

3 The Evolution of Guns and Germs

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This chapter sets itself the modest task of explaining the broad pattern of history on all the continents for the last 13 000 years. Why did history take such different courses for peoples of different continents?

Eurasians, especially peoples of Europe and eastern Asia, have spread around the globe. They and their overseas descendants now dominate the modern world in wealth and power. Other peoples, including most Africans, survived and have thrown off European domination but remain far behind in wealth and power. Still other peoples, including the original inhabitants of Australia, the Americas and southern Africa, are no longer masters of their own lands but have been decimated, subjugated and even exterminated by European colonialists. Why did history turn out that way, instead of the opposite way? Why were American Indians, Africans and Aboriginal Australians not the ones who conquered or exterminated Europeans and Asians?

This question can easily be pushed back one step further. By the year A.D. 1500, the approximate year when Europe's overseas expansion was just beginning, peoples of the different continents already differed greatly in technology and political organization. Much of Eurasia and North Africa was occupied by Iron Age states and empires, some of them on the verge of industrialization. Two Native American peoples, the Incas and Aztecs, ruled over Stone Age or nearly Bronze Age empires. Parts of sub-Saharan Africa were divided among small indigenous Iron Age states or chiefdoms. All peoples of Australia, New Guinea and the Pacific Islands, and many peoples of the Americas and sub-Saharan Africa, lived as Stone Age farmers or hunter-gatherers.

Obviously, those differences as of A.D. 1500 were the immediate cause of the modern world's inequalities. Iron Age empires conquered or exterminated Stone Age tribes. But how did the world get to be the way that it was in the year A.D. 1500?

This question, too, can be pushed back a further step, with the help of written histories and archaeological discoveries. Until the end of the last Ice Age around 11 000 B.C., all humans on all continents were still living as Stone Age hunter-gatherers. Different rates of development on different continents, from 11 000 B.C. to A.D. 1500, were what produced the inequalities of A.D. 1500. While Aboriginal Australians and Native American peoples remained Stone Age hunter-gatherers, most Eurasian peoples and many peoples of the Americas and sub-Saharan Africa gradually developed agriculture, herding, metallurgy and complex political organization. Parts of Eurasia, and one area of the Americas, developed indigenous writing as well. But each of these new developments appeared earlier in Eurasia than elsewhere. For instance, mass production of copper tools was only beginning to spread in the South American Andes in the centuries before A.D. 1500, but was already spreading in parts of Eurasia 5000 years before that. The stone technology of Native Tasmanians in A.D. 1500 was simpler than that of Upper Palaeolithic Europe tens of thousands of years earlier.

Hence we can finally rephrase our question about the origin of the modern world's inequalities as follows. Why did human development proceed at such different rates on different continents for the last 13 000 years? Those differing rates constitute the broadest pattern of history, and the subject of this chapter.

To appreciate how non-obvious is the answer to this question, imagine that a historically minded intelligent being from outer space visited the earth 50 000 years ago. If that visitor had been asked to predict which continent's people would develop technology most rapidly, and who would conquer whom, what would the extraterrestrial have predicted? The visitor might well have answered 'Africa', because human history there had a six million year head start over history on the other continents. The visitor might also have reasonably predicted 'Australia', the continent with perhaps the earliest evidence of anatomically and behaviourally fully modern humans, and with by far the earliest evidence for human use of watercraft. The visitor would surely have written off Europe, where *Homo sapiens* still had not arrived as of 50 000 years ago. To that visitor, the state of the modern world would be unexpected. What were the reasons for the unexpected outcome?

Dismissing progress and IQ

At this point, readers may be beginning to wonder: is this chapter going to be a glorification of so-called progress? Will it be a justification of the status quo, with all its gross injustices? Will it be an apology for racism? I should therefore make two things clear at the outset.

First, I do not hold political and economic development to be an unmitigated good for the human species. It is debatable whether most people alive today are happier or healthier than most hunter-gatherers used to be. We today are certainly at more imminent risk of self-destruction than were our ancestors of 13 000 years ago. I merely want to examine the development of economic and political power without taking a position on whether it has been good for most of us.

