



OUT
OF THE
EARTH

**CIVILIZATION
AND THE LIFE
OF THE SOIL**
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*We must, however, acknowledge,
as it seems to me, that man with
all his noble qualities . . . still
bears . . . the indelible stamp of
his lowly origin.*

CHARLES DARWIN, *The Descent of Man*

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HUMAN ORIGINS

HISTORY DOES NOT merely resurrect a dead past. In the words of Thucydides: "Knowledge of the past is an aid to interpretation of the future." If we can truly learn from past experience, we may be better able to improve our current use of the environment. If we focus our attention exclusively upon the predicaments of the moment, however, we may find ourselves repeatedly surprised by a host of bewildering problems seeming to come out of nowhere, without a past and hence without direction. How did these problems arise? Chances are, the seeds of the phenomena we witness today were planted some time ago by our predecessors, as indeed we are planting the seeds of the future—perhaps unknowingly—at this very moment.

The story of mankind begins more than three million years ago, when a genus of primates evolved to the point where it became recognizably humanoid.¹ Partly because of the baffling course of evolution itself, though, it is difficult to ascribe an exact age to humankind as it gradually diverged from its primate progenitors. Over extended periods of time, biological evolution appears to proceed very slowly by a long series of small, almost imperceptible, changes. Then, periodically, thresholds are

reached that trigger seemingly sudden transformations. Such transformations may be due to chance occurrences of genetic mutations, or to shifts in environmental conditions, or—more likely—to combinations or sequences of these. Genetic and environmental changes may conjoin to trigger an unusually rapid preferential selection, and the consequent emergence, of a new biological type endowed with traits more advantageous than those of its predecessors. Analogous rapid transformations have also occurred in human cultural evolution.

Any attempt to describe the early course of humankind is thwarted by the fact that the very definition of what constitutes true humanity is somewhat arbitrary. Ever since Charles Darwin first elaborated on the possible circumstances of human origin in his 1871 book, *The Descent of Man*, anthropologists have been speculating on the sequence of events that gradually brought about the astonishing metamorphosis of a tree-dwelling, quadrupedal, herbivorous ape into a ground-dwelling, bipedal, tool-making, omnivorous hominid. A crucial step appears to have been the shift from four-legged to two-legged locomotion (bipedalism). This was followed by further structural and functional evolution. The eyes were adapted to stereoscopic vision for judging distances. The hands, preconditioned to grasp branches with an opposing thumb, later developed a capability for the precision grip used in making and employing tools. All the while, the brain grew in size and function as it developed the ability to process more information and to generate complex logical thoughts.

Various hypotheses have been advanced regarding the origin of hominid bipedalism and all that followed. Such hypotheses, no matter how plausible, are virtually impossible to test or to prove conclusively. A long-held popular notion was that the evolutionary shift was induced by the need of an otherwise defenseless "ape" to make and use tools and weapons for hunting and for protection against predators. This notion accords with the idea that the principal effect of walking on two feet was to liberate the hands for the performance of tasks and the acquisition of skills that would have been impossible otherwise.

Other investigators view the origin of bipedalism as a means by which hominids could cover a larger territory in foraging for dispersed plant foods. This idea fits into the context of hominids occupying a more open environment than the dense forests to which primates were initially adapted. The environmental change may have been due to a shift of climate—leading to a partial drying of the original habitat—that apparently took place during the later stages of the Cenozoic era. According to this view, developing the facility to walk and run over the land on two legs, with an upright posture allowing a longer view of the landscape, was an ape's adaptation to living where apes do not normally live. Still others suppose that bipedalism developed for long-distance trekking to scavenge from migrating ungulate herds, like those now found in the Serengeti Plains of Tanzania. This supposition is consistent with the recent perception that, in addition to gathering plant products, the very early hominids might have engaged more in scavenging than in hunting as a means of subsistence. Whatever motivated or triggered the transition to bipedalism, it proved to be irreversible, and its ultimate consequences were fateful for the subsequent course of humankind.

Our species' birthplace was apparently in the continent of Africa, and its original habitat was probably the subtropical savannas which constitute the transitional areas of sparsely wooded grasslands lying between the zone of the humid and dense tropical forests and the zone of the semiarid steppes. We can infer the warm climate of our place of origin from the fact that we are naturally so scantily clad, or furless; and we can infer the open landscape from the way we are conditioned to walk, run, and gaze over long distances.

