CHAPTER 6

TO FARM OR NOT TO FARM

FORMERLY, ALL PEOPLE ON EARTH WERE HUNTER-GATHERERS. Why did any of them adopt food production at all? Given that they must have had some reason, why did they do so around 8500 B.C. in Mediterranean habitats of the Fertile Crescent, only 3,000 years later in the climatically and structurally similar Mediterranean habitats of southwestern Europe, and never indigenously in the similar Mediterranean habitats of California, southwestern Australia, and the Cape of South Africa? Why did even people of the Fertile Crescent wait until 8500 B.C., instead of becoming food producers already around 18,500 or 28,500 B.C.?

From our modern perspective, all these questions at first seem silly, because the drawbacks of being a hunter-gatherer appear so obvious. Scientists used to quote a phrase of Thomas Hobbes's in order to characterize the lifestyle of hunter-gatherers as "nasty, brutish, and short." They seemed to have to work hard, to be driven by the daily quest for food, often to be close to starvation, to lack such elementary material comforts as soft beds and adequate clothing, and to die young.

In reality, only for today's affluent First World citizens, who don't actually do the work of raising food themselves, does food production (by remote agribusinesses) mean less physical work, more comfort, freedom from starvation, and a longer expected lifetime. Most peasant farmers and herders, who constitute the great majority of the world's actual food producers, aren't necessarily better off than hunter-gatherers. Time budget studies show that they may spend more rather than fewer hours per day at work than hunter-gatherers do. Archaeologists have demonstrated that the first farmers in many areas were smaller and less well nourished, suffered from more serious diseases, and died on the average at a younger age than the hunter-gatherers they replaced. If those first farmers could have foreseen the consequences of adopting food production, they might not have opted to do so. Why, unable to foresee the result, did they nevertheless make that choice?

There exist many actual cases of hunter-gatherers who did see food production practiced by their neighbors, and who nevertheless refused to accept its supposed blessings and instead remained hunter-gatherers. For instance, Aboriginal hunter-gatherers of northeastern Australia traded for thousands of years with farmers of the Torres Strait Islands, between Australia and New Guinea. California Native American hunter-gatherers traded with Native American farmers in the Colorado River valley. In addition, Khoi herders west of the Fish River of South Africa traded with Bantu farmers east of the Fish River, and continued to dispense with farming themselves. Why?

Still other hunter-gatherers in contact with farmers did eventually become farmers, but only after what may seem to us like an inordinately long delay. For example, the coastal peoples of northern Germany did not adopt food production until 1,300 years after peoples of the Linearbandkeramik culture introduced it to inland parts of Germany only 125 miles to the south. Why did those coastal Germans wait so long, and what led them finally to change their minds?

BEFORE WE CAN answer these questions, we must dispel some misconceptions about the origins of food production and then reformulate the question. What actually happened was not a *discovery* of food production, nor an *invention*, as we might first assume. There was often not even a conscious choice between food production and hunting-gathering. Specifically, in each area of the globe the first people who adopted food production could obviously not have been making a conscious choice or consciously striving toward farming as a goal, because they had never seen farming and had no way of knowing what it would be like. Instead, as we shall see, food production *evolved* as a by-product of decisions made without awareness of their consequences. Hence the question that we have to ask is why food production did evolve, why it evolved in some places but not others, why at different times in different places, and why not instead at some earlier or later date.

Another misconception is that there is necessarily a sharp divide between nomadic hunter-gatherers and sedentary food producers. In reality, although we frequently draw such a contrast, hunter-gatherers in some productive areas, including North America's Pacific Northwest coast and possibly southeastern Australia, became sedentary but never became food producers. Other hunter-gatherers, in Palestine, coastal Peru, and Japan, became sedentary first and adopted food production much later. Sedentary groups probably made up a much higher fraction of hunter-gatherers 15,000 years ago, when all inhabited parts of the world (including the most productive areas) were still occupied by hunter-gatherers, than they do today, when the few remaining hunter-gatherers survive only in unproductive areas where nomadism is the sole option.

Conversely, there are mobile groups of food producers. Some modern nomads of New Guinea's Lakes Plains make clearings in the jungle, plant bananas and papayas, go off for a few months to live again as hunter-gatherers, return to check on their crops, weed the garden if they find the crops growing, set off again to hunt, return months later to check again, and settle down for a while to harvest and eat if their garden has produced. Apache Indians of the southwestern United States settled down to farm in the summer at higher elevations and toward the north, then withdrew to the south and to lower elevations to wander in search of wild foods during the winter. Many herding peoples of Africa and Asia shift camp along regular seasonal routes to take advantage of predictable seasonal changes in pasturage. Thus, the shift from hunting-gathering to food production did not always coincide with a shift from nomadism to sedentary living.

Another supposed dichotomy that becomes blurred in reality is a distinction between food producers as active managers of their land and hunter-gatherers as mere collectors of the land's wild produce. In reality, some hunter-gatherers intensively manage their land. For example, New Guinea peoples who never domesticated sago palms or mountain pandanus nevertheless increase production of these wild edible plants by clearing away encroaching competing trees, keeping channels in sago swamps clear, and promoting growth of new sago shoots by cutting down mature sago trees. Aboriginal Australians who never reached the stage of farming yams and seed plants nonetheless anticipated several elements of farming. They managed the landscape by burning it, to encourage the growth of edible seed plants that sprout after fires. In gathering wild yams, they cut off most of the edible tuber but replaced the stems and tops of the tubers in the ground so that the tubers would regrow. Their digging to extract the tuber loosened and aerated the soil and fostered regrowth. All that they would have had to do to meet the definition of farmers was to carry the stems and remaining attached tubers home and similarly replace them in soil at their camp.

FROM THOSE PRECURSORS of food production already practiced by hunter-gatherers, it developed stepwise. Not all the necessary techniques were developed within a short time, and not all the wild plants and animals that were eventually domesticated in a given area were domesticated simultaneously. Even in the cases of the most rapid independent development of food production from a hunting-gathering lifestyle, it took thousands of years to shift from complete dependence on wild foods to a diet with very few wild foods. In early stages of food production, people simultaneously collected wild foods *and* raised cultivated ones, and diverse types of collecting activities diminished in importance at different times as reliance on crops increased.

