CHAPTER 2

Hydraulic Civilizations (4000–1500 BCE)

The Book of Genesis in the Bible describes the third day of the Creation in these words:

> God said, "Let the water below the sky be gathered into one area, that the dry land may appear." And it was so. God called the dry land Earth, and the gathering of waters He called Seas. And God saw that this was good. And God said, "Let the earth sprout vegetation: seed-bearing plants, fruit trees of every kind on earth that bear fruit with the seed in it." And it was so. The earth brought forth vegetation: seed-bearing plants of every kind, and trees of every kind bearing fruit with the seed in it. And God saw that this was good.

We now know how this happened. Six thousand years ago, a people called Sumerians began separating land from water and planting crops in the newly reclaimed wetlands rather than relying on rainwater as Neolithic farmers had done. In doing so, they created the first civilization.

The word *civilization*, as historians and anthropologists use it, refers to large-scale societies whose members contribute taxes, labor, or tribute to the state and pay homage to their leaders. Such societies were radically different from Neolithic villages or foraging bands, whose members knew each other and were related by blood or marriage. Not only did civilizations include far more people, but they also built monuments and cities, invented writing, mathematics, and calendars, and created elaborate religions, literatures, philosophies, and other forms of culture. Some civilizations eventually collapsed or were conquered by outsiders, but others survived for millennia. In later centuries, people often looked back nostalgically to a "Golden Age" or a "Garden of Eden" before they became civilized. But once they had crossed the line, they could never return.

Unlike Neolithic villages where everyone helped provide food, in larger societies, some people performed tasks other than farming or

herding. A few were full-time religious, political, or military leaders. Some were warriors, artisans, and merchants. And others were servants to the elites or upper classes. To feed them, the farmers, herdsmen, and fishermen had to produce more food than they themselves consumed. The key to the transformation from Neolithic villages to civilizations, therefore, was the methods used to produce a surplus of food to feed those who did not farm. New and more productive farming practices went hand in hand with a radically new organization of society.

The earliest civilizations did not arise in fertile rain-watered lands in the temperate zone. Instead, they began in dry or desert regions where water came from a river, a lake, or a swamp. Farmers who grew crops on the very banks of the river or the shores of the lake or swamp were always at the mercy of devastating floods or droughts. When they succeeded in controlling the water, however, the results were spectacular. Whereas Neolithic farmers in the Middle East might hope to reap four or five grains of barley for every grain they planted on rain-watered land, in a river valley, a grain of barley receiving the right amount of water during the growing season could yield up to forty grains.

The farmers who settled closest to the rivers could depend on periodic floods to water their fields. Those who came later, however, settled further from the riverbanks. To bring water to their fields, they had to dig canals, dikes, and other earthworks. Building and maintaining these works required the labor of hundreds, even thousands, of men directed by a cadre of supervisors. Although farmers had to contribute their labor, they were not slaves driven by men with whips. People obeyed because they realized the need to work together, because of the peer pressure of their neighbors, and because they were afraid that refusing would bring down the wrath of the gods. Moreover, they knew that they had nowhere else to go. In rain-watered environments, people could wander off seeking new land, but in desert regions, survival was impossible outside the river valleys.

The place where the first civilization arose was Iraq, a land the Greeks called *Mesopotamia*, the "land between the rivers" Tigris and Euphrates. The valley has good alluvial soil but is difficult to farm. It is very hot and dry in the summer and cold and dry in the winter. Although little rain reaches the valley, in the spring water rushes down from the mountains to the east and north when the snows melt. The rivers carry a great deal of silt that gradually raises them above the surrounding plains until they overflow their banks in devastating floods. All the peoples of the region told legends of the flood, most famously the Hebrew story of Noah's Ark told in the Bible (Genesis 5–9).

To the Neolithic farmers who lived in the surrounding hills, the flood plain presented both an opportunity and a challenge. By the sixth millennium BCE, the bolder ones were moving down into the plains and building villages. By the fifth millennium, they were digging short feeder canals to irrigate their fields and drain excess water. To keep the floods from washing away their crops, they built dikes. To hold some of the water back when the floods subsided in the summer when the crops needed water the most, farmers built small reservoirs. Keeping the water flowing was a constant task because silt clogged the canals and the salt and gypsum it contained would poison the fields if they were not properly drained. As the population grew, farmers drained marshes and built canals and reservoirs ever farther from the rivers, requiring ever larger work crews. Success depended on good leadership and the cooperative work of thousands.

