DOMESTICABLE ANIMALS ARE ALL ALIKE; EVERY UNDOMESTICABLE ANIMAL IS UNDOMESTICABLE IN ITS OWN WAY. If you think you've already read something like that before, you're right. Just make a few changes, and you have the famous first sentence of Tolstoy's great novel *Anna Karenina*: "Happy families are all alike; every unhappy family is unhappy in its own way." By that sentence, Tolstoy meant that, in order to be happy, a marriage must succeed in many different respects: sexual attraction, agreement about money, child discipline, religion, in-laws, and other vital issues. Failure in any one of those essential respects can doom a marriage even if it has all the other ingredients needed for happiness.

This principle can be extended to understanding much else about life besides marriage. We tend to seek easy, single-factor explanations of success. For most important things, though, success actually requires avoiding many separate possible causes of failure. The *Anna Karenina* principle explains a feature of animal domestication that had heavy consequences for human history—namely, that so many seemingly suitable big wild mammal species, such as zebras and peccaries, have never been domesticated and that the successful domesticates were almost exclusively Eurasian. Having in the preceding two chapters discussed why so many wild plant species seemingly suitable for domestication were never domesticated, we shall now tackle the corresponding question for domestic mammals.

IN CHAPTER 4 we reminded ourselves of the many ways in which big domestic mammals were crucial to those human societies possessing them. Most notably, they provided meat, milk products, fertilizer, land transport, leather, military assault vehicles, plow traction, and wool, as well as germs that killed previously unexposed peoples. In addition, of course, small domestic mammals and domestic birds and insects have also been useful to humans. Many birds were domesticated for meat, eggs, and feathers: the chicken in China, various duck and goose species in parts of Eurasia, turkeys in Mesoamerica, guinea fowl in Africa, and the Muscovy duck in South America. Wolves were domesticated in Eurasia and North America to become our dogs used as hunting companions, sentinels, pets, and, in some societies, food. Rodents and other small mammals domesticated for food included the rabbit in Europe, the guinea pig in the Andes, a giant rat in West Africa, and possibly a rodent called the hutia on Caribbean islands. Ferrets were domesticated in Europe to hunt rabbits, and cats were domesticated in North Africa and Southwest Asia to hunt rodent pests. Small mammals domesticated as recently as the 19th and 20th centuries include foxes, mink, and chinchillas grown for fur and hamsters kept as pets. Even some insects have been domesticated, notably Eurasia's honeybee and China's silkworm moth, kept for honey and silk, respectively. Many of these small animals thus yielded food, clothing, or warmth. But none of them pulled plows or wagons, none bore riders, none except dogs pulled sleds or became war machines, and none of them have been as important for food as have big domestic mammals. Hence the rest of this chapter will confine itself to the big mammals.

THE IMPORTANCE of domesticated mammals rests on surprisingly few species of big terrestrial herbivores. (Only terrestrial mammals have been domesticated, for the obvious reason that aquatic mammals were difficult to maintain and breed until the development of modern Sea World. If one defines "big" as "weighing over 100 pounds," then only 14 such species were domesticated before the twentieth century (see Table 9.1 for a list). Of those Ancient Fourteen, 9 (the "Minor Nine" of Table 9.1) became important livestock for people in only limited areas of the globe: the Arabian camel, Bactrian camel, llama/alpaca (distinct breeds of the same ancestral species), donkey, reindeer, water buffalo, yak, banteng, and gaur. Only 5 species became widespread and important around the world. Those Major Five of mammal domestication are the cow, sheep, goat, pig, and horse. This list may at first seem to have glaring omissions. What about the African elephants with which Hannibal's armies crossed the Alps? What about the Asian elephants used as work animals in Southeast Asia today? No, I didn't forget them, and that raises an important distinction. Elephants have been tamed, but never domesticated. Hannibal's elephants were, and Asian work elephants are, just wild elephants that were captured and tamed; they were not bred in captivity. In contrast, a domesticated animal is defined as an animal selectively bred in captivity and thereby modified from its wild ancestors, for use by humans who control the animal's breeding and food supply. That is, domestication involves wild animals' being transformed into something more useful to humans. Truly domesticated animals differ in various ways from their wild ancestors. These differences result from two processes: human selection of those individual animals more useful to humans than other individuals of the same species, and automatic evolutionary responses of animals to the altered forces of natural selection operating in human environments as compared with wild environments.