The underlying reason why this transition was piecemeal is that food production systems evolved as a result of the accumulation of many separate decisions about allocating time and effort. Foraging humans, like foraging animals, have only finite time and energy, which they can spend in various ways. We can picture an incipient farmer waking up and asking: Shall I spend today hoeing my garden (predictably yielding a lot of vegetables several months from now), gathering shellfish (predictably yielding a little meat today), or hunting deer (yielding possibly a lot of meat today, but more likely nothing)? Human and animal foragers are constantly prioritizing and making effort-allocation decisions, even if only unconsciously. They concentrate first on favorite foods, or ones that yield the highest payoff. If these are unavailable, they shift to less and less preferred foods.

Many considerations enter into these decisions. People seek food in order to satisfy their hunger and fill their bellies. They also crave specific foods, such as protein-rich foods, fat, salt, sweet fruits, and foods that

—py taste good. All other things being equal, people seek to maximize their return of calories, protein, or other specific food categories by foraging in a way that yields the most return with the greatest certainty in the least time for the least effort. Simultaneously, they seek to minimize their risk of starving: moderate but reliable returns are preferable to a fluctuating lifestyle with a high time-averaged rate of return but a substantial likelihood of starving to death. One suggested function of the first gardens of nearly 11,000 years ago was to provide a reliable reserve larder as insurance in case wild food supplies failed.

Conversely, men hunters tend to guide themselves by considerations of prestige: for example, they might rather go giraffe hunting every day, bag a giraffe once a month, and thereby gain the status of great hunter, than bring home twice a giraffe's weight of food in a month by humbling themselves and reliably gathering nuts every day. People are also guided by seemingly arbitrary cultural preferences, such as considering fish either delicacies or taboo. Finally, their priorities are heavily influenced by the relative values they attach to different lifestyles—just as we can see today. For instance, in the 19th-century U.S. West, the cattlemen, sheepmen, and farmers all despised each other. Similarly, throughout human history farmers have tended to despise hunter-gatherers as primitive, hunter-gatherers have despised farmers as ignorant, and herders have despised both. All these elements come into play in people's separate decisions about how to obtain their food.

As we already noted, the first farmers on each continent could not have chosen farming consciously, because there were no other nearby farmers for them to observe. However, once food production had arisen in one part of a continent, neighboring hunter-gatherers could see the result and make conscious decisions. In some cases the hunter-gatherers adopted the neighboring system of food production virtually as a complete package; in others they chose only certain elements of it; and in still others they rejected food production entirely and remained hunter-gatherers.

For example, hunter-gatherers in parts of southeastern Europe had quickly adopted Southwest Asian cereal crops, pulse crops, and livestock simultaneously as a complete package by around 6000 B.C. All three of these elements also spread rapidly through central Europe in the centuries before 5000 B.C. Adoption of food production may have been rapid and wholesale in southeastern and central Europe because the hunter-gatherer lifestyle there was less productive and less competitive. In contrast, food production was adopted piecemeal in southwestern Europe (southern France, Spain, and Italy), where sheep arrived first and cereals later. The adoption of intensive food production from the Asian mainland was also very slow and piecemeal in Japan, probably because the hunter-gatherer lifestyle based on seafood and local plants was so productive there.

Just as a hunting-gathering lifestyle can be traded piecemeal for a food-producing lifestyle, one system of food production can also be traded piecemeal for another. For example, Indians of the eastern United States were domesticating local plants by about 2500 B.C. but had trade connections with Mexican Indians who developed a more productive crop system based on the trinity of corn, squash, and beans. Eastern U.S. Indians adopted Mexican crops, and many of them discarded many of their local domesticates, piecemeal; squash was domesticated independently, corn arrived from Mexico around A.D. 200 but remained a minor crop until around A.D. 900, and beans arrived a century or two later. It even happened that food-production systems were abandoned in favor of hunting-gathering. For instance, around 3000 B.C. the hunter-gatherers of southern Sweden adopted farming based on Southwest Asian crops, but abandoned it around 2700 B.C. and reverted to hunting-gathering for 400 years before resuming farming.

All these considerations make it clear that we should not suppose that the decision to adopt farming was made in a vacuum, as if the people had previously had no means to feed themselves. Instead, we must consider food production and hunting-gathering as *alternative strategies* competing with each other. Mixed economies that added certain crops or livestock to hunting-gathering also competed against both types of "pure" economies, and against mixed economies with higher or lower proportions of food production. Nevertheless, over the last 10,000 years, the predominant result has been a shift from hunting-gathering to food production. Hence we must ask: What were the factors that tipped the competitive advantage away from the former and toward the latter?

That question continues to be debated by archaeologists and anthropologists. One reason for its remaining unsettled is that different factors may have been decisive in different parts of the world. Another has been the

...of food production.

vever, five main contributing factors can still be identified; the contro-es revolve mainly around their relative importance.

ne factor is the decline in the availability of wild foods. The lifestyle ınter-gatherers has become increasingly less rewarding over the past 00 years, as resources on which they depended (especially animal ırces) have become less abundant or even disappeared. As we saw in ıter 1, most large mammal species became extinct in North and South ica at the end of the Pleistocene, and some became extinct in Eurasia Africa, either because of climate changes or because of the rise in skill ıumbers of human hunters. While the role of animal extinctions in ually (after a long lag) nudging ancient Native Americans, Eurasians, fricans toward food production can be debated, there are numerous trovertible cases on islands in more recent times. Only after the first esian settlers had exterminated moas and decimated seal populations w Zealand, and exterminated or decimated seabirds and land birds ıer Polynesian islands, did they intensify their food production. For ce, although the Polynesians who colonized Easter Island around 00 brought chickens with them, chicken did not become a major ıntil wild birds and porpoises were no longer readily available as Similarly, a suggested contributing factor to the rise of animal tication in the Fertile Crescent was the decline in abundance of the ızelles that had previously been a major source of meat for hunter-ırs in that area.

cond factor is that, just as the depletion of wild game tended to hunting-gathering less rewarding, an increased availability of icable wild plants made steps leading to plant domestication more ing. For instance, climate changes at the end of the Pleistocene in ile Crescent greatly expanded the area of habitats with wild cere-which huge crops could be harvested in a short time. Those wild arvests were precursors to the domestication of the earliest crops, als wheat and barley, in the Fertile Crescent.