By carefully watering the rich alluvial soil, farmers grew an abundance of barley, wheat, and date palms, along with lentils, beans, peas, onions, and reeds, out of which they built houses and boats. They raised sheep, goats, donkeys, cattle, and pigs and caught fish in the canals. There was more than enough for the farmers and herders to eat. After 3500 BCE, villages in the wetlands of southern Iraq grew into towns, and towns grew into cities. The techniques used by the Sumerians gradually spread up the rivers and to the outer edges of the valley. After 2000 BCE, farmers began watering their fields with a *shaduf,* or "well-sweep," a long pole with a bucket at one end and a counterweight at the other. Instead of using a hoe or a digging stick as their ancestors had, they cultivated their fields with an ox-drawn plow and planted seeds with a seed drill, a device that dropped seeds at regular intervals. This shift from horticulture to true agriculture produced much greater yields. Under the direction of their rulers, gangs of laborers dug canals up to 75 feet wide and many miles in length. The most famous of their kings, the lawgiver Hammurabi who reigned from 1792 to 1750 BCE, named one of his canals "Hammurabi-spells-abundance."

Egypt was an easy land to farm compared with Mesopotamia. The Nile flooded its valley in late summer and early fall, after the harvest. Unlike the Tigris and Euphrates, the timing of the Nile flood was predictable, and the silt its waters carried was fertile and salt-free. The Egyptians built low dikes that divided the land into basins, letting water stand for about a month to deposit its silt and soak the soil before it was allowed to flow downstream to the delta of the Nile. Crops were planted in October or November and harvested in April or May, before the next flood.

Neolithic peoples had inhabited the Nile Valley for centuries, farming on the riverbanks and hunting and fishing the wild game in which the land abounded. In the fourth millennium BCE, Egypt was divided into little kingdoms, each of which had a "water house" that planned the building of dikes and the soaking of the fields. In the early third millennium, after lower and upper Egypt were united under the Pharaoh Menes, engineers installed what we call nilometers, devices that measured the height of the river. The regularity of the floods led them to devise a 365¼-day calendar. When they saw Sirius, the brightest star, rising in the dawn sky in line with the rising sun, they knew the flood was imminent. They also developed surveying instruments and a practical geometry to help them place boundary stones to mark the edges of fields and irrigation basins. They used shadufs and other devices such as pulleys and treadmills to lift water above the level of canals. The resulting food surpluses not only supported the creation of the elaborate culture and awe-inspiring monuments for which ancient Egypt has always been famous, but they also produced the most secure and sustainable civilization the world has ever known—one that lasted, with only brief interruptions, for 3,000 years.

Thirteen hundred miles east of Mesopotamia, the Indus River flows through Sind, now a province of Pakistan. The environment of the Indus Valley was similar to that of Mesopotamia, with a rich soil, a hot, dry climate, and a violent river that periodically flooded the plain. Unfortunately, we know far less about the civilization that arose there than about Sumer or Egypt because the few writings that have survived have not yet been deciphered. We know that the organization of flood control in the valley began between 3200 and 2600 BCE. Villagers dug irrigation and drainage canals and built embankments to control the floods and protect their settlements. They grew wheat and barley and traded these crops with nearby nomadic tribes for metals, semiprecious stones, timber, sheep, and goats. They also traded with the peoples of Sumer and the Arabian Peninsula, as evidenced by pieces of Indus pottery and metal objects found in both places. Some time after 1700 BCE, for reasons we do not fully understand, the population shrank, water control was abandoned, and the cities of the Indus Valley were destroyed by floods.

The distinctive cultures of Egypt and the Indus Valley were inspired by the example of nearby Mesopotamia. In China, Mexico, and Peru, three different agricultural systems developed quite independently of outside influences. The earliest center of civilization in East Asia appeared on the plains of northeastern China, along the

Yellow River. The land there was exceptionally fertile, composed of *loess*, windblown and waterborne silt that was soft enough to cultivate with digging sticks. On average, rainfall was adequate for agriculture, unlike the river valleys of Mesopotamia, the Nile, and the Indus, and farmers could plant dry-land crops such as millet and wheat. Some years, however, drought parched the land. Worse were the years when too much rain fell on the mountains of central Asia. Then the Yellow River became so laden with silt (hence its name) that it built up its bed above the flood plain and then broke through its natural embankments in raging floods that swept everything in their path. That is why the Chinese people call it "China's sorrow."