Fossil discoveries in East Africa during recent decades have revealed facts that have added dramatically to our knowledge of human origins. Skeletal finds suggest a succession of primate and hominid types starting several million years ago and progressively approaching the structure that is definitely characteristic of humans. Evidence seems to suggest that the beginnings of stone tool-making followed the origin of bipedalism by more

than a million years. The earliest known hominid capable of a striding bipedal gait and a precision grip (circa 3.75 million years ago) was discovered in Tanzania and in Ethiopia, and has been named *Australopithecus afarensis*. Fossils of one of its presumed descendants, a tool-making hominid called *Australopithecus africanus*, were found in deposits dated some 2.5 million years ago in Sterkfontein cave in South Africa. In time, the tools made by hominids had developed into distinct, consistent implements for cutting, scraping, and grinding foods, including plant products such as nuts and grains, and animal products (flesh, skins, and bones). Such implements were needed to compensate for the inherent inadequacy of hominid teeth and jaws to support the changing life style of the wide-ranging animal that eventually evolved into the genus called *Homo*.

For at least 90 percent of its career, the human animal existed merely as one member of a community of numerous species who shared the same environment. Humans were adapted to subsist within the bounds defined by the natural ecosystem: they neither dominated other species nor brought about any fundamental modification of the common environment. By and large, our ancestors led a nomadic life, roaming in small bands, foraging wherever they could find food. They were gatherers, scavengers, and hunters. Unlike their primate cousins who remained primarily vegetarian, humans diversified their diet to include the flesh of whichever edible animals they could find or catch, as well as a variety of plant products such as nuts, berries and other fruits, seeds, and some succulent leaves, bulbs, tubers, and fleshy roots.

The story of how humans ascended from their humble apelike origins to venture far from their birthplace, and range over a variety of climates and landscapes, is a remarkable saga of audacity, ingenuity, perseverance, and adaptability. In fact, humans have proved to be the most adaptable of all terrestrial mammals. Their mode of adaptation was not entirely genetic or physical: there was not enough time for that. Rather, their adaptation was in large part behavioral. Instead of relying on physical prowess, they had to use inventiveness to survive the elements and

to compete successfully against stronger animals. In the course of their migration and expansion, our ancient forebears therefore had to develop and mobilize all the cunning and intelligence that eventually made them—and us—so unique a species. The increase of brain size and manual dexterity, as well as the invention of various stratagems, gradually enabled humans to overcome the constraints of their ancestry.

By 1 million years ago, hominids had become taller (about 1.5 meters in height), and had acquired a larger brain. Some time later, so-called *Homo erectus* had learned to make and use fire, probably at first only for cooking and softening food. That achievement, following upon the development of stone tools, was a momentous technical innovation, celebrated in the Greek myth of Prometheus. Eventually, it had a great effect on the environment. Some evidence has been found in Southern and Eastern Africa of repetitive occurrences of brush fires, apparently set by humans nearly a million years ago. This early manifestation of pyrotechnology, whether purposeful or accidental, signifies the beginning of human manipulation of the earth's ecosystems. The use of fire became even more important when humans moved out of the tropics into colder climes, where bonfires and hearths were needed to warm their shelters in winter.

By about 250,000 B.P. (Before the Present), humans had evolved into the type that anthropologists call *Homo sapiens*, and had spread to Europe and Asia. Though this geographic migration could not have been a consistent expansion, as it must have been influenced by the alternating glacial and interglacial cycles of the Pleistocene age, it eventually spread humans throughout those continents. (There is no evidence that people had arrived in the Americas, or in Australia, until about 40,000 B.P.) Some time before 50,000 B.P., a race of humans called Neanderthals, who lived during the last Ice Age, were making cutting tools with flaked flint. By about 40,000 years ago, modern humans (*Homo sapiens sapiens*), evidently indistinguishable from us today in physical features and in intelligence, had gained dominance.

Clad in sewn garments made of animal skins, able to make

and use a variety of implements, and armed with a growing array of weapons—including spears and bows and arrows—humans were able to range and settle in locations and climates far from their ancestral home. All the while they continued to evolve biologically through genetic change and natural selection, increasingly aided by cultural and technological development. To survive the harsh winters of colder climates, they had to find or construct shelters, and to huddle in family or tribal groupings for mutual assistance and the rearing of their slow-growing offspring. In their leisure time, they painted animals on cave walls and carved ritual objects. They also had to contrive increasingly sophisticated methods of obtaining and storing foods, including the selective gathering, processing, and preservation of biological products, and eventually the domestication of plants and animals.

