4-1-2001

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The Comparability of Ancient and Modern Civilizations

JOHN K. HORD

Abstract. One of the great questions in the comparative study of civilizations has been, how many civilizations are truly comparable? Are there factors which separate and differentiate civilizations so thoroughly that no comparison between them can be useful? This paper will address the problem of "the" difference between ancient and recent civilizations. It will be proposed that the major differences exist on a range of development rather than as some kind of unbridgeable gulf, and will suggest the possibility of a format for studying this range of development mathematically.

Leonardo da Vinci. Michelangelo. Lorenzo the Magnificent. Lucas Pacioli. Three of these names are familiar to all of us; the fourth is a noise in the dark. And this is odd, because Lucas Pacioli is arguably more important, certainly more influential, than the other three put together.

Fr. Lucas Pacioli (1445?-1515?) was a scholar friar who in typical Renaissance fashion wandered over northern Italy going from one employment to another, teaching in universities from Naples to Milan. He particularly emphasized the importance of application over theory, and collaborated with Leonardo da Vinci in a book on applied mathematics. [Brown and Johnston 1984:5-17]. He also gathered, organized, possibly to some extent invented, and most important published in comprehensible form – his book was the standard text for 100 years, and his precepts “were followed minutely for hundreds of years" [Chatfield 1974:45, 49] – the principles of double-entry bookkeeping. And where would modern business be without that?

So who cares about the history of bookkeeping? Michelangelo, Leonardo da Vinci, etc., are much more interesting. The result has been that such things are relegated to library
shelves obscure even among those of us who delve into libraries. One section of this paper will examine a technical development that is universally agreed to be very important: the growth of roads. All scholars of the ancient empires admit that these states depended for cohesion on their road systems, but it seems that the last book specifically about the development of ancient road systems was published in 1934. The main point of this paper is that this neglect of such problems is a mistake. During our own lifetimes the word “infrastructure” has become popular. This paper is a lesson in applied infrastructure, and not the kind made of concrete and steel.

Business Accounting

Since note has already been made of bookkeeping, the paper will begin with business mathematics. With the advent of computers, computation has become the central skill of the modern world. Anything that can be reduced to figures is, and the ability to produce numbers has become the mark of legitimacy in many fields of study. One could even define those leftovers that are still grouped under the ancient rubric “the humanities” as “those fields of study not amenable to mathematics.” Math is most thought of in terms of theoretical science, but it also affects infrastructure, in just such things as bookkeeping. Here progress has been rather more gradual than one might expect. Some very ancient objects have been suggested to be accounts, for example, “a wolf bone from Moravia, some 30,000 years old; it has fifty-five notches, arranged in groups of five”. [Baxter 1994:200]

Business is a very old institution, dating historically at least to the Sumerians and technologically long before that. The Aztec empire had a Neolithic technology but a market economy that used as standards of value cotton cloaks, copper bells (found as far north as Arizona), beads, shells, and especially cacao (chocolate) beans, used singly as small change to even out individual barters and in sacks of 24,000 for large purchases, to the extent that counterfeit cacao beans are known
[Weatherford 1997:17-19]. In Egypt, even as late as Ptolemaic times, there was an active prejudice against coined money, such that internal commerce was largely handled by warehouse banks issuing drafts against stated amounts of stored grain; these drafts circulated as a general method of payment. [Davies 1994:51-52]

In a more familiar line, the archives of the Syrian kingdom of Ebla, ca. 2500 BC, suggest that silver acted by weight “as the standard of currency, almost coming to act as an international currency.” [Pettinato 1991:93] The Code of Hammurabi, ca. 1750 BC, gives instructions on the validity of contracts. “The principle of credit was understood. It was common practice for drafts to be drawn in one place and paid in another.” Yet all of this was managed by that single ancient career group, the scribes, who would impress on a clay tablet the agreement, including items exchanged, future commitments made, and the names of the parties and the witnesses. Each person involved would impress his own personal seal to verify his part, and the tablet would be baked (sun or kiln, depending on its importance) and stored. That was the sum of development for a very long time. But there was no ruling measure of value in this period, so records were kept for each single item and every exchange was an individual bargain. [Chatfield 1974:5]

Some systems were more complex than others. In ancient China for example, the Zhou dynasty (1045-221 BC) already had separate accounts for specific taxes and disbursement funds. Some development is possible using such a proto-accounting system, and it survived until quite recent times. It was for example common practice in the United States during the colonial period and for some decades thereafter, especially on the frontier:

[Money...was extremely scarce, and until the 1820s trade was carried on largely without it. As a substitute they evolved a system of “bookkeeping barter” – barter with a time lag. For example, a dairy-]
man might deliver milk on credit to a tailor each day, and be paid with a new suit at year end. This required literacy and the ability of both parties to keep books in terms of an identical medium of exchange. In other respects the system could be just as primitive as some found in the ancient world. It needed just a record, or at most a balance, never a summary of all accounts. Ledgers consisted mainly of charges and credits to men's names. No attempt was made to isolate income, success being measured in terms of asset increases. Though known, double entry bookkeeping was rarely used. [Chatfield 1974:5-7]

Or people could recognize substitute currency. Tobacco served this purpose in colonial Virginia; and both in Virginia and along the frontier, for a long time deerskins were used, such that an accepted unit of currency was (the skin of) one buck.

But such makeshifts were gradually displaced by a more convenient standard unit of value, that is, money. There is much argument concerning just what qualifies as money:

A Belgian archaeologist who has excavated many Iron Age burials was criticized by several colleagues at a recent conference for referring to burials from this period as "warrior" graves, even though they contained spears, swords, shields, a male corpse clothed in armor, and in some instances the remains of a chariot. The critics asserted that these weapons and armor were merely status symbols and had only a symbolic function rather than a practical military one. Similarly, copper and bronze axes from the Late Neolithic and Bronze Ages, formally referred to as battle axes, are no longer classified as weapons but are considered a form of money. The 5,000-year-old Austrian glacier mummy recently reported in the news was found with one of these moneys mischievously
hafted as an ax. He also had with him a dagger, a bow, and some arrows; presumably these were his small change. [Keeley 1996:19-20]

Coinage of some sort seems to have been discovered at least twice independently. The conventional date for the invention of coins is 640/630 BC in the west Anatolian kingdom of Lydia [Weatherford 1997:30] China may have been earlier. “In Western Zhou bronze inscriptions [t]he worth of real estate and valuable items could be valued in numbers of strings of cowries. Precious metals also could be used for exchange purposes.” [Hsu 1999:581] Various inscriptions suggest that cowrie shells were already used as standard units of value under the Shang dynasty (ca. 1570-1045 BC), and individual specimens of cowries have been found in Shang and Zhou contexts. Spade coins are mentioned in an ode not later than the sixth century BC, and one inscription suggests the existence of spade coinage as early as the 11th century BC. Wang Yu-chuan assesses a reasonable probability that the spade coinage existed by the 11th century BC, and the knife coinage of eastern China by the 11th through 9th century BC. [Wang 1980:54-69, 106, 113, 129, 153] But actual circulation seems later:

Bronze money began to circulate in the late Spring and Autumn period (771-480 BC), the archaeological evidence for which is bu (spade-coins). These spade-coins are bronze miniatures of a two-pronged digging implement with a socket for a handle. Archaeologists classify these early coins into two groups. One group has been excavated mainly near Luoyang, the area of the Eastern Zhou court. The other group has been excavated mainly in Shanxi, the area of Jin. That these...spade-coins retain a hollow socket for a handle, while similar examples from the Warring States period (480-221 BC) display a solid handle, suggests that the coins of the Spring and Autumn period represent an early stage of development. [Hsu 1999:581]
However, these are only beginnings. The degrees of acceptance and complexity are also important. In Greece, the transition from a household to a commercial economy seems to have occurred only toward the fourth century BC.