By the fourth millennium, Neolithic farmers were clearing the forests and building dikes, channels, and reservoirs to control the waters of the Yellow River. But to protect the inhabitants and support a growing population, better flood control was needed. King Yu, founder of the legendary Xia dynasty, is credited with the first large-scale flood-control project in China, around the year 2200 BCE. During the Shang dynasty (ca. 1600 to ca. 1046 BCE), the first one for which we have evidence in the form of pot shards, walls, and other remains, the Yellow River plain was dotted with thousands of villages whose inhabitants grew millet and wheat, raised pigs and silkworms, and made pottery. Above them ruled an aristocracy of warriors who supervised the engineering projects, built cities, and fought with their neighbors.

If China was almost cut off from other early civilizations, the Americas were completely isolated. Thus, the Native Americans proceeded at their own pace, undisturbed by outside influences until Columbus arrived in 1492. On their own, albeit much later, they created impressive civilizations similar in many ways to those of the Old World, based on water control in similar environments.

As in the Old World, ecological conditions varied from one part of the Americas to another, and so did the methods people devised to make best use of the land and the water. Six thousand years ago, the inhabitants of Mexico began growing maize, beans, squash, and chili peppers and raising dogs and turkeys. There were no large animals that could be domesticated, however, so all work had to be done by humans. By 2000 BCE, villages dotted the landscape of central Mexico, supporting trade between the different ecological zones.

The most spectacular water control system in the Americas, perhaps in the world, was that found in the Valley of Mexico. There, streams from the surrounding mountains fed a series of shallow lakes. On the edges of these lakes, especially Texcoco and Xochimilco, farmers created

chinampas, rectangular islands 300 feet long by 15 to 30 feet wide, separated by canals. They did this by dredging up mud from the bottom of the canals and dumping it onto rectangular plots. To keep the soil from washing away, they put up reed barriers and planted willows. Periodically, they added layers of fresh mud and floating vegetation from the canals, thereby keeping the soil fertile. Seeds were sprouted in nurseries and then carefully planted in the chinampas. The abundant fresh water, fertile soil, warm climate, and constant labor allowed the *chinamperos* to grow up to seven crops a year. Each acre of chinampas produced enough food for five or six people, a yield unmatched anywhere else on earth. The earliest chinampas date from the first century BCE, if not earlier. As the population of the valley grew, more and more wetlands were turned into chinampas. In the first eight centuries CE, they supported Teotihuacán, the largest city in the Americas. Even after the fall of Teotihuacán and the rise of the Toltec and Aztec Empires, farmers continued to reclaim land from the lakes.

In the fourteenth century CE, a small tribe called Aztecs took refuge on an island in Lake Texcoco. There, they built the city of Tenochtitlán and proceeded to construct the most elaborate hydraulic engineering project in the Americas. To prevent the salt-laden waters of eastern Lake Texcoco from harming the chinampas to the west of the city during the annual spring floods, they built a ten-mile-long dike across the lake, with gates to control the level of the water. To supply the chinampas and the city with fresh water, they tapped springs in the nearby hills and constructed aqueducts and causeways to the island. Hernán Cortés, who led the Spanish expedition that conquered Mexico in 1519–1521, wrote:

> Along one of the causeways to this great city run two aqueducts made of mortar. Each one is two paces wide and some six feet deep, and along one of them a stream of very good fresh water, as wide as a man's body, flows into the heart of the city and from this they all drink. The other, which is empty, is used when they wish to clean the first channel. When the aqueducts cross the bridges, the water passes along some channels which are as wide as an ox; and so they serve the whole city.[1]

By 1500 CE, on the eve of the Spanish invasion, chinampas covered almost 30,000 acres, providing food for a city of more than 100,000 inhabitants, one of the largest and wealthiest in the world at the time.

In the same period as the rise of civilization in Mexico, another arose along the west coast of South America, where three distinct ecological zones lie in close proximity. The first was the highlands and foothills of the Andes, a region that was cold but received enough rain to

The city of Tenochtitlán, capital of the Aztec Empire, was built on an island in Lake Texcoco. Surrounded by water, Tenochtitlán was so impregnable that the first Spanish attempt to take it ended in failure. In their second attempt, the Spaniards were able to take the city by building boats. Bildarchiv Preussischer Kulturbesitz/Art Resource, NY

grow crops. There, people domesticated llamas, which provided meat and a coarse wool and could be used as pack animals, and alpacas, a smaller species that gave a finer wool. They also cultivated the potato and a grain called quinoa. The second zone was the waters off the coast of Peru. Among the richest fishing grounds in the world, they provided a livelihood to fishermen as far back as 1500 BCE. The third zone was the narrow coastal plain. Although one of the driest regions on earth, it is intersected by rivers that come down from the Andes. Along the banks of the rivers, farmers grew warm-climate crops, such as maize, beans, squash, and cotton. From very early on, the inhabitants of the three zones traded with one another.