This series of changes has been termed the Paleolithic (Early Stone Age) Transformation.² It was marked by the development of adaptive mechanisms for recognizing and exploiting potentialities within the environment. Utilizing and further refining their distinct physical, intellectual, and social abilities, our ancestors increasingly set themselves apart from other species of animals. Gradually, as they continued to elaborate and perfect their tools of wood, bone, and stone, as well as their techniques and social organization, humans assumed an increasingly active and eventually dominant role in shaping their environment. Each modification of the environment entailed additional human responses, which in turn further modified the environment, so that a process of escalating dual metamorphosis was instigated. Human intelligence and culture were both cause and effect in that fateful interplay. The peculiarly dynamic and progressive evolution of human ecology is the true history of our species.³

At some point, humans began to use fires deliberately and systematically to flush out game and to modify the vegetation. The resultant suppression of woody plants and the fertilizing effect of ash encouraged the growth of herbaceous plants and improved their nutritional quality. This benefited foraging species and raised the carrying capacity for game animals. It also facilitated foot travel and hunting by humans. In time, the

practice of clearing woodlands and shrublands by repeated firings also set the stage for the advent of agriculture.

The practice of burning vegetation, along with the increasing skill of humans as hunters, may have contributed to the extinction of several large herbivores, which had no effective defense against their fire-setting and weapon-wielding two-legged predators. In North America, for example, two-thirds of the mammalian megafauna (species with adults weighing 50 kilograms or more) present at the end of the Pleistocene era (circa 11,000 B.P.) disappeared, including 3 genera of elephants and 15 of ungulates. In Eurasia, the losses included the woolly mammoth, woolly rhinoceros, giant Irish elk, musk ox, dwarf elephant, and steppe bison. It is impossible to state definitively, however, to what extent these extinctions may have been caused (or affected) by climatic changes. In Northwestern Europe, the same practice of forest burning is suspected of having resulted in the development of heathlands and bogs. Areas in North America also seem to have been fire-managed by pre-Columbian Indians.

In Australia, the intentional maintenance of grasslands and open woodlands by periodic burnings was a regular practice of the hunter-gatherer aborigines. In the Cape York Peninsula, there is evidence that the aborigines used repeated firings to eradicate the original vegetation and to encourage the preferential growth of cycad trees, which yield edible kernels. Further into the interior of Australia, the aborigines used fire for hunting, land clearing, communication, and domestic purposes. The animals flushed out by the flames could be captured more easily. In the southern part of Australia, a high fire-frequency apparently helped to convert the original climax forest* of beech trees into a heath or tussock grassland.⁴

As vegetation is affected by fire-setting hunters, so are soils. Following repeated fires and deforestation, soil erosion and landslides often result in the greatly increased transport of silt by

* A climax forest is a community of trees and associated species that has attained stability (equilibrium) within its environment. This is, of course, not an absolute definition, as in time climates shift, species evolve, and the environment changes.

streams, and in the deposit of that silt in river valleys and estuaries. The dating of fluvial sediments in river valleys in England, for example, suggests that they were the products of erosion caused by anthropogenic clearings in the originally closed deciduous forest during the Late Paleolithic period.

The fact that pre-agricultural people caused substantial changes in their environments does not necessarily imply that they were *always* destructive. Not all changes are inevitably deleterious—only those that create unsustainable conditions and result in progressive degradation. The mere substitution of one type of vegetation for another may even be beneficial in the long run, provided the new landscape is more productive and at least equally sustainable. The problem, however, is that it is ever easier to set fire to dry vegetation than to predict, let alone control, the consequences of the resultant conflagration, which is likely to be destructive if repeated too often.

The gradual intensification of land use continued throughout the Paleolithic period, so that by its later stages nearly all the regions of human habitation had experienced some anthropogenic modification of the floral and faunal communities. At some stage, humans began to delineate sections of the environment which they could control and manage to suit their special needs, and in which they could find convenient and secure shelters for at least temporary habitation. They recognized nutritional and medicinal plants, observed their life cycles, and learned to encourage and take advantage of their natural propagation patterns. They learned to build rafts and boats of various types and thereby to exploit aquatic resources. As they became more mobile, the rivers and lakes that were once barriers became arteries of travel and transport. They developed implements for grinding and cooking vegetable and animal products, and weapons for hunting larger game animals. Success in these endeavors provided them with the leisure to develop social and cultural activities: music, dances, rituals, ceremonies, storytelling, rites of passage, creative arts, and the crafting of useful and decorative articles. Their success also brought about a growth in population, which in turn induced further geographic expansion and intensification of land use in quest of additional sources of livelihood.

