

CHAPTER 3

The Early Civilizations

The major construction works undertaken by local village communities of the late Neolithic imply that they had some form of effective organisation and leadership. The execution of such major works as their great monuments, graves and henges would have been impossible without some form of effective leadership. People obviously also had some religious beliefs, probably in the form of a cult of their ancestors. The incomprehensibility of death and the wish to retain links with the loved departed is a strong stimulant of religious beliefs and associated rituals and cults. The desire to seek protection from natural catastrophes and from enemies provided further incentive for seeking to appease the incomprehensible higher powers. Undoubtedly, such religious cults were part of the social life of neolithic communities. It is possible that an elite was formed from the ranks of the more successful farmers, who had acquired a larger proportion of the available land and produced greater surpluses, thus accumulating some wealth. Religious leaders, shamans of one kind or another, probably claiming abilities to heal the sick and to intercede with the spirits of the ancestors, probably were another part of the leadership. We do not know when martial prowess became a qualification for leadership, but by the time the first civilizations became established, the leading elite certainly included both warriors and priests. The monuments and other constructions of the late Neolithic and the early metal ages demonstrate one of the great strengths of humans: they are able to communicate ideas and plans and are able to cooperate to put the plans into practice. We may regard the great monuments of the Neolithic as monuments to the spirit of cooperation and to human technological ingenuity. Unfortunately the first civilizations also demonstrated the opposite trait of humans: their ability for constructive cooperation is matched by their propensity for destructive aggression. The dichotomy between the will to cooperate within groups and the terrible aggression between groups is the hallmark of primitive humans. In that sense, we have not made much progress.

The organisation of the first civilizations went far beyond that found in the Neolithic. Societies in these civilizations were organised on a much larger scale – not merely at local level – and were much more stratified both in the sense of a strong hierarchy and in the sense of a considerable division of labour. Technology had become too complex to be handled by amateurs. The manufacture of spoked wheels, the manufacture of copper at first, and bronze and iron later, were not only too difficult for the untrained hand, but also organisationally too complex to be managed other than professionally. The same applies to trade, to administration, to accountancy, to water and sewage management, to warfare, and to the building of large elaborate edifices that served various purposes of the state and its rulers.

Some technological, social and geographic pre-conditions had to be met before these civilizations could become established. The first condition was the existence of fixed settlements with a substantial population. The civilizations all had cities as their main centres of population and administration, and cities usually grow out of villages. The second condition was that agriculture had to be sufficiently advanced and sufficiently productive to feed a population substantially greater than the agriculturists alone. Agriculture had to produce sufficient food to feed the workers in the necessary infrastructure of builders, artisans, merchants, administrators, soldiers, priests, and rulers.

Water management was possibly the most crucial technology that made the establishment of large-scale settlements and civilizations possible. The first great civilizations were established in Mesopotamia, where the rivers Tigris and Euphrates served as the sources for an elaborate irrigation system that distributed water from

the rivers over a wide agricultural area. To complement the irrigation system, flood controls had to be constructed and in areas of seasonal rainfall the rainwater had to be stored for distribution during the dry season. The water management system varied from region to region and the technologists of the day had to have good knowledge of the rivers and the rainfall, as well as the needs of agriculture. They also had to develop methods of construction for canals, aqueducts and distribution systems. Egypt was exceptional in that it could use the seasonal floodwater of the Nile without too much of a distribution system. The Nile provided both water and fertilizer to a narrow strip of land that formed the basis of Egyptian agriculture and civilization.

Animal breeding became important both for agriculture and for the military. Cavalry and chariots became important instruments of war and needed well-bred horses or asses. Transport, also served by horses, asses and camels was important for trade and for supplying the growing cities with agricultural produce. Good storage facilities had to be built in the cities for the storage and distribution of grain or other food. These storehouses were administered by the state. Plant breeding had to be sufficiently advanced to give good yields and agricultural implements had to be of good quality. Indeed the invention of the plough probably was of critical importance to the establishment of the civilizations.

A further pre-requisite for the establishment of large complex administrations was the invention of a script, even if only as a means of bookkeeping in the first instance, and a small elite able to read and write and do arithmetic. The first accounting system, based on clay tokens, is associated with Ubaid culture and the city of Ur (near the modern An-Nasiriyah in Iraq), precursors to Sumerian culture. Writing proper, so-called cuneiform writing¹, was introduced by what is often regarded as the first of the great civilizations, the Sumerians in southern Mesopotamia. The beginnings of this writing go back to the 4th millennium BC and are associated with the city of Uruk. The Egyptian hieroglyphic script also originated toward the end of the 4th century BC.