Although Aristotle longs for the former [household] system, its replacement by impersonal coined money is what he actually portrays - and rues. This change was fundamental. In the early fifth century, the basic building block of Athenian society, the oikos, had been perceived as self-sufficient, producing for its own private consumption. But by the fourth century, agricultural products were increasingly being raised for cash sale; consumer items were now often being produced by commercial workshops; aristocratic marriages for dynastic continuity had disappeared. In the sixth century, nonagricultural income and property was, for the upper classes, politically negligible; by the fourth century, a variety of economic bases supported the propertied citizens and tended to obliterate differences of origin. This new system naturally required new functionaries. Beyond the exchange of currency, however, these money changers (called trapezitai) provided loans, accepted deposits, and served as intermediaries in facilitating commerce, becoming what we would term “bankers”.

Even in the absence of governmental fiat money or state paper currency, the Athenian private banks developed “paper” transfer and payment mechanisms that provided for expansion of the monetary supply. Widespread dependence on credit is universally recognized as characteristic of Athenian life. [Cohen 1992:6-7, 12, 190]

But one should not read into these developments the prototypes of J.P. Morgan. The operative statement would be more like, “so far, but not yet any farther.” Thus for example while
Chatfield assesses that it "does seem that banking was more highly developed in Greece than in any earlier society," he also notes that

A money economy never fully existed. Greece and Rome were in this sense transitional societies in which monetary assets were usually accounted for in monetary terms, while inventories and other resources were often recorded in physical units. [Chatfield 1974:10, 15]

In contrast to the development of coinage in and around the Mediterranean where the precious metals held the most important role, China concentrated almost exclusively on base metals for coinage with important consequences for the differential development of money in the eastern and western worlds. Because coins were confined to base metals the precious metals generally had to be used for all large purchases and had to be weighed in the primitive fashion even in modern times rather than counted, as with coins. Consequently, although China was easily the first to introduce "coins," the possibilities which they offered were not as fully exploited as in the western world, where, once invented, their development went ahead much more quickly. [Davies 1994:55]

Furthermore, even this level of progress was not permanent. During the first half of the first millennium AD there was a general decline of civilization all across Eurasia (fall of the Roman Empire, fall of the Han dynasty, etc.; see Hord 1987), and the use of coined money was one of the casualties of this decline. This is well-known for the post-Roman milieu, but also occurred in India (where for centuries very few coins were minted [Sharma 1980:53-54]) and China:

Decrease [of population] occurred, however, in the great Chinese cities, especially of the capital; furthermore we witness a disorganization of the monetary system, i.e. in China the reversal to a pre-
dominance of natural economy after some 400 years of money economy [Yang 1963:191]

The Northern Wei dynasty, which reunified northern China gradually during the period 409-439 and ruled this empire for some 100 years, did not even bother to mint coins until 495; then the coinage was still valued in terms of specific goods. When for example in 500 one man was awarded a grant of 10,000 strings of 1,000 coins each, the treasury stock was so insufficient that the difference had to be made up in silk, horses, cattle and slaves. [Eberhard 1949:240-241, 272-273]

Note further that although coined money itself became quite rare during these, so to speak, “Dark Ages,” the concept of the standard unit of value remained in place. This is obvious in China in that just-cited grant, which although actually made in kind, was awarded in terms of money, “10,000 strings of 1,000 coins each.” The same kind of preservation occurred in Europe, and set the pattern for more than a thousand years to come:

However, before the final disappearance of gold in the West, there was a short period in seventh-century Merovingian Gaul which saw a temporary relationship between gold and silver in which one pound (as a weight of silver) equaled twenty old shillings (which we would now call gold trientes) equaled 240 new pence (silver denarii). It was at this time that there originated the familiar arrangement of pounds, shillings and pence, which was almost universally employed in western Europe before the decimalisation of the last two centuries. On the demise of the gold triens (shilling) as a coin, and the decline of the weight of the silver denarius (penny) so that 240 no longer weighed a pound, the relationship remained in a fossilized form as a convenient means of counting silver pennies. A shilling came to mean a dozen pennies, and a pound to mean a score of dozens. [Spufford 1987:794]
The “Middle Ages” of Europe, India and China eventually all saw economic recoveries, with the return of money as a standard of value and the resurrection of banking. This happened much earlier in China than in Europe and India:

The old natural economy, under which pieces of taffeta were the normal measure of value and could be used for the purchase of anything from a camel to an acre of land, creaked and finally gave way, in 731, to an officially recognized money economy. Cash was the oil of commerce, and its acceptance was a boon to the rising merchant class. It was inevitable that the tax system of the seventh century should be superseded: in 780 the new “Double Tax” reform went into effect, replacing the taxes in kind and labor with a semiannual tax payable in cash. This change too was a response to the developing money economy, and the merchant class was vastly encouraged by it. [Schafer 1963:8-9]

Private initiative was responsible for the first instruments of credit. In the eighth century A.D. under the T’ang dynasty, when commercial activities were expanding rapidly, merchants found that large-scale transfer of cash was cumbersome, laborious, and perilous. They invented “flying money,” by means of which merchants, on depositing cash at certain specified offices, received a written receipt guaranteeing reimbursement in other provinces. In 811 the government prohibited the use of flying money by private citizens and adopted the system for its own credit transfers. Merchants were allowed to deposit cash at government finance offices in the capital against payments to be received in the provinces. A 10 per cent fee was charged on the drafts. [Balazs 1964:42]

By comparison, in Europe this period saw only a local economy and accounting. Records were kept not as a business
but as a personal obligation, so that employees and officials could prove that they had accomplished their duties properly. Banking itself seems to have redeveloped only toward AD 1200:

The first references to banking are found in the Genoese notarial records of the twelfth and thirteenth centuries. The acts of the Genoese notaries reveal that the so-called bankers had, by 1200, already extended their activities beyond mere money-changing and were invading the field of banking properly speaking. In the notarial records, we see them forming partnerships, accepting time and demand deposits, extending credit to customers, and even participating directly in business ventures beyond the seas. Occasionally, a contract shows them dealing in foreign exchange and advancing funds repayable at the fairs of Champagne, but transactions of this sort remained the exception rather than the rule. As yet, there was little specialization, and several of the so-called bankers were also cloth-dealers. [de Roover 1981:200-201]

One may also note the absence of one device that is usually taken for granted as part of this development:

The Arabian number system is found in Spain around the year 1000. The judgment that the Italian merchants were also familiar with the Arabian notation is nowadays also held because of a 1202 book by Leonardo Fibonacci of Pisa in [whose] book, entitled Liber Abbaci, the Arabian numeral system is explained and its use is recommended. [He] learned the Arabian numerical notation - which he called figurae Indorum - from his father, a merchant who in his youth had sailed the entire Mediterranean Sea. It is known that the Italian merchants and bankers resisted the introduction of Arabian numerals
because of the ease of fraudulent alteration of the figures. There is an element of truth in this objection, and it surely applied to the way of writing of those times. For example, it was easy to change 4,998 to 4,888, or to 9,999. However, in the Roman script the number appears as follows:

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MMMDCCCCLXXXXVIII
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Probably this was the underlying motive of the interdiction of 1299, issued by what in modern terms may be denoted as the “Industrial Council of Money Changers” in Florence, prohibiting the use of Arabian numerals in books of account. However, the fact that such a prohibition was issued implies that around 1300 Arabian numerals were already used. However, in Italy - up to the 15th century and sometimes also thereafter - the Roman numerical notation was most used. [ten Have 1986:32-33]

The beginnings of written accounting date to the thirteenth century [Harvey 1994:91]. Two ledgers of about 1300 may have used double-entry bookkeeping, though this “is not immediately clear...[which] raises interesting questions about the exact nature of the characteristics of double-entry.” [Nobes 1994:239] There is some possibility of an inter-civilizational interaction here. The Italians may have learned not just the numerals but also very many of their accounting methods from the Arabs. Arabic bookkeeping methods were well developed already in the tenth century, such that “an assumption that the Arabs influenced the development of bookkeeping in Italy has a very strong foundation; however, it has not been validated to this day.” [ten Have 1986:30] Pacioli’s *Summa de Arithmetica* makes a convenient end to this part of the study:

The “method of Venice” described by Pacioli in 1494 was so different from anything known previously that accounting history divides into two distinct
parts, one comprising the 5000 years before the appearance of double entry and the other the 500 years since. Between these two eras there occurs a sharp break in continuity, events of the earlier period seeming at first glance to have a certain historical interest but very little relevance to current accounting issues. [Chatfield 1974:4]

This was so final that the following 300 years have “been called accountancy’s Age of Stagnation” [Chatfield 1974:52].