Second, I want to make clear that this chapter is not about differences in IQ, and that it will not assert that Europeans are smarter than other peoples. Many Europeans tacitly assume this, even though they may have learned that it is no longer considered politically correct to say so in public. Technologically primitive peoples are often considered to be biologically primitive. It seems especially convincing that Aboriginal Australians and many New Guineans remained illiterate Stone Age tribal hunter-gatherers for 50 000 years, on a continent where Europeans, within a century of their arrival, apparently built a literate industrial food-producing modern state. Does that not prove that Europeans themselves are superior to Aboriginal Australians?

Of course it doesn't. Europeans did not develop literacy, food production and government in Australia; they imported it to there from the outside. Many psychologists, especially in the USA, have tried unsuccessfully to document IQ differences among different people. My own anecdotal perception, from my thirty years of work in New Guinea, is that New Guineans appear on the average considerably more intelligent than Europeans. On reflection, that outcome is unsurprising. Natural selection related to intelligence operates much more ruthlessly in traditional New Guinea societies than in politically organized Europe, so that New Guineans probably have an average genetic advantage. In addition, most European children today suffer from the crippling developmental disadvantage of spending much of their time being passively entertained by radio, TV and movies, while traditional New Guinea children spend all of their waking time talking or otherwise active with other children and adults. All

psychological studies are unanimous about the role of childhood stimulation in promoting mental development, and about the irreversible mental stunting associated with reduced childhood stimulation. The same considerations apply more generally to other industrial peoples compared to other so-called technologically primitive peoples.

We therefore have to turn the usual racist assumption on its head. Instead of asking how industrial peoples came to be smarter, we must ask: why is it that modern Stone Age peoples, despite probably being genetically smarter and undoubtedly being developmentally advantaged, were nevertheless technologically outstripped and conquered by Eurasians?

For these broad patterns of history over whole continents, and over thousands of years, the explanation cannot involve accidental appearances of individual geniuses, such as Alexander the Great happening to be born in Macedonia rather than in what is now Mississippi. I shall show that the answer to the question about history's broadest pattern has nothing to do with differences among peoples themselves, but instead lies in differences among the biological and geographical environments in which different peoples found themselves.

Europe and the New World: proximate factors

As our first continental comparison, let us consider the collision of the Old World and the New World that began with Columbus's voyage in A.D. 1492, because the proximate factors involved in the outcome are well understood. I shall now give a brief summary of North American, South American, European and Asian history, including animal domestication, plant domestication and the evolution of infectious diseases!

Most of us are familiar with the stories of how a few hundred Spaniards under Hernan Cortes overthrew the Aztec Empire, and how another few hundred Spaniards under Francisco Pizarro overthrew the Inca Empire. The populations of each of those empires numbered millions, possibly tens of millions. At the Inca city of Cajamarca in modern Peru, when Pizarro captured the Inca Emperor Atahualpa in 1532, Pizarro's Spaniards consisted of only 62 soldiers on horseback plus 106 foot soldiers, while Atahualpa was leading an Inca army of about 40 000 soldiers.

Most of us are also familiar with the frequently gruesome details of how other Europeans conquered other parts of the New World. The result is that

Europeans came to settle and dominate most of the New World, while the Native American population declined drastically from its level as of A.D. 1492. Why did it happen that way? Why did it not happen that Montezuma or Atahualpa led the Aztecs or Incas to conquer Europe?

The *proximate* reasons are obvious. Invading Europeans had steel swords and guns, while Native Americans had only stone and wooden weapons. Just as elsewhere in the world, horses gave the invading Spaniards another big advantage in their conquests of the Incas and Aztecs. Horses had been playing a decisive role in military history ever since they were domesticated at around 4000 B.C. in the Ukraine. Horses revolutionized warfare in the eastern Mediterranean after 2000 B.C., later let the Huns and Mongols terrorize Europe and provided the military basis for the kingdoms emerging in West Africa around A.D. 1000. From prehistoric times until the First World War, the speed of attack and retreat that a horse permitted, the shock of its charge and the raised fighting platform that it provided left foot soldiers nearly helpless in the open. Steel swords, guns and horses were the military advantages that repeatedly enabled troops of a few dozen mounted Spaniards to defeat South American Indian armies numbering in the thousands.

Nevertheless, guns, steel swords and horses were not the sole proximate factors in the European conquest of the New World. The Indians killed in battle by guns and swords were far outnumbered by those killed at home by infectious diseases such as smallpox and measles. Those diseases were endemic in Europe, and Europeans had had time to develop both genetic and immune resistance to them, but Indians initially had no such resistance. Diseases that were introduced with the Europeans spread from one Indian tribe to another, far in advance of the Europeans themselves, and killed an estimated 95% of the New World's Indian population.