*In toil shalt thou eat of the earth all
the days of thy life.*

GENESIS 3:17

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THE AGRICULTURAL TRANSFORMATION

THE BIBLICAL STORY describing the banishment of Adam and Eve from the Garden of Eden may be taken to symbolize humanity's transformation from the carefree "child of nature" hunting-gathering-wandering phase of existence to a life of toil and responsibility as permanently bound tillers of the soil. The actual initiation of settlement appears to have begun in the Late Paleolithic (sometimes called Mesolithic) period that preceded the advent of farming by several thousand years. On finding a particularly favorable location, a clan of humans would naturally tend to prolong its stay there so as to take advantage of its favorable conditions. Those conditions might include an assured supply of water, a relative abundance of game or of edible plant resources, access to useful raw materials such as flint or wood, a benign climate or shelter against inclement weather, as well as safety or protection against potential enemies.

The process of intensification of land use can be seen as an adaptation to increasing population pressure. Several millennia of occupation by hunter-gatherers, even at a very low density and slow rate of population growth, could have filled up the terrain and decimated the natural forageable resources to the

point where subsistence could become difficult.¹ The choice would then be between migration and some form of intensification aimed at inducing the same area to yield a greater supply. Free hunting would be supplanted by manipulative hunting, based on the use of fire to modify the vegetation, or of various stratagems to lure and trap a greater number of animals. The next step would be the selective eradication of undesirable species and the encouragement of desirable ones, leading eventually to herding and domestication. Similarly, selective manipulation of plant communities would involve suppressing some species and promoting the growth of others. The entire series of activities would quite logically lead to plant domestication and propagation, and to purposeful land and soil management aimed at creating favorable conditions for crop production—that is to say, these activities would culminate in the development of agriculture and the agricultural way of life.²

The Agricultural Transformation is very likely the most momentous turn in the progress of humankind, and many believe it to be the real beginning of civilization.³ Often called the Neolithic Revolution, this transformation apparently first took place in the Near East between 10,000 and 8,000 years ago, and was based on the successful domestication of suitable species of plants and animals. The ability to raise crops and livestock, while resulting in a larger and more secure supply of food, definitely required attachment to controllable sections of land, and hence brought about the growth of permanent settlements and of larger coordinated communities. The economic and physical security so gained accelerated the process of population growth, and necessitated further expansion and intensification of production. A self-reinforcing and self-perpetuating pattern thus developed, so the transition from the nomadic hunter-gatherer mode to the settled farming mode of life became in effect irreversible.⁴

Compared to the long period of two or more million years during which our ancestors were hunters and gatherers, the brief interval of two thousand or so years required to accomplish the Agricultural Transformation over most of the region known as the Near East seems almost instantaneous. But why did humans suddenly give up their long natural existence as hunters and

gatherers, to which they were so thoroughly adapted by evolution, both physically and culturally? What impelled them to join together in larger and larger groups, thus presaging the densely packed and often unhealthful cities that ultimately became the characteristic mode of life in much of the modern world? How did the sedentary life become so universally appealing that it was so quickly adopted by people in practically all regions of the world? And why did this momentous transformation first take place in the Near East of all regions? What was the natural setting in which the fateful change was initiated? These are questions to which we still have only partial answers.

Clearly, the old stereotypic portrayal of the Late-Paleolithic pre-agricultural people as ignorant savages is erroneous. We have much evidence, both historical and derived from present-day hunter-gatherers, to prove that their understanding of the environment within which they lived was sophisticated indeed. No doubt they knew a great deal about the life cycles of plants and animals, for instance, as their livelihood depended on that knowledge. In a real sense, therefore, they were professional botanists and zoologists.

Contemporary or recent hunter-gatherers, such as the Bushmen of Southern Africa, the Panare of Amazonian Venezuela, the Dinka of the Sudanese Sudd, and the aborigines of Australia, still maintain and utilize the rich lore amassed by countless generations of their forebears. They know not only how to distinguish nutritious plants from those that are non-nutritious or poisonous, and how to detoxify harmful vegetable products, but also how to use plant-derived drugs, narcotics, arrow poisons, gums and resins, glues, dyes and paints, as well as fibers for spinning ropes and for weaving mats, baskets, and cloth. Thus the reason they did not, for so long, choose to take up agriculture is either that they had no need to do so or that local conditions were not conducive. As long as the population remained low enough so that the carrying capacity of the habitat was not exceeded, humans could continue to subsist as gatherers and hunters and were under no compulsion to change their traditional mode of life.