The Road System

The next example of the developmental history of infrastructure will be one of the best-known tools for keeping a society together: the road system. Road systems turn out to be another very good example of the impermanence of progress. The road itself is a simple concept: clearing and otherwise improving a route of travel so that traffic can move faster. One may suggest that this started as soon as cavemen began removing sharp pebbles from the paths to their caves. The improved road is generally estimated to have been invented in the later 3000s BC, since it was at that time that the Sumerians invented the wheeled vehicle, and so presumably also noticed the utility of having something to drive it on.

In general there are no reports of paving even in the cities; Kramer comments that in the residential quarter of Ur (period not stated) “[t]he unpaved streets are narrow and winding” [1963:89] Only one source reports the remains of paved streets inside a Sumerian city, and one must suspect that these were confined to the official areas. The cited paving is a form of baked brick that seems too fragile for heavy loads, and the Sumerians allowed mud, dust, and garbage to accumulate until this pavement was completely buried, then laid a new one directly over the old. Even this vanished as Sumerian civilization declined. During the following age of migrations, the Babylon of Hammurabi shows no sign of paved streets. It was over a thousand years later, in the second half of the first millennium BC, that street paving reappeared...
in Mesopotamia. [Forbes 1934:71-78] Nearby in the Indus civilization the story is the same: urban brick-paved streets during the height of the civilization, followed by a long hiatus until, about the ninth century BC, street paving reappears, in a form not found elsewhere. Clay and broken pottery were pressed into place and fused by burning. [Hindley 1971:17-18]

There is no indication, however, that outside the cities the roads were anything other than blazed trails. The first well-known general road system occurred in the Persian Empire, but this is false credit. The Persians were lucky, in that a Greek named Herodotus wrote a book. That famous road system was actually first built by the Persians’ predecessors, in Assyria:

The domestication of the horse and its introduction into Mesopotamia by the end of the third millennium made a considerable impact on human life. Used for chariotry, first by the Mitannians and then by the Assyrians, it provided a mobile platform for shooting arrows, which in suitable terrain could dominate the battlefield. Used for cavalry, as it was by the Assyrians in the first millennium, the manoeuvrability and speed of the horse gave an overwhelming tactical advantage in battle, and contributed much to the success of the Assyrian arms throughout the Near East.

But the riding horse was not used only for war. It permitted rapid communications. This was the point at which the Assyrians made a positive advance. As the Assyrian empire made its greatest expansion from the eighth century, it became necessary, in order to control and administer this major power structure, to ensure regular and punctual communication between outlying administrators and the capital. The Assyrians made the horse part of this system. Chains of posting stages were set up across the empire, with relays of horses (or occasionally, in mountain territory unsuitable for horses, mules or donkeys). Along these routes mounted messengers could now make
rapid transit, so that, with the exception of Egypt, which involved the crossing of the Sinai desert, there was no part of the empire which could not send a message to the capital and receive an answer within about a week.

This implied the maintenance of highways. There is no evidence of paved roads away from the capitals, but there were certainly main routes which were kept clear and recognized as highways. [Road works in the mountains are cited.] With such attention to lines of communication in the mountains, it would have been surprising had the main highways not been well maintained in the plains. And indeed they clearly were. Although not paved, the highways were sufficiently well defined and permanent to be named as boundaries for fields in documents of land sale. Without question these were recognized permanent highways, maintained by the state to provide an efficient communication system. [Saggs 1984:196-197]

It was this system that was annexed and expanded to form the famous Persian courier system, and in terms of this paper it is noteworthy that Syria and Persia were the first great empires known in world history.

Two similar systems may be seen at this stage of development elsewhere, both also designed for the maintenance of empire. One is nearby, in the Mauryan empire in 3rd-century BC India. Here the main artery ran for some 4,000 kilometers from the western to the eastern frontier, complete with staging posts and guard houses as in Persia, and also (given the geography of northern India) considerable attention to ferries to cross the rivers [Hindley 1971:18]. In Han China (200 BC - AD 200):

[T]he Han road system was equaled only by that of the Romans. New roads from Sichuan to the south
were opened, one through Guizhou to Guangxi and Guangdong, and one to Yunnan. Han roads were avenues 100 feet wide, divided into three lanes: a paved central lane was reserved for the imperial posts, inspectors on assignment and local officials moving round their district; the two verges were for the use of carts, merchants' barrows and pedestrians. There were small posting stagings for mail every 5 li (about 2 km), a postal relay every 10 li and a larger postal station every 30 li along the Han roads. Postal relays were provided with stabling for horses, an inn for officials and for travelers authorized to use them. [They] often also had a private hostel for those not permitted to use the government inns. The Han road network with the accompanying system of postal relays and the fatigue parties that help to maintain them was not only the backbone of the economic system, but also and above all the key factor in Han military expansion and cultural penetration. [Pirazzoli-t’Serstevens 1982:76, 77]

It should also be kept in mind that in some ways Han China was centuries more primitive than its glorious reputation suggests.

Although iron appears at a Shang site at Gaocheng in Hebei, this is meteoritic iron. The earliest man-made iron pieces discovered to date are iron parts of bronze swords [etc.], none of which dates before the late Spring and Autumn period. Literary records and archaeological data seem to be consistent with respect to iron. In the state of Jin, in 536 B.C., an iron cauldron was cast on which was inscribed a law code. This event is frequently cited by historians to establish the early rise of casting iron. This has now been substantiated by the discovery of an iron cauldron
from the late Spring and Autumn period at a Changsha site in 1978. [Hsu 1999:579]

It was only in the century of Han’s founding that China completed the transition from the bronze to the iron age, replacing bronze weapons with iron ones. [Watson 1961:146-147] The Chinese cities were still located almost exclusively in the north, primarily in the Hwang Ho valley, such that “commerce was largely confined to this area and did not extend to the middle and lower Yangtze regions.” [Sadao 1986:574] And in spite of the presence of a well-developed structure of government, of the nine cabinet-level ministries, none was charged with transportation. The job was handled by one of eight sub-ministers, and then as superintendent of waterways and parks, not of roads. [Loewe 1986:470]

A third example is in the Americas, at a later date of the calendar but even earlier than Han in terms of developmental level. During the Inca period Peru was just entering its bronze age. Nevertheless the Inca rulers managed a network of roads, of which the major highland artery ran some 5500 km, built in some cases at elevations well above 5,000 meters. The entire system has been estimated at 40,000 km long. They conquered obstacles that could not be bypassed, and it is quite certain that some lengthy stretches of road away from the cities were paved:

I never surveyed an Inka road that was paved continually over a great distance. Such roads exist, however, on the eastern Andean slopes where rainfall is high and continuous paving becomes necessary. They tend to run through grass, bush, and forest, and are of limited width (1-3 m), probably because they are difficult to construct and often confront steep slopes.