The role played by infectious diseases in the New World was duplicated in many other parts of the world. For instance, epidemic diseases brought by Europeans decimated Aboriginal Australians, the Khoisan populations of southern Africa and the populations of many Pacific islands. But there are also cases where diseases worked against Europeans: the infectious diseases endemic to tropical Africa, South-east Asia and New Guinea were the most important obstacles to European colonization of those areas.

Finally, there is still another set of proximate factors to be considered. How is it that Pizarro and Cortes reached the New World at all, before Aztec and

Inca conquistadores could reach Europe? That depended in the first instance on ships reliably capable of crossing oceans. Europeans had such ships, while the Aztecs and Incas did not. Those ships were backed by the political organization that enabled Spain and other European countries to finance, build, staff and equip the ships. Equally crucial was the role of writing in permitting the quick spread of accurate detailed information, including maps, sailing directions and accounts by earlier voyagers to motivate later explorers. Writing may also be relevant to what seems to us today the incredible naïveté that permitted Atahualpa to walk into Pizarro's trap and permitted Montezuma to mistake Cortes for a returning god. Since the Incas had no writing and the Aztecs had only a short tradition of writing, they did not inherit knowledge of thousands of years of written history. That may have left them less able to anticipate a wide range of human behaviour and dirty tricks, and made Pizarro and Cortes better able to do so.

Europe and the New World: ultimate factors

So far, we have identified a series of proximate factors behind European colonization of the New World: ships, political organization and writing that brought Europeans to the New World; European germs that killed most Indians before they could reach the battle field; and guns, steel swords and horses that gave Europeans a big advantage on the battle field. Now, let us try to push the chain of causation back further. Why did these proximate advantages go to the Old World rather than to the New World? Theoretically, American Indians might have been the ones to develop steel swords and guns first, to develop ocean-going ships and empires and writing first, to be mounted on domestic animals more terrifying than horses and to bear germs worse than smallpox.

The part of that question that is easiest to answer concerns the reasons why Eurasia evolved the nastiest germs. It is striking that American Indians evolved no devastating epidemic diseases to give to Europeans, in return for the many devastating epidemic diseases that they received from the Old World.

There are two straightforward reasons for this gross imbalance. First, most of our familiar epidemic diseases can sustain themselves only in large dense human populations concentrated into villages and cities, which arose much earlier in the Old World than in the New World. Second, most human epidemic diseases evolved from similar epidemic diseases of the domestic animals with which we came into close contact. For example, measles arose from a disease of

our cattle, influenza from a disease of pigs, smallpox from a disease of cows and falciparum malaria from a disease of birds such as chickens. The Americas had a very few native domesticated animal species from which humans could acquire diseases: just the llama/alpaca (varieties of the same ancestral species) and guinea pig in the Andes, the Muscovy duck in tropical South America, the turkey in Mexico and the dog throughout the Americas. In contrast, think of all the domesticated animal species native to Eurasia: the horse, cow, sheep, goat, pig and dog throughout Eurasia; many local domesticates, such as water buffalo and reindeer; many domesticated small mammals, such as cats and rabbits; and many domesticated birds, including chickens, geese and mallard ducks.

Let us now push the chain of reasoning back one step further. Why were there far more species of domesticated animals in Eurasia than in the Americas? Since the Americas harbour over a thousand native wild mammal species and several thousand wild bird species, you might initially suppose that the Americas offered plenty of starting material for domestication.

In fact, only a tiny fraction of wild mammal and bird species has been successfully domesticated, because domestication requires that a wild animal fulfil many prerequisites: a diet that humans can supply, a sufficiently rapid growth rate, willingness to breed in captivity, tractable disposition, a social structure involving submissive behaviour towards dominant members of the same species (a behaviour transferrable to dominant humans) and lack of a tendency to panic when fenced. Thousands of years ago, humans domesticated every possible large wild mammal species worth domesticating, with the result that there have been no significant additions in modern times, despite the efforts of modern science.