The final precondition for the establishment of a civilization is sufficient social cohesion. Society must be willing to comply with certain rules of an organisation that finances and controls public enterprise, collects taxes, settles disputes, maintains civic order, conducts wars, and so forth. Artisans, administrators and soldiers had to be trained, thus some system of training and education needed to be established. It was hardly possible for these states to be completely self-sufficient in all raw materials and manufactured goods, so traders were required to bring all that was necessary from foreign lands. In order to finance such trade, a reverse flow of exported goods was needed.

The term civilization describes a reasonably homogeneous society with common rules of conduct, normally a common language and a common set of beliefs, ruled in some hierarchical organised way, and using a certain standard of technology and style of artefacts. The central authority is based on a city and the urban elite rules the surrounding rural areas. Generally, with a few exceptions such as the Indus civilization, these societies had an organised army. Warfare and weapons became central aspects of almost all civilizations and were often employed for purposes of conquest and pillage. Civilizations usually construct major works of engineering and major buildings, such as temples and palaces, and produce characteristic works of art.

The word civilization is used to describe well-ordered societies with a façade of great architecture and art, no matter how brutal the rulers may be toward their own population and toward the outside world. Indeed we call rulers great if they kill, conquer and loot on a grand scale. My preferred definition of civilization would describe a society where civilized behaviour is the norm, that is non-violent, polite, considerate and law-abiding, within a reasonably just and fair legal framework. Alas, in the ancient world we are speaking of, my preferred kind of civilization had not been invented. A truly civilized society is a society that endeavours to protect its members as far as possible from the hazards and vagaries of life and attempts to provide as secure and as peaceful an existence as possible. A reasonable standard of comfort, hygiene, health care, infrastructure and environmental protection are subsumed under protection from hazards and security. Members of a civilized society should live in harmony with each other and with their natural and human environments. It is painfully obvious that the old civilizations had little in common with what I would like to define as civilized societies. Some contemporary civilizations come a little closer, but still leave a great deal to be desired. In my own view,

¹ Cuneiform means wedge-shaped (Latin *cuneus*=wedge) and the writing is so called because it was written with a wedge-shaped stylus impressed into wet clay.

humankind cannot be regarded as civilized when wars are still commonplace. Aggressive war is, in my view, a most heinous crime. Yet many so-called civilized states, ancient and modern, have indulged in precisely this crime.

By the 5th millennium BC some Mesopotamian settlements had grown into towns of four to five thousand inhabitants. Each town had a temple with an ornamented façade, an offering table and an altar with a statue of a god. In the larger cities these temples had grown into ziggurats; stepped pyramids with the temple built on the flat top. Some of the towns developed into large cities that became centres of power. In the period about 4300 to 3100BC² Uruk (modern Warka in Iraq) was the centre of Sumerian culture and power. Uruk had two large temple complexes, each devoted to a different god or goddess. These complexes also served as storehouses for the distribution of food to those who could not grow their own. The precise relationship between priests and rulers is not known; they certainly cooperated closely and might even have been identical. The population of Uruk exceeded 10,000 by about 3000BC and later grew to about 50,000.

The city was sustained by intensive agriculture using a complex irrigation and flood control system and the plough. Livestock played an important role and dates and fish formed parts of the diet. Many craft-based industries flourished, including metalworking, sculpture, engraving, carpentry, shipbuilding, pottery, spinning, weaving and brewing. The lost wax method of casting was invented in the late 4th millennium BC.³ Some historians believe that glass was invented in Mesopotamia around 1600 BC, though most sources believe that although glass beads were known in Egypt by 2500 BC, modern glass was developed in Alexandria after about 300 BC. The chariot, especially the four-wheeled chariot, was also invented in this physically and mentally fertile region. Bronze was vital, not only because it was the material from which effective weapons were manufactured, but also because without bronze tools it would not have been possible to produce the elaborate buildings and sculptures of the time. To our modern eyes it seems unbelievable that such complex works of art, architecture and construction were achieved with bronze tools only.

Technology had come a long way in being able to satisfy the essential needs of a large population and to satisfy all the other needs that a civilization required. With the early civilizations and the first large cities the emphasis of technology began to shift from being merely a tool for survival, to becoming also a tool for cementing power, wealth and privilege. In consequence of the warring nature of the various empires, the development of weapons was one of the most important tasks of technology. The bond between rulers and armourers was strong and determined the main thrust of technological development. Weapons and warfare became a major focus of technological endeavour and, alas, have remained so to this day. Transport systems became another major concern of technology, because armies needed transport and so did the large emerging cities for their supplies.

The second major thrust of technology was also determined by demands of the state and the cities. Major public works were required, such as grand palaces as residences for the rulers, grand temples as places of worship and of assembly, statues as symbols of faith and artistic expression, and splendid burials. Improvements in plant cultivation, livestock breeding, water management, and in agricultural implements were necessary to sustain increased populations. City life makes certain demands on technology, such as transportation, storage and distribution of food, housing, administrative buildings, water supplies, drainage and sewerage, roads and streets, and security, including city walls.