These roads seem to have been an Inca creation. It is possible that any use of older roadways was purely accidental. [Hyslop 1984:215, 224, 232-233, 246, 271] Roads did, however, exist as long as
There are some fairly long improved roads elsewhere. Corduroy (log) roads are found in Europe, possibly as early as the third millennium BC in England and certainly by the middle of the second on the Continent; these continued to be built into recent times. The Romans used log roads over boggy areas that would not support their more famous work; and when most of the Roman road system went to ruin, the technology of the Middle Ages was still good enough to keep these log roads in repair (a Carolingian edict of 864 specifically requires this). The accounts of a Spanish traveler report that such roads had also spread into eastern Germany and Bohemia during the tenth century. [Hindley 1971:9-12; Forbes 1934:46]

The invention of the long-distance paved road is associated with the Romans. This is an error. Fifteen hundred years before Rome, in the Middle Minoan period (ca. 2000-1500 BC), Crete had a system of paved highways crossing the island in a north-south direction, such that “between the roads of ancient Crete and the modern U.S. Highway No. 40 no more than half a dozen technical discoveries have been made that are of any significance.” [Schreiber 1961:115] These developed gradually during the Middle Minoan period but, again, do not seem to have survived it; and “even the best Hellenistic road never reached the perfection of the Minoan road.” [Forbes 1934:55] In later times we find grooved roads, in effect, hand-carved wagon ruts, meant initially to keep sacred traffic moving in a stately manner and later used for other traffic. Otherwise roads were meant for pedestrians. The Greeks had an active prejudice against riding in a vehicle:

[Ernst] Curtius [German archaeologist] suggests that there was a politico-psychological reason for this: to the ancient Hellenes, especially when republicanism was at its height, the use of a vehicle was regarded as incompatible with the simple, manly life which meant that vehicles of any kind were reserved almost exclusively for women (but priestesses were
forbidden to use them!). Anyone who traveled by chariot within the precincts of the city was regarded as proud and overbearing, but even on the open road a man who used a vehicle was regarded as either effeminate or ostentatious. Even state officials were no exception to the rule: express messages were carried by foot. [Schreiber 1961:110-111]

It would seem that commercial traffic was not enough to overcome this prejudice, nor was it allowed to become so.

And so we reach the Roman roads. For these only a few numbers need be given. They began to be built in their classical form about 300 BC, with the system reaching completion under the early empire. So far, 12,000 kilometers of roads have been mapped – in just the single province of Britain, which was nearly the last conquered. The total extent of the system is not known. Not all the roads were paved; those that were paved varied from routes through mountain passes, with only the central meter of road being paved, to major carriageways with a central paving forty feet wide and a paved sidewalk on each side twenty feet wide. (The name “sidewalk” is anachronistic; from the wheel ruts, it may be that the “sidewalks” were for wheeled traffic, the central paving for pedestrians, i.e. infantry). The roads seem to have been built with an intended life of 70-100 years, though repair records suggest the heavily used ones were in a deplorable state by that time. [Forbes 1934:138, 140, 146, 159-160]

The fate of these roads may be a useful lesson for the assessments recently in fashion to the effect that Rome never actually “declined,” but only mutated into something else. The last major additions to the road system were made by the emperor Hadrian (117-138). By then only the highways and military roads were being paved; other routes were gravel-surfaced. “In general repairs may have been insufficient, especially after 200 A.D.” [Forbes 1934:128, 143, 160] And there was a gradual rise of a problem of another kind. In the early empire “the imperial power [kept] every corner of the earth safe from bandits,” “orga-
nized groups of robbers are simply not heard of.” But by the 150s AD a traveler “expected to find a bandit problem in the province of Asia,” and beginning in the reign of Antoninus Pius [138-161] “the African provinces were disturbed by Moorish incursions of unusual depth and frequency.” [Macmullen 1966:193-194, 203, 261-264] The wars of Marcus Aurelius (161-180) “left bands of runaway slaves and deserters roaming through Gaul, Spain and Italy.” [Birley 1972:122] This continued and even worsened. And as regards the roads themselves:

The first [things] to fall into decay were the wooden bridges, which were never repaired, and the roads suffered accordingly, for the rivers had once more to be forded and, apart from one or two exceptions (Zeugma on the Euphrates and a few Roman towns in Germany), the fords were some distance from the Roman roads. In the wooded areas trees fell on the roads and were left lying, and no attempt was made to repair the damage done by flood-water, so that the flagstones subsided and even pedestrians found the going difficult. Traffic on the short stretches which were still usable was confined to local transport – peasants’ carts on their way to market – but soon they too were reduced to mere piles of stones which were fair booty for anyone who cared to remove them. Near the towns they disappeared completely, while in the country they were used to mark the boundaries between fields and private estates. [Schreiber 1961:156-157]

There came next in Europe the Middle Ages. Trade began to recover, but regardless of the heritage from the Romans, roads, other than the log roads, do not seem to have been part of the European culture inventory.

From the tenth century on, the roads of Europe were thronged with traffic of the most diverse kinds,
and the overland routes were increasingly used. Yet, although the traffic was comparatively heavy, little or no attempt at road maintenance was made even along those stretches that still followed the line of some long since overgrown Roman road. Although the conditions of medieval roads were fractionally better than those of the seventeenth and eighteenth century, they were often little better than dirt tracks, dusty in summer and virtually impassable quagmires in winter. Nevertheless it is possible that the roads of Europe between the tenth and sixteenth centuries were more suited to the demands made on them than was later to be the case. Somewhat less speculative is the fact that wheeled traffic was far less common and wheeled passenger traffic virtually unknown. Not until the reign of Elizabeth I did the English monarch have an official traveling coach and before that time in England, as in much of Europe, even the greatest men of Europe expected to do their traveling on horseback. [Hindley 1971:48, 49, 52]

An even greater problem than the small number of roads was the large number of thieves, and this continued to be the case into very recent times. But commerce was sufficient that, even away from the great sea and river ports, town life gradually recovered. Conditions remained primitive enough that this could happen in a very random way. In 1156, after a quarrel with a neighboring bishop, a south German duke tore down the bridge across the river between their lands. A neighboring monastery then erected a new bridge a short distance upriver. “Within two years...the settlement at the new crossing had become so prosperous that Duke Henry set up a mint and a town began to emerge from the salt trade – it became known as Munich.” [Schreiber 1961:160]

These European roads remained primitive until the eighteenth century. However, the wars of Louis XIV began a time of
political consolidation in Europe such that improved communications became a vital necessity to the warring states. By the end of that century roads and associated factors, if still far below even 19th-century standards, were improving dramatically. And this prepared the way for another kind of development.

The new tactical principles of offence and mobility suggested a strategy of seeking battle rather than manoeuvre. With improved firepower, holding operations could be performed by smaller numbers of troops. It would thus be possible for a commander to divide his main forces into separate offensive columns, a converging net of detachments, which, if they could move fast enough, should be able to trap an enemy and force him into battle. Guibert [Essay General de Tactique, 1771] suggested that the enterprising general should ignore the fortresses which had obsessed so many eighteenth-century commanders, and march straight on the enemy’s capital: that being the main objective. The idea of such a strategy was made more realistic by the great improvement in communications during the second half of the eighteenth century, particularly roads and canals. Agriculture and industrial productivity were also increasing, and armies could once again expect to live off the country in which they were operating, thus largely dispensing with cumbrous baggage-trains.

