different if Hitler had been killed in the July 1944 attempt, when the Eastern front was still in Russia, or even earlier in a near fatal auto accident in 1930. Are such individuals just "riding the coattails" of their times, or do they really change events? Such individual and cultural idiosyncrasies can be termed "wild cards" in the development of societies.

The author then gives a discussion of history as science, relating it to astronomy, climatology, ecology, evolutionary biology, geology and paleontology. To varying degrees all are affected by the impossibility of performing controlled, replicable experiments, the complexity from an enormous number of variables to be considered, the uniqueness of the systems being studied, and the difficulties of predicting future behavior based on the past.

The appendix includes chapter-by-chapter lists of recommend further readings for topics described in that chapter.