Beyond and above that, once hierarchies became established, technology began to serve the special wants of the elites, such as jewellery, ornaments, large houses, luxury clothing and fine furniture or tableware. With the many new products required by the state and by its elites, specialization increased and whole new classes of trained and skilled craftsmen and of traders emerged. The traders brought luxury goods from foreign lands, including spices and aromatics. The work of the stonemasons, sculptors, painters and builders of the Bronze Age stands unsurpassed to this day. The training of the artisans of the early civilizations must have been very

² All dates in this period are uncertain and different scholars use different chronologies.

³ The lost wax method of casting is used for hollow metal castings. A layer of wax is placed between a clay model and an outer clay mold. The wax is melted and the metal is cast into the space left.

thorough and the standard of knowledge and skills very high. The quality and beauty of these antique works of art are breathtaking.

From roughly the beginning of the 3rd millennium BC competition between cities became intense and royal dynasties began to attain power. The cities, such as Uruk, Ur, Lagash, Babylon, and Nineveh were surrounded by massive defensive walls. The palaces and the royal tombs became more opulent and the first mention of slaves is made. Indeed one of the purposes of the frequent wars was to acquire slaves. Gold, silver, sea-shells and lapis lazuli came into use to ornament sculptures and buildings. This is not the place to tell the tale of shifting fortunes of the various empires, cities, and rulers. The story is extremely complex and is not essential to our main interest.

Even in Sumerian times technology offered real improvements in everyday tools and thus provided the base on which society and its wealth could develop. Wooden ploughs using metal tips were more effective than purely wooden ploughs, and surpassed the efficiency of digging sticks and hoes by a large margin. Irrigation systems increased the efficiency of agriculture, so that large food surpluses, to feed a large non-agricultural population, could be produced. The Sumerian civilization was dominated by city-states, each ruled by a despotic king supposedly appointed by the gods. The cities took it in turn, as it were, to dominate the Sumerian empire. There was a firm mutually advantageous coalition between priests and rulers. Ur had an elaborate tax and bureaucratic system and a written legal code. The rulers lived in great luxury. The kings of Ur were buried in huge graves with their queens and a whole retinue of courtiers. Apparently they had to take poison in order to follow their king into the nether world. Elaborate grave gifts were found, such as sculptures ornamented with lapis lazuli, silver and gold.

The Sumerian army consisted of three different groups: Mobile skirmishers who wore no armour and wielded javelin-like spears and battle-axes. Helmeted infantry arranged in closed ranks and armed with heavy spears. Clumsy chariots, pulled by donkeys, supported the foot soldiers. The bow came into widespread military use only after about 1500 BC.

After the fall of Ur the Sumerian civilization declined and Babylon (near the modern town al-Hillah, Iraq) became the major city in Mesopotamia. A dynasty was established in 1894 BC and the best-known king of this dynasty, Hammurabi (1792 to 1750), conquered a wide territory and raised Babylonia to the leading power of the day. During the rule of Hammurabi many temples were built and the network of irrigation canals was extended. A written code of law, the Hammurabi Law Code, was promulgated. It was engraved on a great stela (standing stone slab) in cuneiform script and is one of the very earliest written collections of laws. An interesting feature is that it distinguishes between three classes of inhabitants: slaves; royal employees and retainers; and free land-owning citizens. Babylon was sacked in 1595 BC by the Hittite king Mursilis.

A new major actor arose when the Assyrians gained independence from Mitanni in about 1340 BC. In frequent wars, chiefly against Mitanni and Babylonia, the Assyrian empire gained importance, temporarily holding most of Mesopotamia. The rivalry between Assyria and Babylonia continued, though both came under pressure from Aramaean and Chaldean tribesmen, pushing in from Syria. Eventually the Assyrian king Adad-nirai II (911 to 891) gained the upper hand. His successors moved the Assyrian capital from Ashur to Nineveh (near modern Mosul, Iraq) and expanded Assyrian power.

The Assyrians had a professional standing army, backed up by a citizen army. Their king Ashurnasirpal II (883 to 859) introduced cavalry into the army as an addition to the chariot force and the infantry. Although many armies introduced cavalry, the horse and rider did not become fully effective until the stirrup was invented in the steppes of central Asia in about the 2nd century BC. The cavalry and chariots became the main attacking force, relying on speed and on missile power. The infantry formed the second wave, using bows and spears and wearing helmets and chest armour. Originally separate shield bearers protected the infantrymen with huge shields. Presumably because of problems of coordination of movement, the shields became smaller and the separate shield bearers were abolished. It is believed that the Assyrian army numbered up to 60,000 infantry, 1,200 cavalry and 4,000 chariots. All winners treated the losers badly, but the Assyrians apparently surpassed all their predecessors in unprecedented cruelty. In 689 the Assyrians destroyed Babylon, but their luck ran out and some 80 years later the Assyrian empire collapsed and their capital, Nineveh, fell in 612 BC to Persian and Babylonian forces.