ınother factor tipping the balance away from hunting-gathering cumulative development of technologies on which food produc-uld eventually depend—technologies for collecting, processing, ing wild foods. What use can would-be farmers make of a ton of ains on the stalk, if they have not first figured out how to harvest, d store them? The necessary methods, implements, and facilities appeared rapidly in the Fertile Crescent after 11,000 B.C., having been invented for dealing with the newly available abundance of wild cereals.

Those inventions included sickles of flint blades cemented into wooden or bone handles, for harvesting wild grains; baskets in which to carry the grains home from the hillsides where they grew; mortars and pestles, or grinding slabs, to remove the husks; the technique of roasting grains so that they could be stored without sprouting; and underground storage pits, some of them plastered to make them waterproof. Evidence for all of these techniques becomes abundant at sites of hunter-gatherers in the Fertile Crescent after 11,000 B.C. All these techniques, though developed for the exploitation of wild cereals, were prerequisites to the planting of cereals as crops. These cumulative developments constituted the unconscious first steps of plant domestication.

A fourth factor was the two-way link between the rise in human population density and the rise in food production. In all parts of the world where adequate evidence is available, archaeologists find evidence of rising densities associated with the appearance of food production. Which was the cause and which the result? This is a long-debated chicken-or-egg problem: did a rise in human population density force people to turn to food production, or did food production permit a rise in human population density?

In principle, one expects the chain of causation to operate in both directions. As I've already discussed, food production tends to lead to increased population densities because it yields more edible calories per acre than does hunting-gathering. On the other hand, human population densities were gradually rising throughout the late Pleistocene anyway, thanks to improvements in human technology for collecting and processing wild foods. As population densities rose, food production became increasingly favored because it provided the increased food outputs needed to feed all those people.

That is, the adoption of food production exemplifies what is termed an autocatalytic process—one that catalyzes itself in a positive feedback cycle, going faster and faster once it has started. A gradual rise in population densities impelled people to obtain more food, by rewarding those who unconsciously took steps toward producing it. Once people began to produce food and become sedentary, they could shorten the birth spacing and produce still more people, requiring still more food. This bidirectional link between food production and population density explains the paradox ı food production, while increasing the quantity of edible calories per e, left the food producers less well nourished than the hunter-gatherers om they succeeded. That paradox developed because human popula- ı densities rose slightly more steeply than did the availability of food.

Taken together, these four factors help us understand why the transition ood production in the Fertile Crescent began around 8500 B.C., not und 18,500 or 28,500 B.C. At the latter two dates hunting-gathering still much more rewarding than incipient food production, because l mammals were still abundant; wild cereals were not yet abundant; ole had not yet developed the inventions necessary for collecting, pro- ing, and storing cereals efficiently; and human population densities e not yet high enough for a large premium to be placed on extracting e calories per acre.

final factor in the transition became decisive at geographic boundaries een hunter-gatherers and food producers. The much denser popula- of food producers enabled them to displace or kill hunter-gatherers heir sheer numbers, not to mention the other advantages associated food production (including technology, germs, and professional sol-). In areas where there were only hunter-gatherers to begin with, those ps of hunter-gatherers who adopted food production outbred those didn't.

a result, in most areas of the globe suitable for food production, er-gatherers met one of two fates: either they were displaced by neigh- g food producers, or else they survived only by adopting food pro- on themselves. In places where they were already numerous or where aphy retarded immigration by food producers, local hunter-gatherers ave time to adopt farming in prehistoric times and thus to survive as rs. This may have happened in the U.S. Southwest, in the western terranean, on the Atlantic coast of Europe, and in parts of Japan. ever, in Indonesia, tropical Southeast Asia, most of subequatorial , and probably in parts of Europe, the hunter-gatherers were ed by farmers in the prehistoric era, whereas a similar replacement place in modern times in Australia and much of the western United .

ly where especially potent geographic or ecological barriers made ration of food producers or diffusion of locally appropriate food- cing techniques very difficult were hunter-gatherers able to persist nodern times in areas suitable for food production. The three out- standing examples are the persistence of Native American hunter-gather- ers in California, separated by deserts from the Native American farmers of Arizona; that of Khoisan hunter-gatherers at the Cape of South Africa, in a Mediterranean climate zone unsuitable for the equatorial crops of nearby Bantu farmers; and that of hunter-gatherers throughout the Aus- tralian continent, separated by narrow seas from the food producers of Indonesia and New Guinea. Those few peoples who remained hunter- gatherers into the 20th century escaped replacement by food producers because they were confined to areas not fit for food production, especially deserts and Arctic regions. Within the present decade, even they will have been seduced by the attractions of civilization, settled down under pressure from bureaucrats or missionaries, or succumbed to germs.

CHAPTER 10

Spacious Skies and Tilted Axes

On the map of the world on page 177 (Figure 10.1), compare the shapes and orientations of the continents. You'll be struck by an obvious difference. The Americas span a much greater distance north–south (9,000 miles) than east–west: only 3,000 miles at the widest, narrowing to a mere 40 miles at the Isthmus of Panama. That is, the major axis of the Americas is north–south. The same is also true, though to a less extreme degree, for Africa. In contrast, the major axis of Eurasia is east–west. What effect, if any, did those differences in the orientation of the continents' axes have on human history?

This chapter will be about what I see as their enormous, sometimes tragic, consequences. Axis orientations affected the rate of spread of crops and livestock, and possibly also of writing, wheels, and other inventions. That basic feature of geography thereby contributed heavily to the very different experiences of Native Americans, Africans, and Eurasians in the last 500 years.