These more ambitious and complicated strategical concepts, on the other hand, demanded an ever improving administrative organization in peace time. Until the French revolutionary wars began in 1792 these new military principles remained mostly debatable and untried theses. [Montgomery 1968:331]

Commanders who knew how to make use of these conditions were dramatically successful. In France the purges asso-
ciated with the Revolution were particularly effective in bringing such commanders to the fore. The most successful of them, Napoleon, appreciated the new conditions to the extent that “he spent roughly twice as much money on roads between 1804 and 1812 as on military fortifications. If one includes the 31 million francs he spent on bridges, then his roads cost more than the numerous buildings he erected in Paris and the official buildings in the French provinces.” [Schreiber 1961:212]

But this exploitation of the new mobility could also become dependence on it, and this may have been the ruin of Napoleon.

In Russia, Napoleon found conditions with which he was unfamiliar – a vast country with few good roads and without supplies, and a sprawling organism of state with no heart at which he could aim a decisive blow. His failure to adjust himself to these conditions is considered by many of his critics as proof that his genius was not creative; he could take over a military machine, improve it, and manipulate it with incredible skill – he could not create a new one. [Montgomery 1968:365]

At this point we have reached the growth of the modern roadway and may turn to another example of the history of infrastructure. The final example to be studied in this essay will be the development of the written word.

**Writing**

Writing has been considered so essential as to be a necessary qualification for a people even to pretend to the status of “civilized.” This is an error, as may be seen from two problems. One is that a historical instance exists in which a people had writing, lost it completely, had to re-invent it in an entirely new form, and nevertheless considered their civilization to include the earlier period quite as much as the later. This is no less than ancient Greece, in which a form of writing (Linear B) existed in Mycenaean times and was lost so thoroughly in the following
Dark Age that a new alphabet had to be adapted from the Phoenicians some three or four centuries later. Yet the *Iliad* and the *Odyssey* depend on elements from Mycenaean times, and the Greeks would have been dumbfounded by any suggestion that these belonged to another civilization. Writing was just not that important. Even classical Greek (and also Roman) civilization remained essentially oral:

It may be symptomatic of this state of affairs that literacy and illiteracy often go unnoticed or unemphasized in Greek and Roman contexts in which we might expect one or the other to be mentioned. The democratic politicians of classical Athens show no interest in mass education, as far as we know. A rustic such as the one who appears in Theophrastus’ *Characters* would commonly have been illiterate, but the detail is not added. In Lucretius’ account of the invention of culture, little attention is given to the art of writing. [Harris 1989:30]

The other problem lies with the nature of “literacy.” Writing is a nebulous concept. For the verb “write” *The New World Dictionary* [1951:1688] lists, among other definitions, “to form or inscribe (words, letters, symbols, etc.) on a surface, as by cutting, carving, or, especially marking with a pen or pencil.” This is so general that it may include even painting and various kinds of sculpture. Civilizationists who make writing a prerequisite for the status of “civilized” find it necessary to include as “writing” strings coded by knots, else the Inca Empire would not qualify. Such string coding is found all over the world, among peoples with very little pretension to civilization; tribes in Nigeria, Tanzania, Hainan, Bengal, California, and all over the Pacific are specifically cited [Diringer 1962:32, 1968:7]. The bead wampum used by some North American Indian tribes could also serve as a formal record. But the most developed string code is certainly the Inca quipu, a string of strings coded by knots, which was in fact a remarkably flexible instrument. Knots were by no means the only coding on the quipu:
Basically, the quipu maker designed each quipu using color coding to relate some cords together and to distinguish them from other cords. The number of colors on a particular quipu depends on the number of distinctions that are being made. The overall patterning of the colors exhibits the relationships that are being represented. The color coding of cords that are compactly connected together and likely to become intertwined, shares with the resistor color system [in electronics] the function of uniting the visual with the tactile. Also, recall that quipu cords can be on different levels, have different directions, and have relative positions. Another feature shared with the resistor color system is that meanings for color and meanings for positions are used in combination with each other.

Yarns dyed different colors were available to the quipu maker. Additional cord colors were created by spinning the colored yarns together. Two solid colors twisted together gives a candy cane effect, two of these twisted together using the opposite direction gives a mottled effect, and the two solid colors can be joined [end to end] so that part of the cord is one color and the rest of it is another color. And the cord colors thus created can then be spun together creating new cord colors. With just three yarn colors [and there were many more], say, red, yellow, and blue, and three operations of candy striping, mottling, and joining, consider the distinctly different cord colors that are possible. There is red alone, yellow alone, blue alone; red and yellow striped...red and yellow mottled....red above yellow...[etc.]. Selecting from these fifteen and using the same operations on them, there are many more.

In some cases, the quipu maker extended the subtlety of the color coding by having a two-color
combination on one cord retain the significance of both colors rather than taking on a significance of its own. In these cases, a cord made of one color yarn had a small portion striped or mottled with a second color. Thus the overall cord color had one significance while the inserted color had another significance. [Ascher and Ascher 1981:20-21]

And there were other variations, for example in materials: cotton, llama, vicuna, alpaca, or combinations of these. Nor is our understanding necessarily complete; only some 400 quipus are known, all of them because they were buried in the desert with their makers [Ascher and Ascher 1981:68], a situation in which one may expect some specialization to have been practiced.

There are other systems. The notched stick is found all over the world, and occurred in Europe at least until 1826, when the British Treasury ceased recognizing tally sticks as official receipts for payments [Gaur 1984:20](and burned out Parliament in the process of disposing of them in 1834). In China, the earliest known possible ancestors of writing are symbols engraved on turtle plastrons and dating ca. 6500-5500 BC, though “early Zhou texts all suggest that writing gradually expanded in its uses at the beginning of the Zhou dynasty or, possibly, at the very end of Shang (ca. 1000 BC).” [Allan 1991:15, 17]

But the development leading to modern writing is certainly that of pictograms. This occurred quite early; one might speculatively include even the cave painting from the European Paleolithic and various petroglyphs from around the world. (Just as an undelivered letter remains a letter, so communication with the spirit world remains communication, even if we do not recognize the addressee.) Not quite as speculatively, Denise Schmandt-Bessarat [1992] has inferred that the clay tokens found in many Neolithic sites represent a primitive accounting system, with first geometric shapes and then pictures of them having specific meanings, beginning as early as 8000 BC. The development of a much more advanced pictographic writing occurred fairly
suddenly in Sumer toward 3000 BC:

It seems almost incredible that what was already a very complex administration should have managed to survive for long using simple methods of control we have been dealing with up to now. Hence we can well imagine that an attempt would have been made to expand the system. In fact, during the Late Uruk period we see the emergence of several different methods of this kind, until finally, at the end of this era, writing appears in its first form. After so many attempts to expand, in so many directions, the extent of what could be recorded – and there were certainly many others of which we know nothing because they have left no traces – it seems an almost logical conclusion that finally a universal means of control – writing – should have been invented, with the help of which everything could be recorded that seemed worth recording. In fact, writing, in so far as it is identifiable, appears in our finds to be well developed from the outset. [Nissen 1988:85, 87, 89]

In its beginning Sumerian writing consisted of some 900 pictograms, “and even this total may be only a fraction of those actually in use at the time.” After 500 years these had adapted to their writing medium, clay, and became some 600 to 700 cuneiform characters. Further evolution occurred nearby in Elam, where the cuneiform was adapted into 113 symbols, 80 of them syllabic. A similar evolution but at first with opposite effect happened to Egyptian hieroglyphics, which over the centuries “became progressively more cluttered with auxiliary signs which, though their intent had at one time been to ensure a correct reading of the words, were now inserted quite uselessly and redundantly.” [Diringer 1962:18, 36, 43] After Egyptian civilization ended, a successor arose southward in what is now the Sudan, called the Meroitic Empire.
The Meroitic inscriptions were discovered in the Nile valley between the first cataract in the north and Soba, on the Blue Nile, in the south. They belong mainly to the second to fourth centuries A.D., but may in part be attributed to the first or even to the second century B.C. The script had two types: (a) the monumental, hieroglyphic form of writing, and (b) the cursive, demotic type. Both are descended from Egyptian scripts. There are, however, fundamental differences; the Meroitic scripts are purely phonetic and with the exception of two syllabic signs, are alphabetic. All the ballast of ideograms, bi-consonantal signs and determinatives, which rendered Egyptian scripts so intricate, has been discarded. The number of signs has thus been reduced to twenty-three. There are no ligatures and the words are separated by two or three dots placed vertically. [Diringer 1968:140]