Babylon experienced a revival and regained considerable importance after a Chaldean leader made it the capital of a new kingdom that again became the dominant power in Mesopotamia under king Nebuchadnezzar II (or Nebuchadnezzar), who ruled from 605 to 561. His claim to fame includes the construction of the hanging gardens of Babylon, one of the Seven Wonders of the World. The gardens formed part of the royal palace and were splendid roof gardens laid out in a series of ziggurat terraces. Water was pumped up to the gardens from the river Euphrates. The centre of the city was marked by a great temple dedicated to the god Marduk and by a 90 m high ziggurat (known as the Tower of Babel) with a temple covered in blue glazed tiles on top. Nebuchadnezzar is also famous for building additional city walls and a ceremonial processional way, paved with stone, that served mainly the transportation of religious statues between temples. This was probably the first paved road ever built. He also built an unpaved road connecting the Persian Gulf with the Mediterranean Sea, a distance of about 2,400km. Last but not least, Nebuchadnezzar acquired biblical fame for capturing Jerusalem in 597, and again in 587, and deporting many of the inhabitants of the kingdom of Judah to Babylon.

One of the major powers of the Middle East was Egypt, with its various kingdoms spanning a period from 3000 to 300 BC. The Sahara became a desert during the 4th millennium BC and this forced its population to migrate to the fertile Nile valley. Egyptian agriculture was unique among the river valley cultures in that it used the annual flooding of the river Nile to irrigate and fertilize its fields. Only a few canals needed to be dug to distribute the floodwaters. The Nile normally flooded in August and the water subsided in the autumn, allowing the crops to grow in the mild winter and be harvested in the spring. What was regarded as surplus grain was collected as tax and stored in state owned storehouses for distribution to the priests, administrators and craftsmen. Some reserves were kept for lean years when the flood failed. The first ruler of the unified kingdom of Upper and Lower Egypt was Narmer, c. 3000 BC. The city of Memphis (near modern Cairo) was founded and the principle of theocratic kingship became established during this early dynastic period that lasted till 2649. It was the period when copper and bronze were first introduced and writing came into use. Egypt had two scripts, the hieroglyphic (pictorial) script used for inscriptions carved in stone, and the hieratic script⁴, used for writing with ink on papyrus.

The next period, 2649 to 2134 is known as the Old Kingdom. The most famous pyramids were built as burials for kings during the Old Kingdom. King Djoser (2630-2611) had his stepped pyramid built at Saqqara. It was the first pyramid built entirely of stone and was designed by the first known architect in history, Imhotep, who was later deified. The smooth pyramids of Giza were built for Cheops (Kufu) (2551 to 2528), his son Khafren (2520 to 2494) and for Menkaure, Khufu's successor⁵. Many other pyramids were built during many centuries, but the Cheops pyramid, at 146 metres, is the highest and most impressive of them all. The pyramids represent the most amazing feat of stonemasonry, building and organization. Experts have not agreed to this day how the buildings were accomplished, but one of the more plausible theories is that the huge stones were transported on sledges, and perhaps rollers, up temporary ramps built alongside the rising pyramid. It remains a mystery how the stonemasons achieved the precision that allowed the stones to fit together so perfectly. Another truly amazing fact about these huge marvellous buildings is that they did not serve any practical purpose. After all, royal graves do not really need such edifices. They were built for purely religious cum political reasons, as acts of reverence, faith and worship, and as symbols of power. Technology had moved a long way from serving only needs of survival and had become the servant of religion and of the high and mighty.

The Old Kingdom collapsed after a succession of low floods in about 2150, and with it ended the building of pyramids. After an intermediate period the Middle Kingdom emerged (2040 to c.1640). The Middle Kingdom became more expansionist and aggressive. It collapsed c.1640 and during a second intermediate period the Hyksos (who came from Palestine) conquered Lower Egypt. They brought with them much technology from the Near East, such as wheeled vehicles, and various bronze tools and weapons. They introduced the war chariot to Egypt and a very effective composite bow, made of layers of different woods, as well as the scimitar. The felloes of wheels for chariots were produced from bent ash, showing that the art of bending wood had been

⁴ After 660 BC a simpler demotic script largely replaced the hieratic script.