Some anthropologists and prehistorians have argued that



semi-nomadic hunting and gathering in small bands was an easier and healthier lifestyle than permanent farming, so the transition to the latter may actually have been disadvantageous, rather than immediately advantageous as it has often been portrayed. Reliance on farming imposed a monotonous diet of grain and a few other edible crops, instead of the rich and varied nutrition which could be obtained by hunting and gathering. Furthermore, life in larger groups residing in dense settlements increased the incidence and spread of contagious diseases, and may thus have shortened the average longevity. The contrary and still the more prevalent view is that the advent of agriculture ensured a supply of food, and freed humans from the need to roam endlessly over the countryside in search of edible wild plants and animal prey. Moreover, since the early farmers domesticated animals as well as plants, their diet may have been no worse, and in some cases better, than that of hunter-gatherers. Finally, stable communities provided more secure conditions for rearing children.

Notwithstanding the arguable disadvantages of the original Agricultural Transformation, the fact remains that this change did occur, that it was rather rapid, and that it was essentially irreversible. Hence, *ipso facto*, it must have been advantageous overall, though it certainly created its own problems. There must have been something in the condition of humans that impelled that transformation once it became possible. That something may well have been an antecedent increase in human population density following the use of tools, weapons, and techniques that had increased the efficiency of hunting and gathering to the point where human groups were depleting the supply of game animals and edible wild plants within the areas available to them.

The advent of farming itself could not have been a sudden discovery or invention by some individual genius. Rather, it must have been the culmination of a long series of observations and trials by numerous generations of humans transmitting and augmenting their experience and methods, until the knowledge, technology, and circumstances were ripe for the seminal transformation.

Although agriculture seems to have been developed first in the Near East, that region is by no means the sole center of crop and animal domestication. At different stages, separate and very likely independent developments took place in other centers, each with its own selection of crops. Among these centers are Sub-Saharan Africa, East Asia (China), Southeast Asia and Oceania, and the Americas.

The process of plant domestication and the evolution of crop plants from their wild progenitors is a fascinating topic of study, made progressively more difficult by the globally accelerating destruction of natural habitats and of native plant communities. By domesticating plants and developing crops, humans created biological artifacts that could no longer thrive autonomously without constant care.⁵ Reciprocally, humans had become so dependent on their crops that, in effect, their crops had domesticated them.

The domestication of animals occurred as a consequence of hunting, not necessarily in conjunction with the domestication of plants. Consequently, the herding of animals and the husbandry of crops were in some places complementary, and in other places divergent, activities. The benefits of animal domestication were obvious—secure supplies of meat, milk, fur, leather, wool, and even bones and horns for tool-making. Animal manure could serve to fertilize crops. Larger animals could also assist in the performance of laborious tasks and in transportation. However, the cost in terms of human labor was high. Human herders needed not only to feed and breed their animals and to confine them to prevent their escape, but also to protect them against predators, diseases, and climatic vagaries. This required a level of planning, commitment, and consistency never before undertaken by humans. Consequently, both the domesticated animals and their keepers developed a mutual dependency.

Pastoralists were able to exploit niches marginal to the agricultural zone, like patches of scrub and grass at the edges of fields and paths, as well as semiarid hill lands peripheral to the river valleys that became the centers of cultivation. Such extensive utilization of patchy and seasonal pastures required moving the animals periodically from one place to another, either from a

permanent base, or by moving the human abode along with the animals—a mode called transhumance. The roving pattern of grazing could become especially extensive in drought-prone regions, where the sparse growth of forage, and the paucity of water, require graziers to roam almost constantly in search of sustenance for their flocks, thus assuming a nomadic life.

As agriculturists, human beings began to affect their environment to a greater degree than ever before.⁶ They cleared away the natural flora and fauna from selected tracts, and in their place introduced and nurtured the species or varieties of plants and animals they preferred. By so doing, they modified the natural ecosystems of increasingly large areas, until they eventually altered entire regions. Their success, as measured in terms of population growth, was considerable, but this success sometimes resulted in the practically irreparable degradation of the once-bountiful environment in which agricultural development began.

The Agricultural Transformation radically changed almost every aspect of human life. Food production and storage stimulated specialization of activities, and greatly enhanced the division of labor which had already started in hunting-gathering societies. The larger permanent communities based on agriculture required new forms of organization, both social and economic. Domestication undoubtedly affected family structure and the roles and status of men, women, and children. With permanent facilities such as dwellings, storage bins, heavy tools, and agricultural fields came the concept of property. Specifically, private ownership of land may well have originated with the advent of agriculture. So also might have the private ownership of springs and other water resources. The inevitably uneven allocation of such property resulted in self-perpetuating class differences. Religious myths and rituals, as well as moral and behavioral standards, developed in accordance with the new economic and social constellation and the new relationship between human society and the environment.