Food production's spread proves as crucial to understanding geographic differences in the rise of guns, germs, and steel as did its origins, which we considered in the preceding chapters. That's because, as we

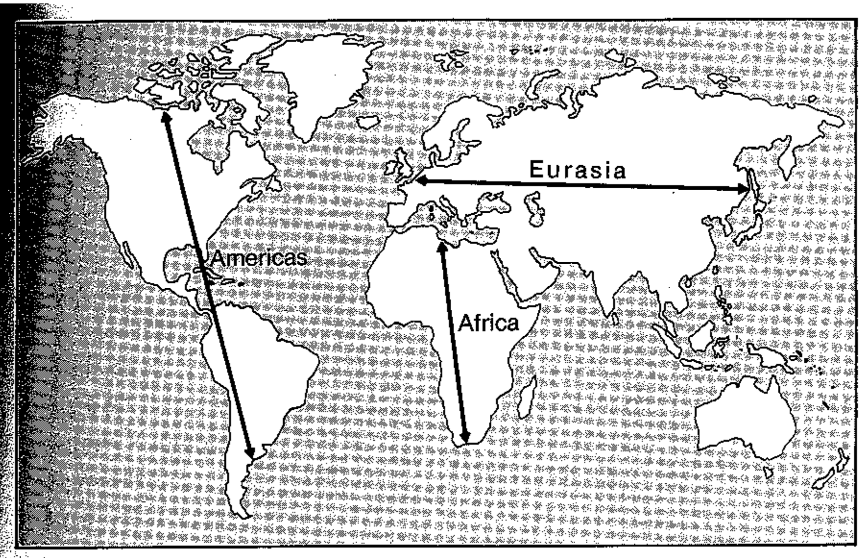

Figure 10.1. Major axes of the continents.

saw in Chapter 5, there were no more than nine areas of the globe, perhaps as few as five, where food production arose independently. Yet, already in prehistoric times, food production became established in many other regions besides those few areas of origins. All those other areas became food producing as a result of the spread of crops, livestock, and knowledge of how to grow them and, in some cases, as a result of migrations of farmers and herders themselves.

The main such spreads of food production were from Southwest Asia to Europe, Egypt and North Africa, Ethiopia, Central Asia, and the Indus Valley; from the Sahel and West Africa to East and South Africa; from China to tropical Southeast Asia, the Philippines, Indonesia, Korea, and Japan; and from Mesoamerica to North America. Moreover, food production even in its areas of origin became enriched by the addition of crops, livestock, and techniques from other areas of origin.

Just as some regions proved much more suitable than others for the origins of food production, the ease of its spread also varied greatly around the world. Some areas that are ecologically very suitable for food production never acquired it in prehistoric times at all, even though areas of prehistoric food production existed nearby. The most conspicuous such examples are the failure of both farming and herding to reach Native

American California from the U.S. Southwest or to reach Australia from New Guinea and Indonesia, and the failure of farming to spread from South Africa's Natal Province to South Africa's Cape. Even among all those areas where food production did spread in the prehistoric era, the rates and dates of spread varied considerably. At the one extreme was its rapid spread along east–west axes: from Southwest Asia both west to Europe and Egypt and east to the Indus Valley (at an average rate of about 0.7 miles per year); and from the Philippines east to Polynesia (at 3.2 miles per year). At the opposite extreme was its slow spread along north–south axes: at less than 0.5 miles per year, from Mexico northward to the U.S. Southwest; at less than 0.3 miles per year, for corn and beans from Mexico northward to become productive in the eastern United States around A.D. 900; and at 0.2 miles per year, for the llama from Peru north to Ecuador. These differences could be even greater if corn was not domesticated in Mexico as late as 3500 B.C., as I assumed conservatively for these calculations, and as some archaeologists now assume, but if it was instead domesticated considerably earlier, as most archaeologists used to assume (and many still do).

There were also great differences in the completeness with which suites of crops and livestock spread, again implying stronger or weaker barriers to their spreading. For instance, while most of Southwest Asia's founder crops and livestock did spread west to Europe and east to the Indus Valley, neither of the Andes' domestic mammals (the llama / alpaca and the guinea pig) ever reached Mesoamerica in pre-Columbian times. That astonishing failure cries out for explanation. After all, Mesoamerica did develop dense farming populations and complex societies, so there can be no doubt that Andean domestic animals (if they had been available) would have been valuable for food, transport, and wool. Except for dogs, Mesoamerica was utterly without indigenous mammals to fill those needs. Some South American crops nevertheless did succeed in reaching Mesoamerica, such as manioc, sweet potatoes, and peanuts. What selective barrier let those crops through but screened out llamas and guinea pigs?

A subtler expression of this geographically varying ease of spread is the phenomenon termed preemptive domestication. Most of the wild plant species from which our crops were derived vary genetically from area to area, because alternative mutations had become established among the wild ancestral populations of different areas. Similarly, the changes required to transform wild plants into crops can in principle be brought about by alternative new mutations or alternative courses of selection to yield equivalent results. In this light, one can examine a crop widespread in prehistoric times and ask whether all of its varieties show the same wild mutation or same transforming mutation. The purpose of this examination is to try to figure out whether the crop was developed in just one area or else independently in several areas.

If one carries out such a genetic analysis for major ancient New World crops, many of them prove to include two or more of those alternative wild variants, or two or more of those alternative transforming mutations. This suggests that the crop was domesticated independently in at least two different areas, and that some varieties of the crop inherited the particular mutation of one area while other varieties of the same crop inherited the mutation of another area. On this basis, botanists conclude that lima beans (*Phaseolus lunatus*), common beans (*Phaseolus vulgaris*), and chili peppers of the *Capsicum annuum / chinense* group were all domesticated on at least two separate occasions, once in Mesoamerica and once in South America; and that the squash *Cucurbita pepo* and the seed plant goosefoot were also domesticated independently at least twice, once in Mesoamerica and once in the eastern United States. In contrast, most ancient Southwest Asian crops exhibit just one of the alternative wild variants or alternative transforming mutations, suggesting that all modern varieties of that particular crop stem from only a single domestication.