Around 1900 BCE, people living along the coastal rivers began digging canals, some of them more than 50 miles long, to bring water and nutrient-rich silt to ever-larger areas of land. Farmers also learned to fertilize their fields with *guano*, the droppings of sea birds that had accumulated for centuries along the coast. In the highlands, farmers built elaborate terraces to grow crops on steep hillsides. The Moche state conquered most of the coastal valleys around 200 BCE and flourished for 800 years, supported by an active trade among the farmers in the rich irrigated lowlands, the herders and farmers of the highlands, and the fishermen along the coast. After 600 CE, the Moche were replaced by two rival civilizations: the Tiwanaku in the southern highlands around Lake Titicaca and the Chimu along the northern coast. By the time the Chimu were overthrown in the 1460s, irrigation canals brought water to millions of acres in more than 60 coastal valleys.

The hydraulic engineering projects of these early civilizations both required and supported large populations. But these civilizations are also known for their building projects and for a rich diversity of crafts that could be produced only by specialists living in settled environments. As Stonehenge and other megaliths attest, the urge to build existed before civilizations arose. But in Neolithic times, such construction took many years because the need to obtain food left the inhabitants with little spare time. In the early civilizations, in contrast, the productivity of agriculture provided a food surplus that could be used to feed construction workers. Furthermore, the habits of cooperation and obedience that came from working together on massive hydraulic engineering projects could be directed by the elites to political and religious construction projects as well.

The earliest building projects undertaken by the Sumerians were temples and cities. They used little wood and no stone but made bricks out of clay and straw and let them dry in the sun. With these sun-dried bricks,

they built *ziggurats*, pyramidal towers containing temples, storerooms, and workshops. Baked bricks, too costly for ordinary construction, were used only for decoration. Each temple complex needed professional priests and artisans, merchants, and servants. Cities grew to tens of thousands of inhabitants; the first was Ubaid, built before 4000 BCE.

Land close to a source of water was so valuable that it led to disputes between neighboring cities. As wars broke out, there arose a class of professional warriors supported, like the priests and their retinues, by the surplus from the farms. Wars forced Mesopotamian cities to surround themselves with high walls and gates with heavy doors that could be closed at night or in the event of an attack.

The Egyptians were more fortunate than the peoples of Mesopotamia, for the Nile Valley is bordered by cliffs of good limestone. Stone temples and palaces have survived for thousands of years, whereas ordinary houses, built of sun-dried bricks, quickly melted back into the ground if they were not carefully maintained. The most spectacular constructions in the world, the pyramids of Giza, are almost as good as new after 5,000 years: Khufu, the largest, is 481 feet high and covers

The Sphinx and the great pyramids of Giza are awesome evidence of the ancient Egyptians' mastery of masonry construction. The Sphinx of Giza, carved out of the limestone bedrock, is the largest single-stone statue in the world. Library of Congress LOT 13550, no. 34 [P&P]

13.5 acres; Khafre is almost as huge; and Menkaure is one-third the size of its two great neighbors.

For what purpose were these enormous monuments built? The usual answer is that they were tombs for Pharaohs. Yet one of the earliest Pharaohs in Egyptian history, Sneferu, who reigned from 2613 to 2589 BCE, built three pyramids in succession, two more than he needed as a tomb. The first, at Meidum, began as a step pyramid; an outer mantle, added later to turn it into a true pyramid with 52-degree sides, collapsed into rubble. Next came the Bent Pyramid, so called because it was begun as a true pyramid with 52-degree sides, but once it reached one-third of its intended height, it was quickly finished off at a shallow 43½-degree angle. The third was the Red Pyramid, a true but squat pyramid with 43½-degree sides.