⁵ There are considerable differences in the modern spelling of ancient names. Khafren, for example, is sometimes spelt Khafre and Kufu is sometimes Khufu. Cheops is the Greek spelling.

mastered. The hub was usually made of elm and the spokes of oak. The axles, however, remained fixed for quite some time and impeded the mobility of the chariot. The Hyksos also brought new types of crop, new musical instruments and new domestic animals, including the horse. Eventually the Hyksos were expelled and the New Kingdom arose and became the greatest power in the Middle East. The title pharaoh was introduced and Egypt achieved its greatest extent under pharaoh Thutmose I (1504 to 1492), when it conquered the whole Levant (Middle East) up to the upper Euphrates. In the south, it reached to the 4th Nile cataract, thus including much of Nubia with its gold and its trade relations with the rest of Africa, bringing in slaves, ebony, and ivory. The Levant provided a useful buffer zone against the powerful empire of the Mittani. Thebes (modern Luxor), with its major temples of Karnak and of Luxor and its necropolis on the west bank of the Nile, became the capital from which the whole of Egypt was ruled.

The mighty Egyptian army used two-wheeled chariots drawn by a pair of horses, manned by an armoured driver and an archer. The infantry was equipped with lances, shields and helmets. The bow and arrow, personal armour, javelins, battle-axes, and swords were all developed and improved during this period.

The earliest fully recorded battle, though certainly not the first battle ever fought, is the battle of Megiddo (in present day Israel), in the late 15th century BC. Here the Egyptians under Thutmose III successfully fought an assortment of enemies who had formed an alliance against them. The Egyptians advanced further north and eventually had to fight the Hittites, whose empire was centred on Anatolia. In the battle of Kadesh (in modern Syria) of 1282 BC, the Egyptians were led by Ramesses II and the Hittites by their king Mutwatallish. Both armies made extensive use of chariots, followed by tightly packed infantry equipped with shields, spears and curved slashing swords. Bowmen followed behind the spearmen. Both armies claimed victory and the war ended with the signature of a non-aggression treaty.

After this brief excursion to Egypt, we return to the region of Mesopotamia. The wheel of fortune turned again when in 550 BC Cyrus the Great became king of Persia and made it the dominant regional power. The Persians conquered most of Lydia (in Western Anatolia) and captured their king Croesus, famed for his wealth, in 546 BC. After Lydia, Cyrus turned his attention to Babylon and captured it in 539 BC. Under king Darius (521 to 486) the Persians conquered Egypt and expanded their empire as far as the Indus and the Caspian Sea, thus turning Persia into the largest ever empire. After these conquests the Persians turned their attention to Europe and the famous wars with the Greeks began. Originally the Persian army relied on moderately armoured infantry equipped with spears and bows. Later they improved the army's mobility by strengthening the cavalry and increasing the number of chariots. The cavalry and the chariots became the spearhead of the Persian army, with the infantry supporting them with showers of arrows. The Greeks used entirely different tactics and fought with deep closed ranks (the phalanx) of so-called hoplites, infantrymen wearing bronze armour, using a shield known as a "hoplon" and armed with iron-tipped spears. Some archers and slingers were mixed in with the infantry and the relatively small cavalry was used on the flanks only.

Before returning to the Persian-Greek wars, we need to say a few words at least about Greece, considered by many as the cradle of Western thought. The collapse of the Mycenaeans left Greece in some turmoil and stability was not re-established till the 10th century BC. There were two main population groups: the Dorians who had migrated from the Balkans and the Ionians who were the direct descendants of the Mycenaeans. Throughout the 9th century, agricultural techniques improved, the population increased, trade expanded and prosperity grew. The Greek alphabet was developed during the Archaic period (800 to 480). It was an expanded and adapted version of the North Semitic alphabet that came to Greece via the Phoenicians, hence it is often referred to as the Phoenician alphabet. Power in Greece was based on cities, of which two, Athens and Sparta, became dominant. Sparta had a particularly strong army, including the only professional standing army, and a severe education system for boys – hence the term Spartan. Gymnastics and warfare were the main subjects taught. Athens was more of a centre of philosophy, literature and learning and invented and experimented with various forms of democracy. Greek cities were often at war with each other, all using closed ranks of hoplites advancing upon each other, killing and pushing till one side submitted. Athens depended on its sea trading routes and its main military strength was based on its navy.

The warships of the time differed in size and in the number of tiers of oarsmen. The smallest vessel had 25 rowers on each side and was used for exploring and raiding. A similar ship, though more suited to fighting, was

the unireme. It had the same arrangement of rowers, but had a reinforced prow and was usually equipped with a beak or ram. The next larger ship had two tiers of rowers arranged above each other and was known as the bireme. It had been developed by the Phoenicians and by the 5th century had been largely replaced by the trireme. The trireme, the mainstay of the Athenian navy, was usually 35 m long, had three decks of rowers and carried a crew of 200. The beak was of bronze and was designed to pierce the enemy ship below the water line. The naval tactic was to attempt to hole the enemy ship, though shearing off the oars was an alternative way of crippling a vessel. Sometimes grappling and boarding an enemy vessel and shooting officers and steersmen with arrows was attempted. Triremes could sail, but in combat they used the speed and manoeuvrability of trained rowers.