The evolution of agriculture has left a strong imprint on the land in many regions. The vegetation, animal populations,

slopes, valleys, and soil cover of land units have all been altered. The processes of tillage and fallowing, of terracing, of irrigation, and drainage have had considerable consequences for such processes as the erosion of slopes and the aggradation of valleys, as well as the formation of deltas in seas and lakes where silt from the land surface naturally comes to rest. Soil lost from deforested and subsequently cultivated slopes is unlikely to be regenerated unless the land is allowed to revert to its forest cover for many scores, perhaps even many hundreds, of years.

Pastoralism, as well as cultivated farming, can cause a great deal of environmental damage. During dry seasons, when large numbers of animals are kept on pastures least able to sustain them, the land is denuded of its vegetation and made most vulnerable to the erosive onslaught of winds and of violent rainstorms that may occur at the end of the dry period. If overgrazing continues over a long period of time, the environmental damage can be profound. In antiquity, shepherds in the fringe-lands of the Mediterranean region were notorious as plunderers of land. Though they must have tried, as do present-day pastoralists, to maintain a rough equilibrium between stocking rates (the number of animals grazed on a unit area of pasture) and the average carrying capacity of the range, that equilibrium could only be maintained as long as the range remained more or less stable. However, such a system would naturally break down during periods of drought, when the pressure on the shriveled vegetation would soon become excessive. To survive during such periods, the pastoralists would have had no recourse but to invade the land of the neighboring farmers. The ancient enmity between these groups has long been legendary and implacable, as it still is today in some semiarid regions.

Two or three millennia after the initial Agricultural Transformation, there began a further process of fundamental change; namely, the process of urbanization.⁷ It was made possible by the very success of agriculture, as the people involved directly in farming produced surpluses beyond their subsistence needs. These surpluses could then support the artisans, traders, priests, administrators, and kings who resided in the cities. The develop-

70 ment of cities was not merely an increase in the size of settlements, but a qualitative change in the structure of society and its relationship to the environment. Today most of us belong to urbanized societies and live in cities quite detached from the land and its natural ecosystems.

The artificial environment of our cities owes many of its features to the early cities developed five thousand years ago in lowland Mesopotamia, and then elsewhere in the Near East. Among numerous innovations attributable to these early cities are writing, formal codes of law, political and ecclesiastical hierarchies, craft specialization, monumental art, mass-production industries, metallurgy, mathematics, scientific and engineering principles, architecture, large-scale trade, and organized warfare in the form both of massive defensive fortifications and long-distance offensive campaigns. The scale and intensity of land and water management in the agricultural hinterlands serving the cities had to change accordingly.

*A land of wheat and barley, vines,
fig trees and pomegranates,
A land of oil olives and honey;
A land wherein thou shalt eat
bread without scarceness.*

DEUTERONOMY 8:8-9

10 EARLY FARMING IN THE NEAR EAST

THE PROCESS OF DEVELOPING a dependable food-producing system was a complex sequence of steps, starting with an initially extensive gathering economy that tended to become increasingly intensive, and culminating in a complete revolution in human society and its management of the environment. An essential step in that process was the selection of favorable wild plants in their natural habitats and their domestication and transformation into artificially propagated crops, to be grown at will in areas that might be far removed from their place of origin.

The end of the Pleistocene and the beginning of the Holocene era (some 10-12 thousand years ago) was a time of great climatic transition. The last ice age ended and a warming trend prevailed. Areas that had been cold and inhospitable in centuries past burst forth with a profusion of plants and animals that responded to the longer and warmer growing seasons. Having survived the vicissitudes of the ice age, doubtlessly thanks to their growing ingenuity and acquired skills, humans now found themselves in a more auspicious ecological situation, in which they could not only survive but even prosper and multiply.

In the Near East, they found a particularly favorable region

for subsistence and habitation. Evidence of this early habitation, the so-called Natufian culture (12,000 to 10,000 B.P.), has been found by archaeologists in the hills of modern Israel. The Natufians were apparently the first hunter-gatherers to make the transition to permanent settlement.¹ Though they continued to live off the native (albeit modified) environment rather than cultivate crops, they were apparently the forerunners of the earliest farmers. The Natufians built elaborate stone houses, had food preparation areas with mortars and pestles, and maintained storage facilities for the wild grain that they collected. Numerous potential crops grew wild on these relatively humid mountains, hills, and valleys. As people gathered the edible grains, fruits, nuts, stalks, leaves, or bulbous roots of these various plants, they observed their mode of growth and learned much about their propagation.