We already saw in Chapter 7 that all of these statements also apply to plant domestication. The ways in which domesticated animals have diverged from their wild ancestors include the following. Many species changed in size: cows, pigs, sheep became smaller under domestication, while guinea pigs became larger. Sheep and alpacas were selected for retention of wool and reduction or loss of hair, while cows have been selected for high milk yields. Several species of domestic animals have smaller brains and less developed sense organs than their wild ancestors, because they no longer need the bigger brains and more
developed sense organs on which their ancestors depended to escape from wild predators. To appreciate the changes that developed under domestication, just

| TABLE 9.1 The Ancient Fourteen Species of Big Herbivorous Domestic Mammals |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **The Major Five**              | **The Minor Nine**              |
| 1. **Sheep**                    | 6. **Arabian (one-humped) camel** | 11. **Water buffalo**          |
| Wild ancestor: the Asiatic mouflon sheep of West and Central Asia. Now worldwide. | Wild ancestor: now extinct, formerly lived in Arabia and adjacent areas. Still largely restricted to Arabia and northern Africa, though feral in Australia. | Wild ancestor lives in Southeast Asia. Still used as a domestic animal mainly in that area, though many are also used in Brazil and others have escaped to the wild in Australia and other places. |
| Wild ancestor: the bezoar goat of West Asia. Now worldwide. | Wild ancestor: the wild boar, distributed over Eurasia and North Africa. Now worldwide. Actually an omnivore (regularly eats both animal and plant food), whereas the other 13 of the Ancient Fourteen are more strictly herbivores. | 13. **Bali cattle**: Wild ancestor: the banteng (a relative of the aurochs) of Southeast Asia. Still confined as a domestic animal to that area. |
| 3. **Cow, alias ox or cattle**: Wild ancestor: the now extinct aurochs, formerly distributed over Eurasia and North Africa. Now worldwide. | 8. **Llama and alpaca**: These appear to be well-differentiated breeds of the same species, rather than different species. Wild ancestor: the guanaco of the Andes. Still largely confined to the Andes, although some are bred as pack animals in North America. | 14. **Mithan**: Wild ancestor: the gaur (another relative of the aurochs) of Indian and Burma. Still confined as a domestic animal to that area. |
| 4. **Pig**                      | 9. **Donkey**: Wild ancestor: the African wild ass of North Africa and formerly perhaps the adjacent area of Southwest Asia. Originally confined as a domestic animal to North Africa and western Eurasia, more recently also used elsewhere. | |
| Wild ancestor: the wild boar, distributed over Eurasia and North Africa. Now worldwide. | Wild ancestor: the reindeer of northern Eurasia. Still largely confined as a domestic animal to that area, though now some are also used in Alaska. | |
| 5. **Horse**: Wild ancestor: now extinct wild horses of southern Russia; a different subspecies of the same species survived in the wild to modern times as Przewalski's horse of Mongolia. Now worldwide. | 10. **Reindeer** | |

compare wolves, the wild ancestors of domestic dogs, with the many breeds of dogs. Some dogs are much bigger than wolves (Great Danes), while others are much smaller (Pekingese). Some are slimmer and built for racing (greyhounds), while others are short-legged and useless for racing (dachshunds). They vary enormously in hair form and color, and some are even hairless. Polynesians and Aztecs developed dog breeds specifically raised for food. Comparing a dachshund with a wolf, you wouldn't even suspect that the former had been derived from the latter if you didn't already know it.

THE WILD ANCESTORS of the Ancient Fourteen were spread unevenly over the globe. South America had only one such ancestor, which gave rise to the llama and alpaca. North America, Australia, and sub-Saharan Africa had none at all. The lack of domestic mammals indigenous to sub-Saharan Africa is especially astonishing, since a main reason why tourists visit Africa today is to see its abundant and diverse wild mammals. In contrast, the wild ancestors of 13 of the Ancient Fourteen (including all of the Major Five) were confined to Eurasia. (As elsewhere in this book, my use of the term "Eurasia" includes in several cases North Africa, which biogeographically and in many aspects of human culture is more closely related to Eurasia than to sub-Saharan Africa.) Of course, not all 13 of these wild ancestral species occurred together throughout Eurasia. No area had all 13, and some of the wild ancestors...
were quite local, such as the yak, confined in the wild to Tibet and adjacent highland areas. However, many parts of Eurasia did have quite a few of these 13 species living together in the same area: for example, seven of the wild ancestors occurred in Southwest Asia. This very unequal distribution of wild ancestral species among the continents became an important reason why Eurasians, rather than peoples of other continents, were the ones to end up with guns, germs, and steel.