Merchant ships were invariably sailing ships that could make 4.6 knots with the wind and 2.1 knots against it. They gradually increased in size and by the end of the 4th century BC could commonly carry loads of 150 tons with some up to 500 and more tons. Steering was by a pair of oars – the stern-post rudder was not invented till the 13th century AD.

During what is known as the Classical Age, Greek technological innovations included wine and olive presses, both in the form of lever presses or screw presses. Greek roads were neither surfaced nor drained and pack animals were more important in land transport than wheeled vehicles. An ingenious method of carrying heavy building beams was to use them as axles for large drums and roll them along. Another Greek invention was the crane with multiple pulleys, presumably used for loading or unloading ships and for building. Stone columns used wooden pins in sockets to locate the parts of the columns. It is hardly necessary to mention the well-known impressive temples, palaces and fortresses built by the Greeks and decorated with wonderful figures carved in relief. Water pumps of different design formed part of the Greek technological arsenal. They invented both the twin-cylinder force pump and the famous Archimedes screw that was widely used for pumping water.

Greek philosophy, political thought and drama undoubtedly form the basis of much of our own thinking. Greek science, on the other hand, is not a direct precursor to our empirical approach to science. Though the Greeks did observe natural phenomena with some care, they did not believe in testing their scientific theories against their observations. The two aspects were kept in separate compartments, with purely speculative theories being given higher value than mere observation. Nevertheless, some of the achievements of men such as Archimedes (c.290-280 to c.212) or Pythagoras (580 to 500) have stood the test of time. It goes without saying that Greek sculpture, Greek architecture, and Greek pottery were all outstanding and have formed much of our artistic taste. The artistic excellence of their art was matched by the technical perfection of their works.

When Persia had run out of places to conquer, it used an uprising in an Anatolian Greek colony, that had been occupied by Persia, as an excuse to turn their attention to Europe, ostensibly to punish the Greeks for this uprising. The main problem of the Persians was to keep their large army supplied. The only solution to this logistic nightmare was to have a fleet of supply ships follow the army along the Mediterranean coast. The Persian army probably consisted of some 7,000 combat troops, including about 1,000 cavalry and some chariots, and a large number of auxiliaries, including the oarsmen⁶. The foot soldiers were equipped with bows, and the cavalry was armed with javelins, bows, or lances. The Persians chose Marathon, some 40 km (25 miles) from Athens, to do battle with the Athenians in 490 BC. Surprisingly, the Athenians routed the mighty Persian army and are said to have killed 6,400 Persians, with only 192 Athenian dead. Legend has it that an Athenian messenger ran all the way to Athens to relay the victory before dropping dead. This is the legendary basis of the modern marathon run.

The war was not over yet. Darius died in 486 and was followed by Xerxes, who in 480 led a new expedition to Greece. His army is said to have numbered some 40 to 50,000 men in total, presumably not all combat troops. The army marched and a naval force protected their flank and their supply ships. Many Greek cities surrendered, but a Spartan force, led by their king Leonidas, held off the Persian army at Thermopylae for several days. The Persians managed to outflank them and marched on Athens, which they sacked. Leonidas and a force of

⁶ Some historical sources describe the Persian army as very much larger, but modern historians view these figures with some scepticism.

some 300 Spartans, augmented with ancillary forces, delayed the main Persian army long enough to enable the main Spartan force to escape and regroup. Another legendary feat, with all 300 Spartans killed. The Persian fleet was lured by the Athenians into waters near the island of Salamis, where it was almost totally destroyed in the battle of Salamis by the Athenian and Corinthian navies. Much of the Persian army and the remaining fleet withdrew to Asia, though quite a large force remained near Plataea. In 479 this army was heavily defeated by a Hellenic force, led by Sparta. A further defeat at Mycale completed the rout and drove the Persians out of Europe.

Though the rise of Rome falls into the end of the period we are discussing, it is such a prime example of an expansionary civilization that I cannot resist the temptation of mentioning it, albeit very briefly. The really important achievements of Rome lie in the realms of administration, politics, law and literature, but Rome also used and developed technology extensively in support of its huge armies and very advanced civilization. Technology served two major purposes of Roman society: military conquest and the technological underpinning of civic society. Military conquest required arms and armaments, fortresses and siege machinery. It also required what we now call a logistic infrastructure of roads and transport and the handling and transmission of information. The underpinning of civic society required great monumental buildings as well as the provision of clean water, public baths with good heating facilities, and a high degree of domestic comfort for leading citizens. The usual problems of supplying a major city with food required the solution of problems of transport and distribution, not to mention the need to produce sufficient food in the first instance. In modern parlance we would say that Rome supported a large arms industry and major civil and building engineering projects, such as the famous baths, circuses, roads and aqueducts.