To put huge limestone blocks into place required a labor force of tens of thousands of farmers recruited during the three-month flood season and fed with the grain taken from them as taxes during the previous harvest. As work progressed, however, fewer workers could fit on the top of the growing pyramid. Instead of being dismissed, the others were put to work starting a new pyramid. That is why the Bent Pyramid is bent: it was finished off in a hurry when the architects learned of the collapse of Meidum. Frightened by the disaster, they built the next one, the Red, at a shallow angle. In the process, they mastered the technique of using large stone blocks safely. Only then did they dare to build true pyramids with steep sides, the famous ones at Giza built under Sneferu's successors Khufu and Khafre. In effect, the purpose of pyramid building was to accustom the people of Egypt to cooperate on great construction projects at the behest of their god-king, the Pharaoh. In so doing, Sneferu turned a land of Neolithic farmers into a single nation, Egypt.

The people who irrigated the Indus Valley also built cities. Two of them, Harappa and Mohenjo-Daro, reveal an elaborate but very tightly controlled civilization. Unlike the Mesopotamian cities that grew from villages in a helter-skelter fashion, the two Indus cities were laid out in a rectangular grid, proof that they were planned. They did not have walls but embankments, for they feared not people but floods.

In the Americas, long before cities appeared, civilization was associated with the building of large ceremonial centers where few people lived year round but to which many came on special holidays. In the first millennium BCE, the Olmecs of Mexico carved gigantic stone statues weighing up to 20 tons and transported up to 100 miles from where they were quarried. By the first century BCE, the temples and pyramids of Monte Albán, in the Valley of Oaxaca, attracted enough

merchants, artisans, and other nonfarmers to qualify as a town. Likewise, the Mayans of southern Mexico and Guatemala created temple complexes such as Tikal surrounded by villages with several thousand inhabitants.

The first true city in the Americas was Teotihuacán in the Valley of Mexico. Founded around 200 CE, it flourished from 300 to 700 but then declined. The people of the region built two great pyramids, the Temple of the Sun and the Temple of the Moon, along with hundreds of smaller pyramids, temples, and religious or political buildings. Around them, they laid out a city in a rectangular grid, with neighborhoods devoted to artisans in obsidian, pottery, cloth, leather, and bird feathers and inhabited by merchants from other parts of Mexico. In its heyday, Teotihuacán had close to 100,000 inhabitants.

In other parts of the Americas, as in Mexico, ceremonial centers preceded cities. El Paraíso in Peru, built about 1800 BCE, included six huge buildings and required 100,000 tons of stone. Not until 2,000 years later was the first true city, Chan Chan, built in South America. In the southwestern part of the United States, the Ancestral Pueblo (or Anasazi) people built several ceremonial centers such as Pueblo Bonito in Chaco Canyon, New Mexico, or the more famous Cliff Palace in Mesa Verde, Arizona, with its 220 rooms and 23 *kivas*, or circular religious centers. These centers had only a small permanent population but served as meeting places on special occasions for thousands of people from outlying villages.

Not all the technologies of the early civilizations were as grandiose or required as much cooperative effort as water control systems or cities and monumental buildings. Some were on a smaller scale, yet were just as important to the lives of the people. Two of these, weaving and pottery, were useful to everyone, even the poorest. Others, like metallurgy and wheeled vehicles, were mainly of interest to the upper classes.

Unlike hunters and gatherers who clothed themselves in animal skins, agricultural people needed textiles. In every civilization, weaving cloth was done by both men and women, but spinning yarn was always the work of women. In the Hebrew Bible, the virtuous woman "seeketh wool and flax and worketh willingly with her hands. She layeth her hands to the spindle, and her hands hold the distaff" (Proverbs 31:13, 19, 24). The distaff was a long stick that held the roving, or loose fibers, while the spindle was a short stick that rotated as it dropped, giving the yarn a twist as it wound it. Using these simple devices, women could spin yarn while walking or carrying out other tasks. To this day, the words *distaff* and *spinster* reflect this ancient women's occupation.