Since we in the West are indoctrinated to alphabetization, we tend to think of it as a necessary element of the progress of writing. This may be another error. Chinese characters are a very complicated script, but right next door to China is Vietnam, with a language not Sino-Tibetan but Austroasiatic. Nevertheless, classical Vietnam used Chinese characters to represent either Chinese or Vietnamese. The French imposed a Romanized alphabet of 24 letters and assorted accents and diacritical marks, a technique useful enough that it has survived independence. If alphabetization is so useful, one would expect this Vietnamese quoc-ngu writing system to be adaptable, and to have been adapted, into other similar languages. It has not. Korea also used Chinese characters for its educated discourse, and also (under royal patronage, yet) invented its own alphabet. Even the source of this invention was not enough for the Korean alphabet to displace Chinese characters from regular use. Japanese practices have been even more complex, using Chinese characters (kanji or
(kana-majiri) for most words and pronouncing them according to three different systems (depending on when and from what part of China they were borrowed), and also using a Japanese syllabary for such things as grammar, prepositions, tenses, phonetic complements, and foreign words. Japan also has a Romanization: the Hepburn system (romaji), and for some time after World War II it was thought that romaji might displace the old system. It has not.

There is some thought that the system of Chinese characters was responsible for holding Chinese civilization together during the period of division after the fall of the Han dynasty:

Still more decisive may have been the nature of the Chinese writing system, which did not reflect regional or dialectical differences in the pronunciation of Chinese. While European "barbarians" and the Romance inheritors of Latin soon found themselves split into several linguistic groups, the Chinese and their "barbarian" invaders remained closely tied to classical Chinese for all purposes of writing, and China therefore continued to be a well-knit cultural unit. [Reischauer 1955:149]

This may be overdrawn – Latin and Greek, after all, remained the languages of writing in their respective halves of the former Roman Empire in spite of local vernacular growths – but it does remain the case that the former Roman Empire was split among several different successor civilizations, while the former Han Empire was eventually reunited into a single China.

The written word once established, the next question becomes, what is done with it. In early Mesopotamia and Egypt there were already the beginnings of libraries, tablets sorted by subject (medical works, etc.) and kept in chests or sometimes in jars. In earliest Egypt some tablets were marked with year dates and perforated, which may mean that they had been strung together as a sort of running record. It is not known how the hold-
ings of the first libraries were indexed, but memory was still a very normal indexing device in those times. “[I]n the very earliest records the librarian goes with the king or the investigating committee when they go to look up the records.” [Richardson 1914:148-150]

The earliest known great libraries are from Mesopotamia, a consequence of the durability of clay tablets. The first is the some 20,000 tablets and fragments thereof in the archives of Ebla, only about 500 years after the development of writing itself. Giovanni Pettinato classifies the tablets into four subject-groups, administrative, historical, lexical, and literary. [Pettinato 1991:55-60] The most famous of these libraries comes from one of the last kings of Assyria, Ashurbanipal (669-627 BC). The collection was a miscellany, including nearly a thousand business documents and some 1500 letters besides what would now be called reference books. Texts were identified by type, but the categories had other purposes than ready reference. Grammatical and bilingual texts, for example, were tagged:

Palace of Ashur-bani-apal, king of the world, king of Assyria, who trusts Ashur and Ninlil, to whom Nabu and Tashmetum have granted a wide-open ear, and have endowed me with clear insight into the noble art of writing; whereas none of the kings who had preceded me had acquired that art, the wisdom of Nabu, the grouping of all extant collections on tablets I wrote, compiled, and revised, and placed them to be seen and revised in my palace.

Omen texts were labeled:

Palace of Ashur-bani-apal, king of the world, king of Assyria, darling of the great god, to whom Shamash and Adad have given a wide-open ear and the science of the seer, the mystery of heaven and earth, the wisdom of Shamash and Adad has he heard, with it his breast has been filled

and possibly more. [Olmstead 1961:491-493]
No other great libraries are known until that of Alexandria. There is thought that the Library of Alexandria was modeled on that of Ashurbanipal [Parsons 1952:206 n1], but no intermediaries have been found. The Greeks seem to have developed book-learning very much from scratch, and more slowly than may be guessed.

Fully alphabetic writing was invented by Greeks in or shortly before the eighth century B.C., probably well before 750. In the inscriptions of the eighth and seventh centuries, of which L.H. Jeffrey registered about 100, the largest group of surviving texts served to identify the owners of ceramic vessels; a few inscribed tombstones are known, a few religious dedications and a few draftsmen’s signatures. Some of the earliest Athenian inscriptions on ceramics create the impression, by the insistence on the verb *graphein* and by their repetition of the first few letters of the alphabet, that writing was still an impressive achievement. At Dreros, in eastern Crete, laws of no great length were inscribed on stone in the middle or late seventh century, and the Athenians later believed that in the 620s, in Draco’s times, they had first had written laws – a plausible belief, at least as far as homicide law is concerned. The conclusion which should be drawn from all this is that archaic Greece reached no more than a rather low level of craftsmen’s literacy. It would be astonishing if as much as 10% of the population as a whole was literate.

Literacy was never a popular cause or a subject which interested democratic politicians. They did not see mass literacy as a sign of, or a necessity of, democratic government or think that a democratic government ought to foster literacy. No classical city is known to have required all free-born boys, let alone girls, to attend school or to learn to read or
write; nor is any city of this era known to have subsidized elementary education in any way. In fact the earliest philosopher whose writings are known to have had reverberations in and soon after his own time was Xenophanes of Colophon, [not] much before the last quarter of the sixth century.

The functions of writing in public life seem gradually to increase after 480. It is in 405 that we first hear of a personal collection of books, that of Euripides. Who in fact was the first truly bookish individual among the Greeks? Some might say Euripides, but by the standards of the later Greek intelligentsia, the best answer is Aristotle, for he is the first extant writer who makes it plain that he has consulted a large number of written works for himself. (In the third century BC) it was thought more and more the responsibility of governments to maintain written records. Already when Theophrastus wrote his *Laws* towards the end of the fourth century, there was an Athenian rule that the officials had to receive written notice of a sale of real estate at least sixty days before the sale could take effect; and in some other cities the officials were supposed to keep up-to-date property registers. This represents a growth of governmental power, but also a stronger belief that the most vital facts needed to be recorded in writing. The likely overall illiteracy level of the Roman Empire under the principate is almost certain to have been above 90%. Even for the most educated populations – which would mainly have been found, I think, in Greek cities in the fourth to first century B.C. – the range is to be sought, if we include women and country people, far above 50%. [Harris 1989:22, 45-47, 61-64, 75, 85, 99, 121]

The relative primitiveness of the use of the written word
in classical times may also be seen in the very lack of development of reading aids inside each book:

[T]he whole battery of aids to reading and comprehension which the reader of today takes for granted – the separation of words, systematic provision of accents and breathings, punctuation, paragraphing, chapter headings, lists of contents, footnotes, indexes, bibliographies, etc. – simply did not exist in the ancient world nor (and this is important) was their absence felt, however indispensable they may seem to us. [Roberts and Skeat 1987:73-74]

The decline of ancient civilization was, again, reflected in the use of the written word, or rather in its increasing disuse. The early Middle Ages are well known for a lack of literary material – this is why historians label the period “the Dark Ages” – but the beginning of this condition may be seen while the Empire was still reasonably intact, in the fourth century AD:

The papyri show that in Egypt certain kinds of business documents, leases and sales contracts, were much less used in the fourth century, and especially after the 330s, than they had been in the third. The main cause may have been a sheer contraction of economic activity, but documentation may also have come to be regarded as less necessary. The decline of banking in the Roman Empire in the decades around 300, a complex problem in itself, is likely to have meant in the end that city-dwellers had rather less to do with documents. (Diocletian’s) taxation system soon died of its own complexity, at least in Egypt, where our knowledge is best. What replaced it in that province were successively cruder systems, which relied on much lower levels of information and presumably of documentation; it is probable that by 341-42 the government had ceased to differentiate
between the levels of tax to be paid on different qualities of land. The so-called "library of properties," the register of properties on which an accurate census might in theory have been based, is attested no more after 319. In any case documents generated by the administration of the towns eventually grow much rarer. The trend is clear from the 340s and very marked indeed in the last third of the century.