Military technology served the Roman desire to expand to an enormous size and to hold the far-flung empire together by military and administrative means. The formidable Roman army consisted of legionaries as the elite foot soldiers, and ancillary specialist troops, such as cavalry, archers and slingers. All soldiers wore body armour of one kind or another. Some, especially ancillary troops, wore chain mail, though in later times plate armour prevailed because of its greater effectiveness. The Romans designed a form of articulated plate armour – *lorica segmentata* – that replaced the solid plate armour used earlier. It consisted of segments of armour, joined together by leather straps. It afforded excellent protection and yet allowed considerable freedom of movement. Roman armourers were able to produce sophisticated iron products in great numbers. The legionaries carried short swords with hardened blades and a javelin. The wooden shaft of the javelin was tipped with a soft metal shank with a hard metal tip. The idea was that the sharp metal tip would pierce its target and the soft metal shank would bend, making it impossible to throw the javelin back at the Romans. The soldiers also carried shields, often made of laminated wood, rather like modern plywood.

The army was largely self-sufficient in its technology. Military commanders were involved in technological developments and armourers and other artisans were often part of the army itself. In occupied territories the army built a closely spaced network of legionary fortresses. These accommodated the soldiers and their officers, as well as workshops, storage facilities, a hospital, and bathhouses. The fortresses were first built quickly as temporary structures from timber, and later constructed in stone. They were substantial self-contained units with a standard layout of fortifications, buildings and streets. Water supplies and drainage were provided in accordance with local circumstances. The total investment in labour and materials into such fortresses was enormous, but the purpose of housing the army and having it at hand to counter or deter any possible external attack or internal rebellion was apparently of supreme importance⁷.

Another aspect of Roman military technology is concerned with siege. They built several different models of devices that could shoot sharp metal bolts over a fairly long distance – the *ballista*. It was something like a stationary version of a crossbow, itself a Roman development. They also produced a variety of catapults and battering rams, as well as siege towers and mobile shelters to protect the attacking soldiers from missiles hurled at them by the defenders⁸.

⁷ See e.g. Shirley, Elizabeth. (2001). *Building a Roman Legionary Fortress*.

⁸ See e.g. Oakeshott, R. Ewart. (1960). *The Archaeology of Weapons: arms and armour from prehistory to the Age of Chivalry*. London: Lutterworth Press.

To give the army its required mobility and flexibility, and to give the empire its political and administrative cohesion, a good system of transport and communications was an essential requirement. The Romans constructed a dense network of roads, connecting all the major towns and fortresses. Whereas in earlier times roads were just simple cart tracks built where necessary without any overall plan or system, the Romans went about the business of road building with an unprecedented thoroughness. Roads were of varying width, from 4 to 9m, depending on their importance. They were all layered: a foundation of large stones, then a layer of smaller stones, followed by a layer of gravel. For minor roads the gravel was rammed to produce a reasonable surface. For major roads a further layer of large flat stones – the *pavimentum* – formed the actual road surface. The real secret of the Roman road was drainage. The foundation drained well and the surface was cambered. Ditches on both sides carried away the run-off. The Roman civil engineers realised that mud was the greatest enemy of transport and drainage was the only means to beat mud.

Rome wanted to rule as much of the world as possible, presumably in order to gain economic advantage, to achieve security from potential raiders, and to bestow the benefits of Roman civilization upon a barbarian world. No full answer to the question why so many countries, from ancient times to our day, have attempted to build empires by conquering other countries. The answer I have given is lamentably incomplete, but this book is about technology and not about imperialism, though a link between them is undeniable. Technology has often been developed and misused in support of imperialist aspirations, and is so misused to this day. To make conquests and build the Roman Empire, a strong army was the most essential requirement. To maintain the huge empire, it was essential to build an effective administration and effective communications. Finally, to bestow civilization, required urbanization and the building up of civic amenities.

Roman civilization was a well-ordered political system, i.e. a system of decision-making and distribution of power and wealth. It was also a highly sophisticated legal system, with a codex of law that is still regarded as exemplary in many parts of the world. The Latin language became the *lingua franca*; the Latin alphabet came into widespread use. Literature developed both in the sense of poetry and in the sense of writing history and science. All these developments required an efficient agriculture, capable of feeding a large urban population, and the development of urban centres where all these civilised activities could take place. In fact the Romans built a large number of planned cities with administrative buildings, courts of law, markets, dwellings and shops and a grid of streets. Much of the building was in timber and posed a fire hazard, hence the Romans introduced the first organized fire fighters, equipped with water containers and pressure pumps mounted on carts. The wealthy classes tended to invest in land and built elaborate villas in the country. These villas provided separate rooms for separate activities, unlike earlier dwellings that consisted of a single room. The villas were often beautifully ornamented with mosaic floors and wall paintings. They usually had a private bath with underfloor heating, a precursor to modern central heating systems. The towns required water supplies and sometimes the water had to be brought over long distances by aqueducts. Drainage and sewerage had to be provided and was carried in stone-clad and covered ditches or in ceramic pipes. Water was often carried and stored in lead (*plumbum*) pipes and containers; hence the word plumber.