What does it imply if the same crop has been repeatedly and independently domesticated in several different parts of its wild range, and not just once and in a single area? We have already seen that plant domestication involves the modification of wild plants so that they become more useful to humans by virtue of larger seeds, a less bitter taste, or other qualities. Hence if a productive crop is already available, incipient farmers will surely proceed to grow it rather than start all over again by gathering its not yet so useful wild relative and redomesticating it. Evidence for just a single domestication thus suggests that, once a wild plant had been domesticated, the crop spread quickly to other areas throughout the wild plant's range, preempting the need for other independent domestications of the same plant. However, when we find evidence that the same wild ancestor was domesticated independently in different areas, we infer that the crop spread too slowly to preempt its domestication elsewhere. The evidence for predominantly single domestications in Southwest Asia, but frequent multiple domestications in the Americas, might thus provide more subtle evidence that crops spread more easily out of Southwest Asia than in the Americas.

Rapid spread of a crop may preempt domestication not only of the same wild ancestral species somewhere else but also of related wild species. If you're already growing good peas, it's of course pointless to start from scratch to domesticate the same wild ancestral pea again, but it's also pointless to domesticate closely related wild pea species that for farmers are virtually equivalent to the already domesticated pea species. All of Southwest Asia's founder crops preempted domestication of any of their close relatives throughout the whole expanse of western Eurasia. In contrast, the New World presents many cases of equivalent and closely related, but nevertheless distinct, species having been domesticated in Mesoamerica and South America. For instance, 95 percent of the cotton grown in the world today belongs to the cotton species *Gossypium hirsutum,* which was domesticated in prehistoric times in Mesoamerica. However, prehistoric South American farmers instead grew the related cotton *Gossypium barbadense.* Evidently, Mesoamerican cotton had such difficulty reaching South America that it failed in the prehistoric era to preempt the domestication of a different cotton species there (and vice versa). Chili peppers, squashes, amaranths, and chenopods are other crops of which different but related species were domesticated in Mesoamerica and South America, since no species was able to spread fast enough to preempt the others.

We thus have many different phenomena converging on the same conclusion: that food production spread more readily out of Southwest Asia than in the Americas, and possibly also than in sub-Saharan Africa. Those phenomena include food production's complete failure to reach some ecologically suitable areas; the differences in its rate and selectivity of spread; and the differences in whether the earliest domesticated crops preempted redomestications of the same species or domestications of close relatives. What was it about the Americas and Africa that made the spread of food production more difficult there than in Eurasia?

To ANSWER THIS question, let's begin by examining the rapid spread of food production out of Southwest Asia (the Fertile Crescent). Soon after food production arose there, somewhat before 8000 B.C., a centrifugal wave of it appeared in other parts of western Eurasia and North Africa farther and farther removed from the Fertile Crescent, to the west and east. On this page I have redrawn the striking map (Figure 10.2) assembled by the geneticist Daniel Zohary and botanist Maria Hopf, in which they illustrate how the wave had reached Greece and Cyprus and the Indian subcontinent by 6500 B.C., Egypt soon after 6000 B.C., central Europe by 5400 B.C., southern Spain by 5200 B.C., and Britain around 3500 B.C. In each of those areas, food production was initiated by some of the same suite of domestic plants and animals that launched it in the Fertile Crescent. In addition, the Fertile Crescent package penetrated Africa southward to Ethiopia at some still-uncertain date. However, Ethiopia also developed many indigenous crops, and we do not yet know whether it was these crops or the arriving Fertile Crescent crops that launched Ethiopian food production.

The spread of Fertile Crescent crops across western Eurasia

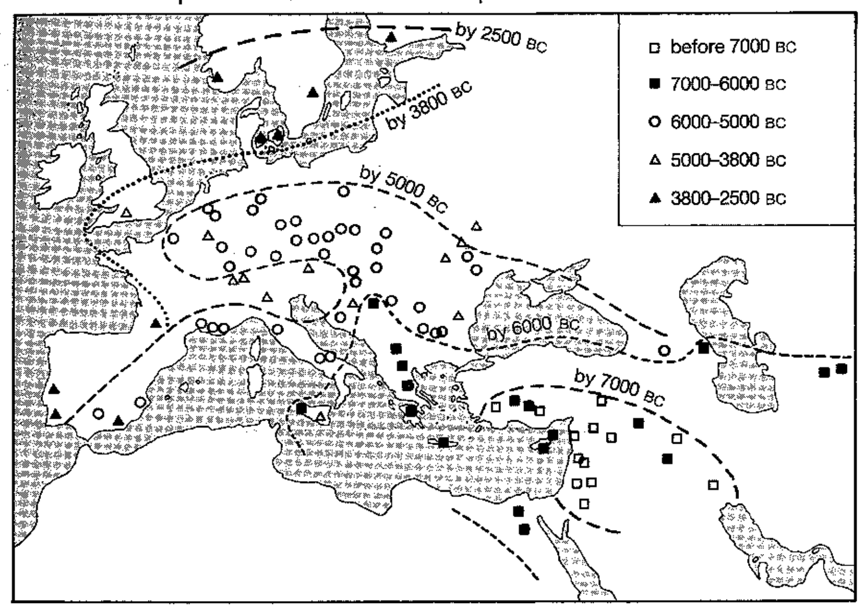

Figure 10.2. The symbols show early radiocarbon-dated sites where remains of Fertile Crescent crops have been found. □ = *the Fertile Crescent itself (sites before 7000* B.C.*). Note that dates become progressively later as one gets farther from the Fertile Crescent. This map is based on Map 20 of Zohary and Hopf's* Domestication of Plants in the Old World *but substitutes calibrated radiocarbon dates for their uncalibrated dates.*

Of course, not all pieces of the package spread to all those outlying areas: for example, Egypt was too warm for einkorn wheat to become established. In some outlying areas, elements of the package arrived at different times: for instance, sheep preceded cereals in southwestern Europe. Some outlying areas went on to domesticate a few local crops of their own, such as poppies in western Europe and watermelons possibly in Egypt. But most food production in outlying areas depended initially on Fertile Crescent domesticates. Their spread was soon followed by that of other innovations originating in or near the Fertile Crescent, including the wheel, writing, metalworking techniques, milking, fruit trees, and beer and wine production.