How can we explain the concentration of the Ancient Fourteen in Eurasia? One reason is simple. Eurasia has the largest number of big terrestrial wild mammal species, whether or not ancestral to a domesticated species. Let's define a "candidate for domestication" as any terrestrial herbivorous or omnivorous mammal species (one not predominantly a carnivore) weighing on the average over 100 pounds (45 kilograms)....Eurasia has the most candidates, 72 species, just as it has the most species in many other plant and animal groups. That's because Eurasia is the world's largest landmass, and it's also very diverse ecologically, with habitats ranging from extensive tropical rain forests, through temperate forests, deserts, and marshes, to equally extensive tundras. Sub-Saharan Africa has fewer candidates, 51 species, just as it has fewer species in most other plant and animal groups—because it's smaller and ecologically less diverse than Eurasia. Africa has smaller areas of tropical rain forest than does Southeast Asia, and no temperate habitats at all beyond latitude 37 degrees. As I discussed in Chapter 1, the Americas may formerly have had almost as many candidates as Africa, but most of America's big wild mammals (including its horses, most of its camels, and other species likely to have been domesticated had they survived) became extinct about 13,000 years ago. Australia, the smallest and most isolated continent, has always had far fewer species of big wild mammals than has Eurasia, Africa, or the Americas. Just as in the Americas, in Australia all of those few candidates except the red kangaroo became extinct around the time of the continent's first colonization by humans.

Thus, part of the explanation for Eurasia's having been the main site of big mammal domestication is that it was the continent with the most candidate species of wild mammals to start out with, and lost the fewest candidates to extinction in the last 40,000 years. But the numbers... warn us that that's not the whole explanation. It's also true that the percentage of candidates actually domesticated is highest in Eurasia (18 percent), and is especially low in sub-Saharan Africa (no species domesticated out of 51 candidates!). Particularly surprising is the large number of species of African and American mammals that were never domesticated, despite their having Eurasian close relatives or counterparts that were domesticated. Why were Eurasia's horses domesticated, but not Africa's zebras? Why Eurasia's pigs, but not American peccaries or Africa's three species of true wild pigs? Why Eurasia's five species of wild cattle (aurochs, water buffalo, yak, gaur, banteng), but not the African buffalo or American bison? Why the Asian mouflon sheep (ancestor of our domestic sheep), but not North American bighorn sheep?

DID ALL THOSE peoples of Africa, the Americas, and Australia, despite their enormous diversity, nonetheless share some cultural obstacles to domestication not shared with Eurasian peoples? For example, did Africa's abundance of big wild mammals, available to kill by hunting, make it superfluous for Africans to go to the trouble of tending domestic stock? The answer to that question is unequivocal: No! The interpretation is refuted by five types of evidence: rapid acceptance of Eurasian domesticates by non-Eurasian peoples, the universal human penchant for keeping pets, the rapid domestication of the Ancient Fourteen, the repeated independent domestimations of some of them, and the limited successes at further domestimations... IN ALL, OF the world's 148 big wild terrestrial herbivorous mammals—the candidates for domestication—only 14 passed the test. Why did the other 134 species fail? To which conditions was Francis Galton referring, when he spoke of those other species as "destined to perpetual wildness"? The answer follows from the Anna Karenina principle. To be domesticated, a candidate wild species must possess many different characteristics. Lack of any single required characteristic dooms efforts at domestication, just as it dooms efforts at building a happy marriage. Playing marriage counselor to the zebra/human couple and other ill-sorted pairs, we can recognize at least six groups of reasons for failed domestication.