Roman society pursued its main aims with singular determination. The main aim was the growth of the empire to achieve wealth and security, though perhaps it became an obsession and an aim in its own right, without consideration of the benefits or disadvantages. Romans believed that large and powerful was beautiful. Wealth was gained by favourable imports and trade, as well as by carrying off slaves and loot in wars. The state was all powerful and regulated most things. Rome is an example of a determined and autocratic state. In a society that knows exactly what it does and does not want, technology may have some autonomy, but is basically subservient to the general aims of society. It is true to say that technology invents, but it invents in view of circumstances where society chooses the technologies it is willing to accept within narrowly prescribed social goals. Roman technology had the task of strengthening the empire and making life comfortable for the ruling elite. Strengthening of the empire required mostly military technology and an infrastructure of communications and buildings. Strengthening the empire also required strong administration and keeping the bulk of the population quiet by providing circuses and many urban amenities for them.

By this time in the history of mankind, technology had come a long way from merely enabling humans to survive. It was now supporting social requirements that can be characterised as dominated by greed, lust for

power, and a desire for order in all aspects of life. Technology provided great wealth and luxury for the elite and provided the means of achieving wider social goals, set by the elite. Technology also provided the means for feeding a large population and providing their basic needs at a much higher level of comfort than in the Stone Age. Finally, technology provided the weaponry and the logistics for large armies. Technology had not, however, become a main source of wealth, nor the prime mover in the quest for more private wealth. The main sources of wealth were agriculture, conquest and trade, whereas technology remained an ancillary instrument for the achievement of social goals.

The ruling elite made demands on technology in accord with its own perception of what society needs. The demands included the satisfaction of the most elementary needs, such as food supplies, clean water, basic housing, and so forth. Elementary needs by this time in history are not quite as basic as during the Stone Age, but basic still. The state may pay for some of these requirements, such as irrigation and water management systems, directly out of taxation⁹. Other needs, such as food and perhaps housing, will be paid for, or produced, by the consumer and the balance between demand and supply will be found by a rudimentary barter mechanism. The elite may also decide, and mostly did decide, that expansion of the state is a legitimate and essential social need and that the state should build up and maintain a military force to achieve this expansion. A further social need, as perceived by the ruling elite, consists of palaces, monuments, splendid graves, temples, buildings for public administration, storehouses, and so forth. These were all social needs articulated by the elite and went far beyond the essential needs of survival. The need for expansion, domination and conquest was, of course, driven predominantly by greed.

The elites had their own private needs, above and beyond the basic needs for food and shelter. They required, or, more accurately, desired a whole range of luxury goods. I do not think that they were able to articulate these wishes, except in very general terms. The items for luxury consumption were suggested to the elite by their suppliers, and these were either merchants or artisans. The elite as private consumers could choose between the items on offer, be it imported luxuries or luxuries produced by local craftsmen. Even in those days the craftsmen, i.e. the technologists, made offers to the consumers and tried to arouse their interest, rather than being told by the consumers what their needs were. Luxury consumption was, of course, driven by greed – not by need.

Military expenditure pursued two aims: defence against outside raiders, and offence with the aim of conquest and plunder. The desire for conquest was driven by greed – by the desire to own slaves, gold, silver, jewellery, and precious stones, that could all be obtained by plunder in conquered lands. It was also driven by vanity and the lust for more power, more grandeur, more vassals, and more fame. Military commanders were drawn from the governing elite and military technology was under the direct control of such commanders. Local artisans, particularly armourers, were attached directly to the Roman military. In the supply of arms there probably was real interaction between the articulation of needs and the capabilities of technologists.

Some form of religion played a major role in all the civilizations and priests became members of the privileged classes, often at the very top of the social pyramid. Indeed religion was often used as the spiritual argument for civil obedience and helped to cement the worldly hierarchy by appealing to supernatural powers. Religion provided the simple uneducated people with a prescription on how to deal with dangers and disasters. They would pray for rain, pray for the sick, and pray to be spared from floods, plunder and pestilence. And they gladly paid the priests to serve as intermediaries between them and the superior mysterious divine powers. The priests regulated their everyday lives and they believed that by obeying the rules they would be spared the dreadful consequences of disobedience and would lead a decent and orderly life in this world and in the next. The priest became surrogate fathers, guides and protectors.

The priests provided the spiritual underpinning for the rule of the elites. Technology provided the material underpinning in the shape of military technology and of worldly splendour of the rulers. A ruler who lived in worldly splendour and claimed divine powers commanded greater respect and more obedience than rulers

⁹ Taxation may, of course, have taken many forms, such as a proportion of the harvest or other products, forced labour or military service or, in later times, money.

without these trappings of power. Technology had come a long way since the time when it provided only the barest necessities of life.

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