Why did the same plant package launch food production throughout western Eurasia? Was it because the same set of plants occurred in the wild in many areas, were found useful there just as in the Fertile Crescent, and were independently domesticated? No, that's not the reason. First, many of the Fertile Crescent's founder crops don't even occur in the wild outside Southwest Asia. For instance, none of the eight main founder crops except barley grows wild in Egypt. Egypt's Nile Valley provides an environment similar to the Fertile Crescent's Tigris and Euphrates Valleys. Hence the package that worked well in the latter valleys also worked well enough in the Nile Valley to trigger the spectacular rise of indigenous Egyptian civilization. But the foods to fuel that spectacular rise were originally absent in Egypt. The sphinx and pyramids were built by people fed on crops originally native to the Fertile Crescent, not to Egypt.

Second, even for those crops whose wild ancestor does occur outside of Southwest Asia, we can be confident that the crops of Europe and India were mostly obtained from Southwest Asia and were not local domesticates. For example, wild flax occurs west to Britain and Algeria and east to the Caspian Sea, while wild barley occurs east even to Tibet. However, for most of the Fertile Crescent's founding crops, all cultivated varieties in the world today share only one arrangement of chromosomes out of the multiple arrangements found in the wild ancestor; or else they share only a single mutation (out of many possible mutations) by which the cultivated varieties differ from the wild ancestor in characteristics desirable to humans. For instance, all cultivated peas share the same recessive gene that prevents ripe pods of cultivated peas from spontaneously popping open and spilling their peas, as wild pea pods do.

Evidently, most of the Fertile Crescent's founder crops were never domesticated again elsewhere after their initial domestication in the Fertile Crescent. Had they been repeatedly domesticated independently, they would exhibit legacies of those multiple origins in the form of varied chromosomal arrangements or varied mutations. Hence these are typical examples of the phenomenon of preemptive domestication that we discussed above. The quick spread of the Fertile Crescent package preempted any possible other attempts, within the Fertile Crescent or elsewhere, to domesticate the same wild ancestors. Once the crop had become available, there was no further need to gather it from the wild and thereby set it on the path to domestication again.

Repeated domestication = multiple people taking seeds from same field and planting it in different places (not spreading crop w/ common ancestors)

The ancestors of most of the founder crops have wild relatives, in the Fertile Crescent and elsewhere, that would also have been suitable for domestication. For example, peas belong to the genus *Pisum,* which consists of two wild species: *Pisum sativum,* the one that became domesticated to yield our garden peas, and *Pisum fulvum,* which was never domesticated. Yet wild peas of *Pisum fulvum* taste good, either fresh or dried, and are common in the wild. Similarly, wheats, barley, lentil, chickpea, beans, and flax all have numerous wild relatives besides the ones that became domesticated. Some of those related beans and barleys were indeed domesticated independently in the Americas or China, far from the early site of domestication in the Fertile Crescent. But in western Eurasia only one of several potentially useful wild species was domesticated—probably because that one spread so quickly that people soon stopped gathering the other wild relatives and ate only the crop. Again as we discussed above, the crop's rapid spread preempted any possible further attempts to domesticate its relatives, as well as to redomesticate its ancestor.

WHY WAS THE spread of crops from the Fertile Crescent so rapid? The answer depends partly on that east–west axis of Eurasia with which I opened this chapter. Localities distributed east and west of each other at the same latitude share exactly the same day length and its seasonal variations. To a lesser degree, they also tend to share similar diseases, regimes of temperature and rainfall, and habitats or biomes (types of vegetation). For example, Portugal, northern Iran, and Japan, all located at about the same latitude but lying successively 4,000 miles east or west of each other, are more similar to each other in climate than each is to a location lying even a mere 1,000 miles due south. On all the continents the habitat type known as tropical rain forest is confined to within about 10 degrees latitude of the equator, while Mediterranean scrub habitats (such as California's chaparral and Europe's maquis) lie between about 30 and 40 degrees of latitude.

But the germination, growth, and disease resistance of plants are adapted to precisely those features of climate. Seasonal changes of day length, temperature, and rainfall constitute signals that stimulate seeds to germinate, seedlings to grow, and mature plants to develop flowers, seeds, and fruit. Each plant population becomes genetically programmed, through natural selection, to respond appropriately to signals of the seasonal regime under which it has evolved. Those regimes vary greatly with latitude. For example, day length is constant throughout the year at the equator, but at temperate latitudes it increases as the months advance from the winter solstice to the summer solstice, and it then declines again through the next half of the year. The growing season—that is, the months with temperatures and day lengths suitable for plant growth—is shortest at high latitudes and longest toward the equator. Plants are also adapted to the diseases prevalent at their latitude.

Woe betide the plant whose genetic program is mismatched to the latitude of the field in which it is planted! Imagine a Canadian farmer foolish enough to plant a race of corn adapted to growing farther south, in Mexico. The unfortunate corn plant, following its Mexico-adapted genetic program, would prepare to thrust up its shoots in March, only to find itself still buried under 10 feet of snow. Should the plant become genetically reprogrammed so as to germinate at a time more appropriate to Canada—say, late June—the plant would still be in trouble for other reasons. Its genes would be telling it to grow at a leisurely rate, sufficient only to bring it to maturity in five months. That's a perfectly safe strategy in Mexico's mild climate, but in Canada a disastrous one that would guarantee the plant's being killed by autumn frosts before it had produced any mature corn cobs. The plant would also lack genes for resistance to diseases of northern climates, while uselessly carrying genes for resistance to diseases of southern climates. All those features make low-latitude plants poorly adapted to high-latitude conditions, and vice versa. As a consequence, most Fertile Crescent crops grow well in France and Japan but poorly at the equator.

Animals too are adapted to latitude-related features of climate. In that respect we are typical animals, as we know by introspection. Some of us can't stand cold northern winters with their short days and characteristic germs, while others of us can't stand hot tropical climates with their own characteristic diseases. In recent centuries overseas colonists from cool northern Europe have preferred to emigrate to the similarly cool climates of North America, Australia, and South Africa, and to settle in the cool highlands within equatorial Kenya and New Guinea. Northern Europeans who were sent out to hot tropical lowland areas used to die in droves of diseases such as malaria, to which tropical peoples had evolved some genetic resistance.