Prominent among the native plant resources of the Near East were wild species and varieties of the graminæ (grass-related) and leguminosæ families, whose seeds could be collected and stored to provide food for several months.² Most native plants scatter their seeds as soon as they mature, and are therefore difficult to harvest efficiently. A few anomalous plants, however, due to chance mutations, retain their seeds. The discovery and preferential selection of such seeds, and their propagation in favorable plots of land, constituted the real beginnings of agriculture, providing the early farmers with crops that could be harvested more uniformly and dependably than could the wild plants.³

The most important of the early crop domesticates were the annual cereal grains: barley and especially wheat, along with various leguminous grains, such as lentils, peas, chickpeas, and vetch. As settlements and villages acquired permanence, several fruit-bearing trees (which require years to mature) could also be domesticated. These included figs, olives, and dates, as well as grapes, pomegranates, and almonds. The earliest animal domesticates were sheep, goats, pigs, dogs, and cattle.

The progenitors of the region's cereal crops—namely, wild emmer wheat, wild einkorn wheat, and wild barley—evidently originated in the broad arc of uplands and foothills fringing

the Fertile Crescent on the west, north, and east. Whether or not any historic shift in climate might have occurred since the beginning of the Holocene and might have affected the geographic distribution of these species, it is interesting to note that stands of these plants are prevalent even today in the hills of northern Israel, Lebanon, western Syria, southern Turkey, northeastern Iraq, and western Iran. Patches of these wild cereals would surely have constituted an attractive source of food for pre-neolithic hunter-gatherers. The wild grain could easily be harvested with the flint-bladed sickles of the period. Native patches or stands of these cereals were naturally limited in size, so the people dependent on the grain would obviously wish to extend such stands, by actively helping to spread their seeds and by selectively eradicating competing vegetation.

As long as human intervention was confined merely to harvesting the wild grain, the effect would have been to encourage such wild-type characteristics as shattering rachis (the spikes connecting the seeds to the stalk) and nonuniform maturation, since it was the seeds that escaped the harvester that tended to produce the next spontaneous generation of wild grain. In contrast, the harvested batch of seeds would be selected in favor of non-shattering and uniform maturation. As soon as humans began to sow the seeds that they had harvested, they automatically—even if unintentionally—initiated a process of selection in favor of the non-shattering genotype. Each season, most of the seeds that shattered evaded the harvest, while most of the seeds that remained attached were harvested and hence tended to concentrate in the seedstock disproportionately to their prevalence in the wild. Similarly, the seeds that matured early were shed before the harvest, and those that matured late were unripe at the time of harvest, so neither contributed to the seedstock. By this process, the proportion of the non-shattering, uniformly maturing genotype was enhanced progressively until it became a dominant characteristic of the crop. Consequently, of all the adaptations that distinguish domesticated crops from their wild progenitors, the non-shattering and uniform-ripening traits are the most conspicuous.

The initial efforts at domestication probably took place close to each crop's center of origin,⁴ which in the case of the cereal grains would have been the uplands and foothills girding the Ferrile Crescent. The early farmers would naturally tend to seek a favorable plot of ground from which they could remove competing plants and in which they could conveniently sow their seeds with reasonable expectation of a worthwhile yield. Such plots were likely to be located in intermontane valleys, where the ground is relatively level and the alluvial soils are generally deep and fertile. Remnants of small Neolithic field plots have been found in some of the narrow valleys of the Carmel and Galilee ranges in Israel.

An important factor in the evolution of agriculture in the Near East, as elsewhere, was the development of the tools of soil husbandry. Seeds scattered on the ground are often eaten by birds and rodents, or subject to desiccation, so their germination rate is likely to be very low. Given a limited seed stock, farmers would naturally do whatever they could to promote germination and seedling establishment. The best way to accomplish this is to insert the seeds to some shallow depth, under a protective layer of loosened soil, and to eradicate the weeds that might compete with the crop seedlings for water, nutrients, and light.