Eurasia ended up with the most domesticated animal species in part because it is the world's largest land mass and offered the most wild species to begin with. That pre-existing difference was magnified 13 000 years ago at the end of the last Ice Age, when more than 80% of the large mammal species of North and South America became extinct, probably exterminated by the first arriving Indians. Those extinctions included several species that might have furnished useful domesticated animals had they survived, such as North American horses and camels. As a result, American Indians inherited far fewer species of big wild mammals than did Eurasians, leaving them only with the llama/alpaca as a domesticate. Differences between the Old and New Worlds in domesticated

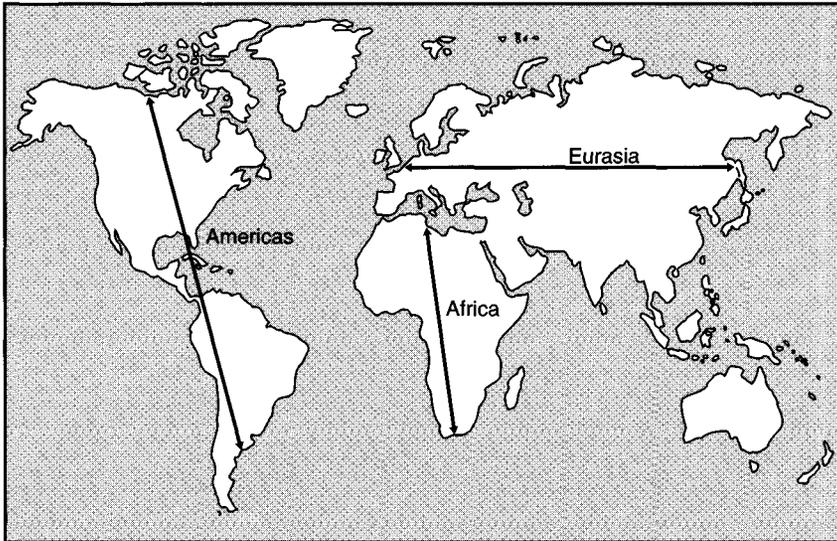


FIGURE 1 The major axis of Eurasia is east/west, facilitating rapid diffusion of crops and livestock and migration of peoples over long distances without encountering different latitudes, daylengths, climates or diseases. For the Americas and for Africa, the major axis is instead north/south, slowing diffusion and migration over long distances because of the need to adapt to different latitudes, daylengths, climates and diseases.

plants are qualitatively similar to these differences in domesticated mammals, though the difference is not so extreme.

A further reason for the higher local diversity of domesticated plants and animals in Eurasia than in the Americas is that Eurasia's main axis is east/west, whereas the main axis of the Americas is north/south (Figure 1). Eurasia's east/west axis meant that species domesticated in one part of Eurasia could easily spread thousands of miles at the same latitude, encountering the same daylength and climate to which they were already adapted. As a result, chickens and citrus fruit domesticated in South-east Asia quickly spread westwards to Europe, horses domesticated in the Ukraine quickly spread eastwards to China and the sheep, goats, cattle, wheat and barley of the Middle East quickly spread both west and east.

In contrast, the north/south axis of the Americas meant that species domesticated in one area could not spread far without encountering daylengths and

climates to which they were not adapted. As a result, the turkey never spread from Mexico to the Andes; llamas/alpacas never spread from the Andes to Mexico, so that the Indian civilizations of Central and North America remained entirely without pack animals; and it took thousands of years for the corn that evolved in Mexico's climate to become modified into a corn adapted to the shorter growing season and seasonally changing daylength of North America. That seems to be the main reason why North America's Mississippi Valley, which you might think should have been fertile enough to support a populous and politically advanced Indian society, did not give rise to one until around A.D. 1000, when a variety of corn adapted to temperate latitudes was finally developed.

Eurasia's domesticated plants and animals were important for several other reasons besides letting Europeans develop nasty germs. Domesticated plants and animals yield far more calories per acre than do wild habitats, in which most species are inedible to humans. As a result, populations of farmers and herders are typically ten to 100 times greater than those of hunter-gatherers. That fact alone explains why farmers and herders almost everywhere in the world have been able to push hunter-gatherers out of land suitable for farming and herding. Domestic animals revolutionized land transport. They also revolutionized agriculture, by letting one farmer plough and manure much more land than the farmer could till or manure by his/her own efforts. In addition, hunter-gatherer societies tend to be egalitarian and have no political organization beyond the level of the band or tribe, whereas the food surpluses and storage made possible by agriculture permitted the development of stratified societies with political élites. The food surpluses produced by farmers also accelerated the development of technology, by supporting craftspeople who did not raise their own food and could instead devote themselves to developing metallurgy, writing, swords and guns.