The string skirts and belts made by Neolithic peoples were of silk, hemp, and flax. By the fourth millennium BCE, the people of Mesopotamia wove woolen cloth from the inner fleece of goats and of sheep; later, they bred sheep specifically for their fleece. Wool was first made by pounding the fibers together into felt. Documents written in the Sumerian city of Ur describe flocks of sheep and the female occupations of spinning and weaving. Around 2300 BCE, herdsmen on the Mediterranean island of Crete began breeding sheep with long woolly fleece that could be combed, spun into yarn, and woven into cloth. Unlike hemp and flax, wool yarn came naturally in a variety of colors ranging from black to white and moreover could be dyed in vivid colors. The women of Crete and nearby Greece began producing colorful textiles, including new weaves such as twill and tapestry, that were traded throughout the eastern Mediterranean. The Greek poet Homer wrote: "And fifty women serve Alcínoüs: some grind the yellow corn, their mill in hand; and others weave their webs or, while they sit, twist their swift spindles as their fingers glint like leaves of poplar trees swayed by the wind. . . . As the Phaeácians are the most expert of men in sailing brisk ships over seas, so are their women peerless when they weave."[2]

Wool was also the principal textile used by the people of the highlands of Peru. Ordinary people wore cloth made from the wool of llamas. The cloth worn by the elites came from the wool of alpacas raised specifically for that purpose; it was the finest and most skillfully woven cloth in the world, with up to 500 threads per inch, and came in many colors with elaborate designs of birds, jaguars, and snakes.

Egyptians, alone among the peoples of antiquity, dressed almost exclusively in linen garments made from flax. Fragments of Egyptian linen date back to 4500 BCE. Egyptians used linen not only to clothe the living but also to wrap mummies for burial and to make sails for the boats that plied the Nile. Men grew, harvested, and prepared the flax fibers, and both women and men wove the cloth. Much weaving was done in large workshops where workers toiled under the watchful eye of male—and sometimes female—overseers. The Greek historian Herodotus was shocked: "Their habits and their customs are the exact opposite of other folks'. Among them the women run the markets and shops, while the men, indoors, weave. . . ."[3] Since linen could not be dyed, wealthy Egyptians wore white clothes decorated with colorful jewelry made of gold from sub-Saharan Africa, silver from the Aegean, lapis lazuli from Persia, amber from the Baltic, and other precious materials carried over long distances by merchants.

In China as in western Eurasia and North Africa, women also wove cloth; before the fourth millennium BCE, it was made from hemp or ramie, both vegetable fibers. Then the Chinese learned to raise the silkworm *Bombyx mori* that eats only mulberry leaves. Making silk involves boiling the cocoons, reeling or unwinding the fibers, and twisting them into threads, all delicate hand operations. The result is a wonderfully strong and smooth fiber that can be dyed in brilliant colors and woven into many patterns such as tabby and brocade. Although farmers most probably discovered this fiber, Chinese legend attributes it to the mythical Empress Xi Ling-shi. As in other cultures, the Chinese divided tasks by gender; as their saying had it, "men till, women weave."[4] By the Shang dynasty, aristocrats dressed in silk robes while ordinary people clothed themselves in hemp, ramie, or cotton. For several thousand years, the secret of raising silkworms and making silk was known only to the people of China.

Cotton has two origins: India and the Americas. The people of the Indus Valley cultivated cotton and wove cloth as early as 3500 BCE. In 700 BCE, travelers brought the plant to Mesopotamia, from where its use spread to Egypt and sub-Saharan Africa. Another variety of cotton was used by the peoples of the lowlands of Peru and of Mesoamerica, tropical regions where the plant grew well and the cloth was better suited to the climate than wool.

Next to textiles, pottery was the most important craft of ancient times. The history of pottery has been carefully studied, for pottery shards, unlike textiles, do not deteriorate when left in the ground. Because pots are heavy and fragile, they were of no use to nomadic peoples. The very first potters, the Jomon people of Japan, were unique among foragers in having permanent villages. Elsewhere, pottery was a characteristic of Neolithic peoples and of civilizations.

The earliest potters after the Jomon were the inhabitants of the Zagros Mountains, north of Mesopotamia. Beginning in the seventh millennium BCE, they made pots by forming spirals of clay mixed with straw or grit that they then smoothed out, dried, and fired in a bonfire or a kiln. Pottery had many uses. Large pots were used to store grain, oil, and wine. People used smaller ones to carry water, to cook in, and to drink and eat out of. Like spinning and weaving, pottery making was a domestic art that created domestic objects; in many cultures, it was practiced by women. Pots were often decorated, each culture and period creating its own distinctive pattern. This has allowed archaeologists to identify the origin of pieces of pottery found in the ground and to trace the diffusion of styles and the patterns of trade; pieces of Indus

Valley pottery have been found in Mesopotamia, and Chinese pottery was traded throughout East Asia.