That's part of the reason why Fertile Crescent domesticates spread west and east so rapidly: they were already well adapted to the climates of the regions to which they were spreading. For instance, once farming crossed from the plains of Hungary into central Europe around 5400 B.C., it spread so quickly that the sites of the first farmers in the vast area from Poland west to Holland (marked by their characteristic pottery with linear decorations) were nearly contemporaneous. By the time of Christ, cereals of Fertile Crescent origin were growing over the 8,000-mile expanse from the Atlantic coast of Ireland to the Pacific coast of Japan. That west–east expanse of Eurasia is the largest land distance on Earth.

Thus, Eurasia's west–east axis allowed Fertile Crescent crops quickly to launch agriculture over the band of temperate latitudes from Ireland to the Indus Valley, and to enrich the agriculture that arose independently in eastern Asia. Conversely, Eurasian crops that were first domesticated far from the Fertile Crescent but at the same latitudes were able to diffuse back to the Fertile Crescent. Today, when seeds are transported over the whole globe by ship and plane, we take it for granted that our meals are a geographic mishmash. A typical American fast-food restaurant meal would include chicken (first domesticated in China) and potatoes (from the Andes) or corn (from Mexico), seasoned with black pepper (from India) and washed down with a cup of coffee (of Ethiopian origin). Already, though, by 2,000 years ago, Romans were also nourishing themselves with their own hodgepodge of foods that mostly originated elsewhere. Of Roman crops, only oats and poppies were native to Italy. Roman staples were the Fertile Crescent founder package, supplemented by quince (originating in the Caucasus); millet and cumin (domesticated in Central Asia); cucumber, sesame, and citrus fruit (from India); and chicken, rice, apricots, peaches, and foxtail millet (originally from China). Even though Rome's apples were at least native to western Eurasia, they were grown by means of grafting techniques that had developed in China and spread westward from there.

While Eurasia provides the world's widest band of land at the same latitude, and hence the most dramatic example of rapid spread of domesticates, there are other examples as well. Rivaling in speed the spread of the Fertile Crescent package was the eastward spread of a subtropical package that was initially assembled in South China and that received additions on reaching tropical Southeast Asia, the Philippines, Indonesia, and New Guinea. Within 1,600 years that resulting package of crops (including bananas, taro, and yams) and domestic animals (chickens, pigs, and dogs) had spread more than 5,000 miles eastward into the tropical Pacific to reach the islands of Polynesia. A further likely example is the east-west spread of crops within Africa's wide Sahel zone, but paleobotanists have yet to work out the details.

CONTRAST THE EASE of east–west diffusion in Eurasia with the difficulties of diffusion along Africa's north–south axis. Most of the Fertile Crescent founder crops reached Egypt very quickly and then spread as far south as the cool highlands of Ethiopia, beyond which they didn't spread. South Africa's Mediterranean climate would have been ideal for them, but the 2,000 miles of tropical conditions between Ethiopia and South Africa posed an insuperable barrier. Instead, African agriculture south of the Sahara was launched by the domestication of wild plants (such as sorghum and African yams) indigenous to the Sahel zone and to tropical West Africa, and adapted to the warm temperatures, summer rains, and relatively constant day lengths of those low latitudes.

Similarly, the spread southward of Fertile Crescent domestic animals through Africa was stopped or slowed by climate and disease, especially by trypanosome diseases carried by tsetse flies. The horse never became established farther south than West Africa's kingdoms north of the equator. The advance of cattle, sheep, and goats halted for 2,000 years at the northern edge of the Serengeti Plains, while new types of human economies and livestock breeds were being developed. Not until the period A.D. 1–200, some 8,000 years after livestock were domesticated in the Fertile Crescent, did cattle, sheep, and goats finally reach South Africa. Tropical African crops had their own difficulties spreading south in Africa, arriving in South Africa with black African farmers (the Bantu) just after those Fertile Crescent livestock did. However, those tropical African crops could never be transmitted across South Africa's Fish River, beyond which they were stopped by Mediterranean conditions to which they were not adapted.

The result was the all-too-familiar course of the last two millennia of South African history. Some of South Africa's indigenous Khoisan peoples (otherwise known as Hottentots and Bushmen) acquired livestock but remained without agriculture. They became outnumbered and were replaced northeast of the Fish River by black African farmers, whose southward spread halted at that river. Only when European settlers arrived by sea in 1652, bringing with them their Fertile Crescent crop package, could agriculture thrive in South Africa's Mediterranean zone. The collisions of all those peoples produced the tragedies of modern South Africa: the quick decimation of the Khoisan by European germs and guns; a century of wars between Europeans and blacks; another century of racial oppression; and now, efforts by Europeans and blacks to seek a new mode of coexistence in the former Khoisan lands.

CONTRAST ALSO THE ease of diffusion in Eurasia with its difficulties along the Americas' north–south axis. The distance between Mesoamerica and South America—say, between Mexico's highlands and Ecuador's—is only 1,200 miles, approximately the same as the distance in Eurasia separating the Balkans from Mesopotamia. The Balkans provided ideal growing conditions for most Mesopotamian crops and livestock, and received those domesticates as a package within 2,000 years of its assembly in the Fertile Crescent. That rapid spread preempted opportunities for domesticating those and related species in the Balkans. Highland Mexico and the Andes would similarly have been suitable for many of each other's crops and domestic animals. A few crops, notably Mexican corn, did indeed spread to the other region in the pre-Columbian era.

But other crops and domestic animals failed to spread between Mesoamerica and South America. The cool highlands of Mexico would have provided ideal conditions for raising llamas, guinea pigs, and potatoes, all domesticated in the cool highlands of the South American Andes. Yet the northward spread of those Andean specialties was stopped completely by the hot intervening lowlands of Central America. Five thousand years after llamas had been domesticated in the Andes, the Olmecs, Maya, Aztecs, and all other native societies of Mexico remained without pack animals and without any edible domestic mammals except for dogs.