Those professional specialists supported by agriculture also included full-time soldiers. That gave a decisive military advantage to many colonizing empires. For example, it was the decisive factor in the eventual success of New Zealand's British colonists at defeating New Zealand's indigenous Maori population, who were tough and well-armed fighters. While the Maori won some stunning temporary victories, each Maori man could fight for only a short time before having to go home to tend his garden. The Maori were eventually worn down by the full-time soldiers of the British colonists.

Thus, we began by identifying a series of proximate explanations – guns, germs and so on – for the conquest of the Americas by Europeans. Those proximate factors seem to me ultimately traceable in large part to the Old World's greater number of domesticated plants, much greater number of domesticated animals and east/west axis. The chain of causation is most direct in explaining the Old World's advantages of horses and nasty germs. But domesticated plants and animals also led more indirectly to Eurasia's advantage in guns, swords, ocean-going ships, political organization and writing, all of which were products of the large, dense, sedentary, stratified societies made possible by agriculture.

The history of Africa

Let us next examine whether this scheme, derived from the collision of Europeans with Native Americans, helps us to understand the broadest pattern of African history. I shall concentrate on the history of sub-Saharan Africa, because it was much more isolated from Eurasia by distance and climate than was North Africa, whose history is closely linked to Eurasia's history.

There are two big puzzles in the broad pattern of sub-Saharan African history. First, just as we asked why Cortes invaded Mexico before Montezuma could invade Europe, we can similarly ask why European countries colonized sub-Saharan Africa before sub-Saharan countries could colonize Europe. The proximate factors were the same familiar ones of guns, steel, ocean-going ships, political organization and writing; horses played much less of a role in Africa, and diseases in Africa may even have worked against Europeans rather than for them. Again, we can ask why guns and ships and so on ended up being developed in Europe rather than in sub-Saharan Africa. To the student of human evolution, this question is particularly puzzling, because humans have been evolving for millions of years longer in Africa than in Europe, and even anatomically modern *Homo sapiens* may have reached Europe from Africa only within the last 50 000 years. If time were a critical factor in the development of human societies, Africa should have enjoyed an enormous advantage over Europe.

The other puzzle in the broad pattern of African history is a collision within Africa. Until about 2000 years ago, most of sub-equatorial Africa seems to have been occupied by two groups of hunter-gatherers: pygmies in the moist equatorial areas, and Khoisan populations (alias Bushmen and Hottentots) through-

out the drier parts of southern Africa. About 2000 years ago, Bantu populations originating ultimately from tropical West Africa rapidly expanded over almost the whole of southern Africa and replaced its Khoisan populations, except in the Cape Region and in dry areas unsuitable for agriculture. That Bantu expansion was powered by the advantages that Bantu gained over pygmies and Khoisan by possessing agriculture, herding and metal. Again, though, one can ask: why were those advantages developed by the Bantu rather than by the Khoisan?

Again, those advantages largely reflect biogeographical differences in the availability of domesticatable wild animal and plant species. Beginning with domestic animals, it is striking that the sole animal domesticated within sub-Saharan Africa was a bird, the guinea fowl. All of Africa's mammalian domesticates – cattle, sheep, goats, horses, even dogs – entered sub-Saharan Africa from the north, from Eurasia. At first that sounds astonishing, since we now think of Africa as *the continent par excellence* of big wild mammals. In fact, none of those famous big wild mammal species of Africa proved domesticatable. They were all eliminated by one or another problems such as unsuitable social organization, intractable behaviour, slow growth rate and so on. Imagine what the course of world history might have been like if Africa's rhinoceroses and hippopotamuses had lent themselves to domestication! Cavalry mounted on horses would have been helpless against cavalry mounted on rhinos or hippos. If those animals could have been domesticated, sub-Saharan Africans would have made mincemeat of Europeans. But it did not happen.

Instead, as I mentioned, the livestock adopted in Africa were Eurasian species that came in from the north. Africa's long axis, like that of the Americas, is north/south rather than east/west. Those domestic mammals spread southwards only slowly in Africa, because they had to adapt to different climate zones and different animal diseases. While cattle, sheep and goats reached the northern edge of the Serengeti Plains soon after 3000 B.C., it then took another 2000 years for them to cross the Serengeti and reach the Khoisan in southern Africa, just ahead of the invading Bantu.