Metallurgy began with the use of native copper and gold. Such were the pieces of copper that the inhabitants of the Great Lakes region of North America and of Anatolia (now Turkey) hammered into knives, chisels, axe blades, and arrowheads. The axe blade belonging to the Ice Man of the Alps was of native copper. Native metals are rare, however. In nature, most metals exist in the form of ores or minerals containing metal oxides and other compounds. Stone Age foragers were familiar with many different kinds of stones such as malachite and azurite that ooze metallic copper when heated. Traders deliberately brought such ores to Mesopotamia by the fifth millennium BCE and later to Egypt, the Indus Valley, and northern China. Though fairly common, copper ores are concentrated in certain locations such as Anatolia, Iran, the Sinai Peninsula, Oman, Cyprus, and Nubia. Thus, ores and metals were among the most important items of long-distance trade.

Mining ores and turning them into copper were complicated processes. Surface deposits were quickly exhausted, and underground ores tended to be sulfides (compounds containing sulfur) that had to be crushed and roasted before they could be smelted. Smelting required furnaces with a strong draft and a great deal of fuel. The earliest furnaces were not hot enough to melt the metal, which had to be repeatedly heated and hammered into the required shape. Bellows, to create a blast of air and increase the temperature of the fire to the melting point of copper (1,200 degrees Celsius), did not come into use until the late second century BCE. After that, it became possible to cast the molten metal into molds of the desired shape.

The many skills involved in making metal objects turned their practitioners into full-time specialists—miners, smelters, smiths, and others—who jealously guarded their secrets and passed them on from father to son. They made axe and adze heads, saw blades, drainpipes, knives, swords, armor, and many other objects. Such items were very costly, however, and reserved for the elites. Farmers and ordinary artisans continued to use tools of stone and wood long after copper became available to the wealthy.

Although copper is easy to work, it tends to become hard and brittle with use and needs to be reheated and reshaped periodically. In the third millennium BCE, metallurgists learned to mix copper with softer metals to create alloys that were easier to work yet stronger and more durable than pure copper. The first of these was arsenic, often found in nature mixed with copper ores, producing an alloy called arsenical

bronze. Arsenic is a poison, however, and it was soon replaced by tin, which was less dangerous to work with. Bronze made of copper and tin (usually in a 10:1 ratio) was a superior metal in every way; it had a lower melting point than copper, was easy to cast, did not become brittle, and kept an edge. Tin ores, however, were rare and had to be imported to the Middle East from as far away as England. Although their names have long since been forgotten, we know that merchants traded over long distances because archaeologists have found Middle Eastern pottery shards thousands of miles from where they were manufactured.

Bronze was well known in the Middle East, North Africa, and Europe, but it was Chinese metallurgists who perfected the lost-wax method of casting the metal into intricate shapes. They first created a rough model of the desired object in clay. Once it was dry, they covered it with wax into which they carved fine details. They then coated the wax carving with clay and again allowed it to dry, forming a mold. They then heated it, allowing the molten wax to run out through holes left in the mold. This left a void inside the mold into which they poured molten bronze that took on the exact shape vacated by the wax. When the mold cooled, they cracked it open, revealing inside an exact replica in bronze of the wax carving. The aristocrats of the Shang dynasty period controlled access to the copper and tin mines and managed the smelters and workshops in which bronze was worked. Under their direction, bronze smiths made intricately decorated ritual vessels, musical instruments, chariot fittings, and especially the weapons with which the nobles maintained their power over the rest of the population.

The Americas also had centers of metallurgy. Native copper, gold, and silver were found in several places in the New World. Peruvian smiths fashioned gold into decorative items as early as 500 BCE. By the first century BCE, smiths had learned to cast copper in Colombia and later in Peru and Mexico. By the fifth century CE, smiths were casting objects of bronze. On the eve of the Spanish invasion, metalsmiths were using the lost-wax method and making beautiful objects of gold, silver, and platinum, as well as knives, weapons, and tools of copper and bronze.

The inhabitants of these ancient civilizations were remarkably creative in many fields, but one technological artifact they were slow to develop was the wheel. In today's world, the wheel is so ubiquitous and indispensable that it is hard to imagine a world without it. Yet even when the people of early civilizations understood the principle of the wheel, they made little use of it.