In the north African provinces, there are still some signs of municipal offices at work in the second half of the fourth century. That probably ceased to be the case in all the regions which were affected by barbarian invasions in the fifth century. The steep decline in the production of literary papyri in Egypt comes in the fourth century (the peak was in the second century), and while there is no way of measuring this trend in other places it was presumably one which affected the whole Empire. This was at the same time a symptom of and a cause of a profound cultural change, an extensive loss of awareness of past achievements in history-writing, in philosophy, in all genres of imaginative literature, and eventually in mathematics.

Many if not all the works of Cicero were impossible to find even in a considerable town such as Hippo in Augustine's time (ca. AD 400). In the literary world of the late fourth century and of Sidonius Apollinaris, well-to-do intellectuals obtained their books by borrowing them from their acquaintances and having them copied, and friends might send copies of their own works; booksellers are seldom mentioned. [Harris 1989:289-298]

There remain two other developments in the history of books and libraries that are already well known, the inventions of paper and of printing. Of this last it should be noted that neither Gutenberg in the fifteenth century nor the Chinese in the seventh
century were the first inventors of the art. It may even be said that printing antedates writing; the Sumerian cylinder seal is a device for multiple identical reproduction of a specified piece of information on a standardized medium of communication, and the oldest cylinder seals are older than the oldest writing. [Nissen 1988:85-87] Beyond this there is one of the most curious mysteries in archaeology, what appears to be a printed record, found on Crete of the Middle Minoan period.

In 1908 the so-called Phaistos disc, one of the most puzzling objects ever discovered, was found in an outbuilding of the Minoan palace at Hagia Triada. The disc, 160 millimetres in diameter, and preliminarily dated 17th century BC because of some tablets of that date found next to it, is inscribed on both sides. "Inscribed" is perhaps not the right word: a text, arranged in bands spiraling either to or from the centre, has been impressed with forty-five different wooden or metal punches into the originally soft clay.

There are altogether 241 signs arranged in groups (words?) divided by vertical lines. Nothing similar has ever been found in Crete – or indeed anywhere else. The method of impressing the signs by means of specially prepared matrices (practically a form of printing with movable type) has apparently never been repeated, and it seems strange that such matrices should have been cut solely for the purpose of producing one single inscription or imprint. The signs themselves are clearly recognizable pictures of human beings, parts of the human body, objects, houses and plants. They bear no resemblance to the ancient pictorial script of Crete or indeed to any other hieroglyphic form of writing. The fact that we can neither read this text nor identify the individual signs used for its composition, and that nothing similar has so far come to light, puts us at a distinct disadvantage as far as meaningful interpretation, or even meaning-
ful speculation, is concerned; it does not however alter the facts. Somewhere, for reasons we cannot yet comprehend, more than 2,000 years before experiments with movable type were made in the Far East, the basic principles of typography were understood and used by somebody in the ancient Mediterranean world. [Gaur 1984:144-145, 194-195]

Thus, three basic examples of the development of infrastructure in world history. It remains next to suggest the place of such problems in civilizational studies.

One of the great questions in the comparative study of civilizations has been, how many civilizations are truly comparable? Are there factors which separate and differentiate civilizations so thoroughly that no comparison between them can be meaningful?

Various catastrophic fault lines have been proposed: that “Orient” and “Occident” are so incongruous as to be incomparable, that “secular” and “religious” cultures have such different orientations that similarities can be only superficial. But there is one obvious physical difference among civilizations that makes comparative studies appear particularly ridiculous. The populations of the early civilizations were quite small. As late as the reign of Rameses II (thirteenth century BC), for example, Egypt is estimated to have had a total population of only about three million [Durant 1954:214]. At the beginning of the Christian era one finds population estimates for the Roman Empire on the order of 100 million, for the Han Empire, on the order of 20 million. Nowadays these would count only as average to large states, in a technological milieu that has grown vastly more complex. Can there be any real comparison between such different periods?

This study of infrastructure has been intended to give the impression that, for most of history, progress has been slow and by no means necessarily permanent. But “technology” has always existed; it is not a monopoly of the modern West.
Neolithic cultures depended on their technology; the three traditional qualifiers for Neolithic status are dependence on agriculture, use of polished stone tools, and use of pottery; and all these involve technological advances over Paleolithic (in the Americas, Paleo-Indian or Lithic) techniques. This paper submits that the major technological differences between ancient and recent, and for that matter between any, civilizations can be allowed for in comparative studies, and indeed that these differences do not affect most comparative studies. This is because as a civilization acquires new technology to integrate its units or to expand into new areas (geographic, economic, whatever), it will tend to accomplish this integration and expansion to the limit of the new technology. This is obvious in two cases cited earlier in this paper, the Assyrian and Napoleonic empires. The Assyrian communications system was never able to integrate Egypt effectively, and Egypt remained only intermittently a province of the Assyrian empire. Field Marshal Montgomery, cited earlier, specifically remarks how the Napoleonic war machine foundered in roadless Russia.

Therefore a hypothesis is proposed: *The size and the level of integration of a civilization tend to be in balance with the social technology available to the civilization, so that differences in social technology among different civilizations tend automatically to be canceled out in civilizational comparisons* – unless, of course, the effect of social technology on individuals is precisely what one is studying. This hypothesis is the subject of the remainder of this paper.

Such a proposal implies there must be some comprehensible mechanism through which “social technology” would operate. The following is an intuitive suggestion as to what such a mechanism could be.

“Social technology” would involve the binding together, or lack of it, of those parts from which the polity may consider itself constituted. It is proposed that the key factor in any such problem is communications, the ability to transmit data without garbling (counting disobedience and sloppiness as forms of garbling). Well prior to our modern communications revolution
there was a tremendous efflorescence of social technology, such that one civilizationist prefaced his magnum opus with the statement that “the one dominant central fact of European history over the last thousand years has been the almost steady growth of public authority and the public services” [Quigley 1961:ix]. Roads and books are obvious instruments of communication; money and banking are intended for the communication of resources from one place or person to another and so would also qualify.

It should be possible to make maps of the social technology of each civilization at any point of time, and even to make an evolutionary map of it over several points in time. For this, consider the possible existence of a measurable variable in the development of social technology. For initial treatment this determinant will be called “connectivity,” a term borrowed from that branch of mathematics called topology, which may be defined as the study of systems of coordinates. (For easy visualization one may think of the study of the mathematical natures of different kinds of surfaces— for example, changing a sphere into a donut (torus) – which are included along with higher-order systems.) An area’s social technology would be the physical and organizational basis of the network of connecting links between points. Connectivity may tentatively be defined as the relationship among three variables:

- The number of different types of decision relations (elected council, bureaucratic hierarchy, ad hoc consultations, etc.), which may vary at different levels of the society;
- The number of autonomous nuclei dealing in each type;
- The effective units of distance between them.