Diet. Every time that an animal eats a plant or another animal, the conversion of food biomass into the consumer's biomass involves an efficiency of much less than 100 percent: typically around 10 percent. That is, it takes around 10,000 pounds of corn to grow a 1,000-pound cow. If instead you want to grow 1,000 pounds of carnivore, you have to feed it 10,000 pounds of herbivore grown on 100,000 pounds of corn. Even among herbivores and omnivores, many species, like koalas, are too finicky in their plant preferences to recommend themselves as farm animals. As a result of this fundamental inefficiency, no mammalian carnivore has ever been domesticated for food...

Growth Rate. To be worth keeping, domesticates must also grow quickly. That eliminates gorillas and elephants, even though they are vegetarians with admirably non-finicky food preferences and represent a lot of meat. What would-be gorilla or elephant rancher would wait 15 years for his herd to reach adult size? Modern Asians who want work elephants find it much cheaper to capture them in the wild and tame them.

Problems of Captive Breeding. We humans don't like to have sex under the watchful eyes of others; some potentially valuable animal species don't like to, either. ..

Nasty Disposition. Naturally, almost any mammal species that is sufficiently large is capable of killing a human. People have been killed by pigs, horses, camels, and cattle. Nevertheless, some large animals have much nastier dispositions and are more incurably dangerous than are others. Tendencies to kill humans have disqualified many otherwise seemingly ideal candidates for domestication...
Tendency to Panic. Big mammalian herbivore species react to danger from predators or humans in different ways. Some species are nervous, fast, and programmed for instant flight when they perceive a threat. Other species are slower, less nervous, seek protection in herds, stand their ground when threatened, and don’t run until necessary. Most species of deer and antelope (with the conspicuous exception of reindeer) are of the former type, while sheep and goats are of the latter. Naturally, the nervous species are difficult to keep in captivity. If put into an enclosure, they are likely to panic, and either die of shock or batter themselves to death against the fence in their attempts to escape…

Social Structure. Almost all species of domesticated large mammals prove to be ones whose wild ancestors share three social characteristics: they live in herds; they maintain a well-developed dominance hierarchy among herd members; and the herds occupy overlapping home ranges rather than mutually exclusive territories…

Let’s now return to the problem I posed at the outset of this chapter. Initially, one of the most puzzling features of animal domestication is the seeming arbitrariness with which some species have been domesticated while their close relatives have not. It turns out that all but a few candidates for domestication have been eliminated by the Anna Karenina principle. Humans and most animal species make an unhappy marriage, for one or more of many possible reasons: the animal’s diet, growth rate, mating habits, disposition, tendency to panic, and several distinct features of social organization. Only a small percentage of wild mammal species ended up in happy marriages with humans, by virtue of compatibility on all those separate counts. Eurasian peoples happened to inherit many more species of domesticable large wild mammalian herbivores than did peoples of the other continents. That outcome, with all of its momentous advantages for Eurasian societies, stemmed from three basic facts of mammalian geography, history, and biology. First, Eurasia, befitting its large area and ecological diversity, started out with the most candidates. Second, Australia and the Americas, but not Eurasia or Africa, lost most of their candidates in a massive wave of late-Pleistocene extinctions—possibly because the mammals of the former continents had the misfortune to be first exposed to humans suddenly and late in our evolutionary history, when our hunting skills were already highly developed. Finally, a higher percentage of the surviving candidates proved suitable for domestication on Eurasia than on the other continents. An examination of the candidates that were never domesticated, such as Africa’s big herd-forming mammals, reveals particular reasons that disqualified each of them. Thus, Tolstoy would have approved of the insight offered in another context by an earlier author, Saint Matthew: “Many are called, but few are chosen.”

Questions after reading this section:

1. What is the Anna Karenina principal, and how does Jared Diamond apply this principal to the domestication of mammals?

2. Summarize, in your own words, Diamond’s explanation for why Eurasia was the site of big mammal domestication. Include three (3) specific examples of evidence that proves his point.
ON THE MAP OF THE WORLD (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 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

Figure 10.1. Major axes of the continents.
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…

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 re-domestications of the same species or domestizations of close relatives. What was it about the Americas and Africa that made the spread of food production more difficult there than in Eurasia?
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 before 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.

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* and related species, 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.

3. Why did food production spread at different rates on different continents?
4. What was it about the Americas and Africa that made the spread so difficult?

5. What impact did this difference have on the development of the Americas and Africa?

6. Summarize the main idea of the entire reading here in approximately 250 words. What have you learned after reading these chapters? How does this influence or change what you know about world history?