The situation with domesticated plants in Africa is even more interesting. Agriculture based on indigenous wild plants did arise independently in Africa, from the equator *north* to the Sahara. Among those African domesticated plants, the one most familiar to readers of these pages is coffee, which was indigenous to Ethiopia, was domesticated there and has now spread around the

world. Other plants domesticated between the Sahara and the equator include sorghum, several types of millet and yams and the oil palm. But no wild plant species was domesticated in Africa *south* of the equator. The result was that the Bantu developed agriculture but the Khoisan never did. Farming was instead carried into southern Africa by the invading Bantu, who were thereby able to displace most of the indigenous Khoisan peoples.

The difficulties posed by a north/south axis to the spread of domesticated species are even more striking for African crops than they are for livestock. Remember that the food staples of ancient Egypt were Fertile Crescent and Mediterranean crops like wheat and barley, which require winter rains and seasonal variation in daylength for their germination. Those crops were unable to spread south in Africa beyond Ethiopia, where the rains come in the summer and there is little or no seasonal variation in daylength. Instead, the development of agriculture in the Sahara and sub-Saharan had to await the domestication of native plant species like sorghum and millet, adapted to Central Africa's summer rains and relatively constant daylength.

Ironically, those crops of Central Africa were for the same reason then unable to spread south to the Mediterranean zone of South Africa, where once again winter rains and big seasonal variations in daylength prevailed. Instead, agriculture in South Africa's Cape region required crops adapted to winter rains and seasonally varying daylength, like the crops of the Fertile Crescent and Mediterranean. But those crops could not survive conditions in Central Africa and so could not be transmitted overland through chains of farmers from the Mediterranean to the Cape. Instead, those Mediterranean crops reached Africa's Cape region only with European settlers in the seventeenth century. The Bantu advance southwards halted in Natal, beyond which the zone of winter rainfall began and Bantu crops were unable to grow. Those facts about adaptations of domesticated plants had notorious consequences for modern South African politics, because Bantu farmers were not occupying the Cape when European farmers arrived.

A further consequence of Africa's north/south axis has to do with an irony of agriculture in modern tropical Africa. Some of modern tropical Africa's most important crops are no longer the crops native to tropical Africa, but are instead tropical Asian crops such as bananas, yams and taro, or tropical American crops such as corn and cassava. Because tropical Africa is flanked by oceans on both sides, tropical Asian crops did not reach Africa until Arab and

Indonesian traders began arriving across the Indian Ocean about 2000 years ago, while tropical American crops did not reach Africa until Europeans colonized the New World and then brought New World crops to Africa. If the Indian or Atlantic Oceans had been bridged by land similar to the broad east/west expanse of Eurasia, those productive tropical Asian and American crops would have reached tropical Africa thousands of years earlier, just as Asian chickens and citrus fruits had reached Europe.

In short, a north/south axis and a paucity of wild plant and animal species suitable for domestication were doubly decisive in African history, just as they were in Native American history. First, the indigenous Khoisan people of most of sub-equatorial Africa never developed nor adopted agriculture, and they acquired livestock from the north late, just before most of the Khoisan were overwhelmed by the far more numerous, better armed, Iron Age Bantu. Second, although the Bantu themselves had some plants domesticated locally in tropical West Africa, they acquired valuable domestic animals only later, from the north. The resulting advantages of Europeans in guns, ships, political organization and writing permitted Europeans to colonize Africa, rather than Africans to colonize Europe.

The history of Australia

Let us now conclude our whirlwind tour around the world by devoting some space to the last continent, Australia. In modern times, Australia was the sole continent still inhabited only by hunter-gatherers. Native Australia had no farmers or herders, no writing, no manufacture of metal tools and no political organization beyond the level of the tribe or band. Those are the reasons why European guns and germs destroyed Aboriginal Australian society. But why had all Native Australians remained hunter-gatherers?

There are three obvious reasons. First, even to this day no native Australian animal species and only one plant species (the macadamia nut) has proved suitable for domestication. There still are no domestic kangaroos.

Second, Australia is the smallest continent, and most of it can support only small human populations because of low rainfall and productivity. Hence the total number of Australian hunter-gatherers was only about 300 000.