The Shang culture made tremendous progress in bronze working and other military technologies. This object may have been a chariot fitting. Gift of Charles Lang Freer, F1911.89, Freer Sackler Gallery

The potter's wheel made its appearance in Mesopotamia in the fifth millennium and was adopted in many parts of Eurasia. Around 3700 BCE, cattle herders who lived on the plains north of the Caucasus Mountains began burying their leaders with two-wheeled carts or four-wheeled wagons drawn by oxen, signs of wealth and power rather than utilitarian vehicles. Their wheels, made of three heavy planks encircled by leather straps with big copper nails, were firmly attached to their axles, which turned with them. Such vehicles became common in Mesopotamia and Syria by 3000 BCE and in the Indus Valley 500 years later. They were also known in northern Europe by 3000 BCE and in Egypt after 1650 BCE. However, they were very heavy and bogged down in soft soils and could not be used on rocky terrain. Long after the wheel was known, it was much easier to transport goods over long distances in caravans of donkeys. The peoples of the Americas did not use wheeled vehicles at all because they had no domesticated animals large enough to pull them.

One of the most important technologies we have inherited from the ancient civilizations is writing, a means of storing and transmitting

information through space and time by inscribing symbols to represent things, ideas, and sounds. Many different writing systems have appeared in the world. Those of Mesopotamia, China, and Mesoamerica were independently invented. Others, like the Egyptian hieroglyphs and our own alphabet, were inspired by the writings of neighboring societies.

The Sumerians created the first writing system, called *cuneiform*, meaning "wedge shaped." Around 8000 BCE, people in and near Mesopotamia began using small clay tokens to represent such things as sheep, bushels of grain, or jars of oil. Meanwhile, others were drawing designs on pottery. Between 3300 and 3200 BCE, Sumerian scribes began depicting not only people and things but also abstract ideas. They used the rebus principle, like drawing a picture of a bee and a leaf to indicate the word *belief*. They inscribed these symbols with a stick with a wedge-shaped end on small tablets of wet clay. Once dried in the sun, these tablets lasted for thousands of years.

For the first 500 years after cuneiform was developed, it was used only to make lists, keep track of donations to temples, and the like; 90 percent of the tablets found are bookkeeping and administrative documents. Only later did scribes begin writing histories, laws, legends, and other forms of literature. To do so, they needed 500 to 600 different signs, requiring many years to learn. Only a very few people had the leisure to learn this esoteric skill or the wealth to send their

A cuneiform tablet is enclosed in a clay envelope with an inscription and seal, dating from about 2000 BCE and found in Turkey. Consisting of a combination of wedge shapes, cuneiform permitted a high level of commercial and government transactions. The figures at the top, impressed into the moist clay with a cylinder seal, represent a man standing (probably a king) presenting a gift or tribute to a larger seated figure, who is most likely a god. The inscription is written vertically from top to bottom. Library of Congress LC-USZ62-82973

children to school. Writing became a way to distinguish the literate elite from the rest of the population.

The early civilizations brought forth many admirable innovations not only in agriculture and construction but also in all the arts, crafts, and sciences. These civilizations are traditionally extolled as "the dawn of history." There are good reasons to celebrate their accomplishments, for our own civilization is based on theirs.

But the evidence is loaded, as is the very word *civilization*. All the writings and monuments and most of the artifacts left by these ancient civilizations were created by or for their elites. The historians who have described them, and the readers of their works, are also members of literate elites. For them and for us, civilization represents a great advance over the lives of the hunter-gatherers and Neolithic farmers who preceded them.

Why, if civilization represented such an advance, did it remain restricted to a few regions and not spread to the rest of the world for many centuries? This question is usually asked about the indigenous peoples of North America, Africa, and Australia. The same question can be asked about the Greeks and other Europeans, who resisted the attractions of civilization for 2,000 years after the beginnings of Egyptian civilization. Were they somehow "retarded"?

In fact, quite the contrary is true. The ancestors of today's Europeans were Neolithic farmers who lived in Anatolia some 10,000 years ago. As their food supply increased, so did their numbers, and some of them began to migrate, seeking fertile rain-watered lands. Wherever they settled, their numbers soon exceeded those of the indigenous foragers. Long after civilizations had emerged in Mesopotamia, Egypt, and the Indus Valley, these early farmers were still finding new lands to farm. They deliberately avoided becoming civilized as long as possible. Not until the first millennium BCE did the inhabitants of Greece and Italy occupy all the arable land and find themselves in the same predicament that had led the peoples of the Middle East to adopt civilization. Only then did they submit to the discipline of taxes, laws, and religious or political authorities.

Thus, the technologies that characterize the early civilizations represented a great advance in the power of human beings over nature but also in the ability of a small elite to impose their rule on large numbers of their fellow humans.