The simplest tool developed for this purpose was a paddle-shaped digging stick, by which a farmer could make holes for seeds. The use of this simple device was extremely slow and laborious, however, so at some point the digging stick was modified to form the more convenient spade, which could not only open the ground for seed insertion but also loosen and pulverize the soil and eradicate weeds more efficiently. In time, the spade developed a triangular blade, initially made of wood but later made of stone, and eventually of metal. Such a spade, initially designed to be used by one person, was later modified so that it could be pulled by a rope so as to open a continuous slit, or furrow, into which the seeds could be sown. A second furrow could then be made alongside the first, to facilitate seed coverage. In some cases, the rows were widely enough separated

to permit a person to walk between the rows, weeding the cultivated plot.

The man-pulled traction spade or *ard* gradually metamorphosed into an animal-drawn plow. The first picture of such a plow, dating to 3000 B.C.E., was found in Mesopotamia, and numerous later pictures have been found both there and in Egypt, as well as in China. It was not long before these early plows were fitted with a seed funnel, so that the acts of plowing and sowing could be carried out simultaneously. The same ancient implement is still very much in use today throughout the Near and Middle East.⁵

Although the development of the plow represented a huge advance in terms of convenience and efficiency of operation, it had an important side effect. As with many other innovations, the benefits were immediate, but the full range of consequences took several generations to play out, long after the new practice became entrenched. The major environmental consequence was that plowing made the soil surface—now loosened, pulverized, and bared of weeds—much more vulnerable to accelerated erosion. In the history of civilization, contrary to the idealistic vision of the prophet Isaiah, the plowshare has been far more destructive than the sword.

Though perhaps slower than the effects of land clearing for cultivation, the results of herding and overgrazing are ultimately no less destructive. In addition to being the natural habitats for the wild progenitors of several of the principal cultivated grain grasses, the mountains, foothills, and valleys of the Near East also hosted wild sheep, goats, pigs, and cattle that were later domesticated. These animals are at home in ecotonal habitats where grassland, brushland, and forest interpenetrate. Here, intensified herding, especially during drought seasons, eventually became a force for the destruction of the natural vegetation on which it had originally depended. Goats not only browse their favorite shrubs but can climb right up into trees to eat the foliage, and they eagerly consume trees seedlings, so that where they are constantly herded, forests cannot regenerate. Sheep, too, can do great damage when they overgraze, since they will

eat grass, roots and all, and their sharp hooves, like those of goats, tear up the sod and pulverize the soil. Cattle, though not quite so destructive, can also overgraze, and herders often set fires to encourage the growth of grass.

As the early farming venture met with some success, the activity spread and the growing farming population could no longer be confined to the narrow intermontane valleys where agriculture apparently began. Villages were formed in the larger valleys below the foothills, and along the coastal plains of the Near East. For quite some time, villagers evidently combined localized farming with continued gathering activities and hunting forays. Increasingly, however, they became attached to their farming sites. More and more, their artifacts (grinding stones, stone mortars and pestles, ground-working and planting implements) and their installations (grain-storage pits or bins, and animal corrals) became permanent and non-transportable. Thus, the process of sedentarization, which actually began some time before the advent of agriculture, was reinforced by the vocation of farming. With permanent habitation, an important new industry could be developed—pottery, which began in the Near East about 8,000 B.P. The shaping and baking of clay to form hardened vessels for grain, for liquid storage, and for cooking, represented the first transmutation of matter by humans. Such an innovation could not have been possible, owing to the fragility of the ceramic objects, during the nomadic phase.

The Mediterranean-type climate of the Near East is at best semihumid, but more typically semiarid, with a rather high incidence of drought. Hence the practice of rainfed farming could not provide anything like total food security. The early farmers who depended only on seasonal rainfall to water their crops were always at the mercy of a capricious and highly unpredictable weather regime. The Hebrew Bible, for instance, is replete with references to the ever-present threat of drought and consequent famine. In time of need, therefore, it was only logical for farmers located near river courses to attempt to augment the water supply to their crops by artificially conveying water from the river—first by hand, and later by digging a diversion

channel. It was also logical to try to raise crops on riverine flood plains that were naturally inundated, and thereby irrigated, periodically.

At some point, then, farming was extended from the relatively humid centers of its origin toward the extensive river valleys of the Jordan, the Tigris-Euphrates, the Nile, and the Indus. As the climate of these river valleys is generally quite arid, a new type of agriculture based primarily or even entirely on irrigation came into being. With a practically assured perennial water supply, an abundance of sunshine, a year-round growing season, deep and fertile soils, and relative security from the hazards of drought and erosion that beset rainfed agriculture, irrigated agriculture became a highly productive enterprise. However, behind its success lurked an insidious problem which could not initially have been foreseen: the problem of land degradation.