Finally, Australia is the most isolated continent. The sole outside contacts of Aboriginal Australians were tenuous overwater ones with New Guineans and Indonesians. The coast of north-west Australia, where occasional visiting

Indonesian fishermen landed, is one of the most barren parts of Australia, quite unsuitable for growing any crops that the Indonesians might have brought with them. As a result, the cultural barrier between Australia and Indonesia or New Guinea remains astonishingly sharp. For example, in New Guinea there were bows and arrows, agriculture, pigs, chickens and pottery for thousands of years, but not one of those cultural items crossed the hundred-mile or so water gap of the Torres Strait to become established in Australia.

To get an idea of the significance of that small population size and isolation for the pace of development in Australia, consider the Australian island of Tasmania, which had the most extraordinary human society in the modern world. Tasmania is an island of about 26 000 square miles, lying 130 miles south of Australia at the latitude of Vladivostok or Chicago. When first visited by Europeans in 1642, Tasmania was occupied by 4000 hunter-gatherers related to mainland Australians, but with the simplest technology of any recent people on Earth. Cultural features that mainland Aboriginal Australians possessed and that Tasmanians lacked included the following. Tasmanians could not start a fire; if a family's fire went out, they had to get fire from neighbours to re-light it. The sole Tasmanian weapons were hand-held spears and clubs. They lacked the boomerangs, spear-throwers and shields of mainland Australians. Tasmanians had no bone tools, no specialized stone tools and no compound tools like an axe-head mounted on a handle. Their only stone tool was a crude hand-held scraper without ground edges. With only those scrapers, Tasmanians could not fell a tree or hollow out a canoe. They lacked sewing, nets, traps and ropes. Since they could not sew, their clothing consisted just of a one-piece cape, occasionally worn by being thrown over the shoulder. Their watercraft were rafts that remained afloat for only about ten miles. Though they lived mostly on the sea coast, the Tasmanians – incredibly – did not catch or eat fish.

Anthropologists feel uncomfortable discussing the Tasmanians, because of the awful end of their society: they were exterminated by British settlers within a few decades. To acknowledge that the Tasmanians had a relatively simple technology *seems* to be construed as justifying their extermination, which is, of course, nonsense. In particular, some anthropologists argue that Tasmanians had simple technology because they did not need anything more complicated. That interpretation is also manifestly incorrect. For humans anywhere in the world, it is convenient to be able to light a fire, to have nets and traps, to be able to sew clothes in order to keep warm during cold wet winters and to have

devices such as bows or spear-throwers in order to discharge a projectile with much greater force than one can discharge a hand-held spear. Tasmanians surely would have profited from those things as did all other peoples, and there is a real problem in explaining their absence in Tasmania. How did those gaps in Tasmanian material culture arise?

Remember that Tasmania used to be joined to the southern Australian mainland at Pleistocene times of low sea level, until the land bridge was severed by rising sea level 12 000 years ago. People walked out to Tasmania tens of thousands of years ago, when it was still part of Australia. Once that land bridge was severed, though, there was absolutely no further contact of Tasmanians with mainland Australians or with any other people until the Dutch explorer Abel Tasman arrived in 1642, because both Tasmanians and mainland Australians lacked watercraft capable of crossing those 130-mile straits between Tasmania and Australia. Tasmanian history is thus a study of human isolation unprecedented except in science fiction – namely, complete isolation from all other humans for 12 000 years.

If all those technologies that I mentioned, absent from Tasmania but present on the opposite Australian mainland, were invented by Australians within the last 12 000 years, we can surely conclude that the Tasmanians did not invent them independently. Astonishingly, the archaeological record demonstrates something further: Tasmanians actually *abandoned* some technologies that they brought with them from Australia and that persisted on the Australian mainland. For example, bone tools and the practice of fishing were both present in Tasmania at the time that the land bridge was severed, and both disappeared from Tasmania around 1500 B.C. That represents the loss of valuable technologies: fish could have been smoked to provide a winter food supply, and bone needles could have been used to sew warm clothes. What sense can we make of these cultural losses?

The only interpretation that makes sense to me goes as follows. All human societies go through fads in which they temporarily either adopt practices of little use or else abandon practices of considerable use. For example, there are several instances of people on Pacific islands suddenly deciding to taboo and kill off all of their pigs, even though pigs are their only big edible land mammal! Eventually, those Pacific islanders realize that pigs are useful after all, and they import a new breeding stock from another island. Whenever such senseless taboos arise in an area with many competing human societies, only some societ-

ies will adopt the taboo at a given time. Other societies will retain the useful practice, and will either outcompete the societies that lost it or else will be there as a model for the societies with the taboos to repent their error and reacquire the practice. If Tasmanians had remained in contact with mainland Australians, they could have rediscovered the value and technique of fishing and making bone tools. But that could not happen in the complete isolation of Tasmania, where cultural losses became irreversible.