Conversely, domestic turkeys of Mexico and domestic sunflowers of the eastern United States might have thrived in the Andes, but their southward spread was stopped by the intervening tropical climates. The mere 700 miles of north–south distance prevented Mexican corn, squash, and beans from reaching the U.S. Southwest for several thousand years after their domestication in Mexico, and Mexican chili peppers and chenopods never did reach it in prehistoric times. For thousands of years after corn was domesticated in Mexico, it failed to spread northward into eastern North America, because of the cooler climates and shorter growing season prevailing there. At some time between A.D. 1 and A.D. 200, corn finally appeared in the eastern United States but only as a very minor crop. Not until around A.D. 900, after hardy varieties of corn adapted to northern climates had been developed, could corn-based agriculture contribute to the flowering of the most complex Native American society of North America, the Mississippian culture—a brief flowering ended by European-introduced germs arriving with and after Columbus.

Recall that most Fertile Crescent crops prove, upon genetic study, to derive from only a single domestication process, whose resulting crop spread so quickly that it preempted any other incipient domestications of the same or related species. In contrast, many apparently widespread Native American crops prove to consist of related species or even of genetically distinct varieties of the same species, independently domesticated in Mesoamerica, South America, and the eastern United States. Closely related species replace each other geographically among the amaranths, beans, chenopods, chili peppers, cottons, squashes, and tobaccos. Different varieties of the same species replace each other among the kidney beans, lima beans, the chili pepper *Capsicum annuum / chinense,* and the squash *Cucurbita pepo*. Those legacies of multiple independent domestications may provide further testimony to the slow diffusion of crops along the Americas' north–south axis.

Africa and the Americas are thus the two largest landmasses with a predominantly north–south axis and resulting slow diffusion. In certain other parts of the world, slow north–south diffusion was important on a smaller scale. These other examples include the snail's pace of crop exchange between Pakistan's Indus Valley and South India, the slow spread of South Chinese food production into Peninsular Malaysia, and the failure of tropical Indonesian and New Guinean food production to arrive in prehistoric times in the modern farmlands of southwestern and southeastern Australia, respectively. Those two corners of Australia are now the continent's breadbaskets, but they lie more than 2,000 miles south of the equator. Farming there had to await the arrival from faraway Europe, on European ships, of crops adapted to Europe's cool climate and short growing season.

I HAVE BEEN dwelling on latitude, readily assessed by a glance at a map, because it is a major determinant of climate, growing conditions, and ease of spread of food production. However, latitude is of course not the only such determinant, and it is not always true that adjacent places at the same latitude have the same climate (though they do necessarily have the same day length). Topographic and ecological barriers, much more pronounced on some continents than on others, were locally important obstacles to diffusion.

For instance, crop diffusion between the U.S. Southeast and Southwest was very slow and selective although these two regions are at the same latitude. That's because much of the intervening area of Texas and the southern Great Plains was dry and unsuitable for agriculture. A corresponding example within Eurasia involved the eastern limit of Fertile Crescent crops, which spread rapidly westward to the Atlantic Ocean and eastward to the Indus Valley without encountering a major barrier. However, farther eastward in India the shift from predominantly winter rainfall to predominantly summer rainfall contributed to a much more delayed extension of agriculture, involving different crops and farming techniques, into the Ganges plain of northeastern India. Still farther east, temperate areas of China were isolated from western Eurasian areas with similar climates by the combination of the Central Asian desert, Tibetan plateau, and Himalayas. The initial development of food production in China was therefore independent of that at the same latitude in the Fertile Crescent, and gave rise to entirely different crops. However, even those barriers between China and western Eurasia were at least partly overcome during the second millennium B.C., when West Asian wheat, barley, and horses reached China.

By the same token, the potency of a 2,000-mile north–south shift as a barrier also varies with local conditions. Fertile Crescent food production spread southward over that distance to Ethiopia, and Bantu food production spread quickly from Africa's Great Lakes region south to Natal, because in both cases the intervening areas had similar rainfall regimes and were suitable for agriculture. In contrast, crop diffusion from Indonesia south to southwestern Australia was completely impossible, and diffusion over the much shorter distance from Mexico to the U.S. Southwest and Southeast was slow, because the intervening areas were deserts hostile to agriculture. The lack of a high-elevation plateau in Mesoamerica south of Guatemala, and Mesoamerica's extreme narrowness south of Mexico and especially in Panama, were at least as important as the latitudinal gradient in throttling crop and livestock exchanges between the highlands of Mexico and the Andes.

Continental differences in axis orientation affected the diffusion not only of food production but also of other technologies and inventions. For example, around 3,000 B.C. the invention of the wheel in or near Southwest Asia spread rapidly west and east across much of Eurasia within a few centuries, whereas the wheels invented independently in prehistoric Mexico never spread south to the Andes. Similarly, the principle of alphabetic writing, developed in the western part of the Fertile Crescent by 1500 B.C., spread west to Carthage and east to the Indian subcontinent within about a thousand years, but the Mesoamerican writing systems that flourished in prehistoric times for at least 2,000 years never reached the Andes.

Naturally, wheels and writing aren't directly linked to latitude and day length in the way crops are. Instead, the links are indirect, especially via food production systems and their consequences. The earliest wheels were parts of ox-drawn carts used to transport agricultural produce. Early writing was restricted to elites supported by food-producing peasants, and it served purposes of economically and socially complex food-producing societies (such as royal propaganda, goods inventories, and bureaucratic record keeping). In general, societies that engaged in intense exchanges of crops, livestock, and technologies related to food production were more likely to become involved in other exchanges as well.

America's patriotic song "America the Beautiful" invokes our spacious skies, our amber waves of grain, from sea to shining sea. Actually, that song reverses geographic realities. As in Africa, in the Americas the spread of native crops and domestic animals was slowed by constricted skies and environmental barriers. No waves of native grain ever stretched from the Atlantic to the Pacific coast of North America, from Canada to Patagonia, or from Egypt to South Africa, while amber waves of wheat and barley came to stretch from the Atlantic to the Pacific across the spacious skies of Eurasia. That faster spread of Eurasian agriculture, compared with that of Native American and sub-Saharan African agriculture, played a role (as the next part of this book will show) in the more rapid diffusion of Eurasian writing, metallurgy, technology, and empires.

To bring up all those differences isn't to claim that widely distributed crops are admirable, or that they testify to the superior ingenuity of early Eurasian farmers. They reflect, instead, the orientation of Eurasia's axis compared with that of the Americas or Africa. Around those axes turned the fortunes of history.