In case it is still difficult for you to believe that these cultural losses really happened in Tasmania, there are similar examples from other Pacific islands, such as the isolated Chatham Islands east of New Zealand, settled by New Zealand Maori who proceeded to live there in complete isolation for at least five centuries. There are also fourteen small and isolated Pacific Islands on which human populations actually went extinct after many centuries. The best known of these mystery islands is Pitcairn, famous for its rediscovery by the *H.M.S. Bounty* mutineers many centuries after the disappearance of Pitcairn's former Polynesian population. All of those islands on which human populations actually disappeared were so small that they could have held at most a few hundred people. Evidently, a few hundred people are just too few to maintain human society indefinitely in total isolation. If so, the 4000 Tasmanians and the 2000 Chatham Islanders were enough to keep their societies alive, but not enough to protect their societies against significant cultural losses.

In short, the message of the differences between Tasmanian and mainland Australian society seems to be the following. All other things being equal, the rate of human invention is faster, and the rate of cultural loss slower, in areas occupied by many competing societies with many individuals and in contact with societies elsewhere. If this interpretation is correct, it is likely to be of much broader significance. It probably provides part of the explanation (in addition to Australia's paucity of domesticatable wild animal and plant species) for native Australians remaining as Stone Age hunter-gatherers, while people of other continents were adopting agriculture and metal. It is also likely to contribute to the differences that I have discussed between the farmers of sub-Saharan Africa, of the much larger Americas and of the still larger Eurasia.

Conclusion and outlook

As for the overall meaning of this whirlwind tour through human history, it is that our history has been moulded by our environment. The broadest pattern

of human history – namely, the differences between human societies on different continents – seems to me to be attributable to differences in continental environments. In particular, the availability of wild plant and animal species suitable for domestication, and the ease with which those species could spread without encountering unsuitable climates, have contributed decisively to the varying rates of rise of agriculture and herding, which in turn have contributed decisively to human population numbers, population densities and food surpluses, which in turn contributed decisively to the development of writing, technology and political organization. In addition, the histories of Tasmania and other isolated societies warn us that continental areas and isolations, by determining the number of competing societies, may have been another important factor in human development.

As a biologist also at home in laboratory experimental science, I am aware that these interpretations may be dismissed as unprovable speculation, because they are not founded on replicated laboratory experiments. The same objection can be raised against any of the historical sciences, including astronomy, evolutionary biology, geology and palaeontology. It can, of course, be raised against the entire field of history. That is the reason why we are uncomfortable about considering history as a science: it is classified as a social science, which is not considered quite scientific.

But remember that the word ‘science’ is not derived from the Latin word for ‘replicated laboratory experiment’, but instead from the Latin word for ‘knowledge’. In science, we seek knowledge and understanding by whatever means are available and appropriate. There are many fields that no one hesitates to consider sciences, even though replicated laboratory experiments in those fields would be immoral, illegal or impossible. We cannot manipulate stars while maintaining other stars as controls, nor can we start and stop ice ages, nor can we experiment with evolving dinosaurs. Nevertheless, we can still gain considerable insight into these historical fields by other means. We should surely be able, then, to understand human history, since introspection and preserved writings give us far more insights into the ways of past humans than those of dinosaurs. For that reason I am optimistic that we can eventually arrive at convincing explanations for these broadest patterns of human history.

FURTHER READING

Cavalli-Sforza, L. L. and Cavalli-Sforza, F. *The Great Human Diasporas*, Reading, MA: Addison-Wesley, 1995.

The evolution of guns and germs

Crosby, A. *Ecological Imperialism: The Biological Expansion of Europe, 900–1900*, Cambridge: Cambridge University Press, 1986.

Diamond, J. M. *Guns, Germs, and Steel*, New York: W. W. Norton, London: Jonathan Cape/Random House, 1997.

Zohary, D. and Hopf, M. *Domestication of Plants in the Old World*, 2nd edition, Oxford: Oxford University Press, 1993.