The key words in this proposed definition are “autonomous” and “effective.” Autonomy is a very relative thing, such that a theoretically pure command flow, e.g. a bureaucracy, may in practice reduce to a situation such that His Majesty’s Imperial Enforcers must pay frequent visits even to collect some small share of the taxes. Official descriptions of theoretical levels of complexity are very unreliable indicators. Thus for example, the Roman Empire under the dominate (fourth century AD)
had a famously more elaborate and oppressive political system than under the principate (first and second centuries AD).

The question asked was whether a government characterized among modern historians as particularly oppressive and intrusive actually touched people’s lives more after A.D. 284 than earlier. The answer at least for Egypt (where, by reason of desert conditions, more documents have survived than elsewhere) was no. [Macmullen 1990:9]

At least a part of this was caused by the sheer ineptitude of this amplified late bureaucracy: “An entire decree might have to be re-enacted, in almost identical form, eight or ten times, evidently because no one had paid any attention to it,” and even more drastic instances of evasion of both the law and the official police are cited. [Macmullen 1990:67] Thus even when local units are supposed to be totally subordinate, the existence of multiple overlapping and poorly defined and maintained chains of authority will nevertheless send the state to the edge of disintegration.

The modern communications revolution and its predecessors noted above would in this hypothesis be inputs to connectivity in the field of effective distance. As that newborn creature the automobile commuter has discovered, “distance” is a function at least as much of time as of space. When discussing the integration of a civilization, the importance of the time factor can be overwhelming. “Effective distance” is measured in units of time, in hours per horseback mile, or in communications satellite availability, or in the presence of those Roman and Inca roads over which the imperial army and the commercial trader could march when need arose – or in the presence of an inconvenient mountain range to complicate that route over which crows so straightly fly. Time is very much of the essence.

Note further that in connectivity study, time measurement is, unlike the standard image involving clocks and calendars, not a simple linear flow. The goat track over which a mes-
enger can speed across a mountain will be totally inadequate for a merchant caravan, much less a cavalry regiment; the automobile commuter’s travel time is heavily dependent both on whether his chosen route is a one-lane alley or a five-lane freeway and on the number of other users on the same route at the same time; a communications satellite is much more useful with a thousand channels than with only one. Connectivity-time is a volumetric flow, such that quantity of communicated data (including trade goods, armies, etc. as data) per unit effort becomes the factor involved. Thus for example, as noted earlier in this paper, “writing” was not a simple revolution but something that evolved over a considerable length of time. An alphabetically written message on paper is a much more flexible instrument than cuneiform on clay. Nor is even this a simple linear measurement.

Alphabetic writing has many good points, but it is restricted to readers and writers of each specific language at issue. Chinese characters are much more difficult to learn, but can be read by anyone familiar with them, whether or not the reader and writer know the same spoken language, even when reader and writer come from different language families. Alphabetic writing goes from meaning to sound (the spoken language) to writing (the written language) and so is understood only by people who speak those sounds; Chinese characters, though often based on a homophone current some thousands of years ago, go from idea directly to writing, and so could bind China together in spite of repeated centuries of political division. Systems of connectivity are in the first place different from, not merely “better” or “worse” than one another. At the present level of investigation, “better” and “worse” are very dangerous judgments to make.

This point also implies just why connectivity mechanisms tend to cancel out in most comparative studies, and in the process it returns to the hypothesis that began this section. As communications improve and effective distance decreases, the physical size and complexity of the polity can and do increase without harm to the polity’s ability to function. The increase in size and number of authorities that comes of such expansion is
balanced by the decrease in the size of the effective distance between them, so that the overall degree of connectivity remains the same. Thus, to note three revolutionary polities which my work has suggested to be specimens of the same type, a small member of a differentiated state system such as Rome of 509-490 BC, an equally primitive and physically larger but accidentally better connected state such as Egypt of ca. 1570-1550 BC (with the Nile connection), and a modern tremendously larger and more differentiated one such as the Soviet Union of 1917-1939, can remain connectively equivalent, and the constitutional dynamics of the three specimens can be roughly the same. Growth in social technology is balanced by increasing size and complexity, and so cancels out in comparisons of polities widely separated in time.

On the other hand, connectivity mechanisms cannot be neglected in detailed studies over shorter periods, because this process of cancellation is neither quick nor, usually, comfortable for the peoples involved. Thus also on a more diachronic basis, one could write a history of the Roman Empire in terms of the effort first to formulate, then to maintain the Roman imperial system – though, probably, a vast majority of the necessary data are still to be collected.

**Conclusion**

This paper will conclude with three observations, two regarding procedure in connectivity study, the other a sort of application. The points regarding procedure are words of caution. One is straightforward: In normal history and archaeology, explanations of causation, however desirable, are still subsidiary to the events themselves. But connectivity study is something new in this respect; what appears in other works as interpretation is likely to be basic data here. Take for example a very ancient item. Pottery is usually held to predate civilization itself. The particular forms of its construction are good indicators of culture change and, for some peculiar forms (e.g. the Greek amphora), even for economic change. But what place does pottery itself hold in social development, i.e. why was it invented in the first place? The conventional answer has been part of its traditional standing
as one of the three key indicators of the Neolithic revolution, along with polished stone tools and subsistence agriculture. Pottery is required to process or store the additional food produced by subsistence agriculture. But this solution has been seriously endangered by the finding of a continuous sequence of pottery in Paleolithic Japan:

Pottery began as early as 10,500 BC in Japan within terminal Pleistocene foraging economies and slowly spread in the following 2000 years throughout the three southern islands in the Initial Jomon period. Thereafter, pottery slowly expanded in frequency, variety, and sophistication in the succeeding 9500 years, during which time native plants were brought under cultivation, before cereal agriculture was introduced. [Brown 1989:205]

Therefore, however much the agricultural revolution may have contributed to the success of pottery in a large part of the world, it cannot be counted a sole cause or even a necessary maintenance factor. The social position of even so basic an item remains open to question. Thus further, all the sociological conclusions that have been drawn based on that accepted social position of pottery are also thrown into question.

A similar example may be found in an item mentioned earlier, the falling-off of commerce consequent to the decline of the Roman Empire. This appears very straightforward: shipping of cargo decreased, therefore commerce decreased. But when one examines the nature of these Roman imperial cargos, it turns out that very many of them were not business but tribute, brought to the imperial capital or its military garrisons by transports which made the return trip in ballast. [Pounds 1973:58] One must expect that with the collapse of the empire such tribute shipments would end as well, but this does not necessarily say much about the nature and extent of actual commerce at the time. There was a major decline of actual trade consequent to the end of the empire, but it is a different question from the end of the tribute relationships.
The other procedural caution is that connectivity study is probably going to require a much more multi-civilizational viewpoint, a considerably greater open-mindedness, than anything this Society has ever before attempted to handle. This may be illustrated by combining two examples. For the first, there is a lot of argument as to whether animals, any animals at all other than ourselves, are intelligent. Some of these arguments revolve around points of theology, others around problems in defining intelligence. How can we tell what intelligence is when we see it? Consider one coyote:

Coyotes appear to enjoy puzzling situations. Possessing seemingly unlimited patience and perseverance, they willingly seek solutions to problems they encounter. The following account of a captive coyote illustrates this ability. Although the coyote was fed on a commercial diet, chicken feathers were found in the coyote’s den on several occasions. Chickens wandered freely on the surrounding grounds, but it was difficult to believe that a chicken would willingly enter an enclosure containing a coyote. To discover the solution to the mystery, an observer watched the coyote from a hidden location. After the coyote received his usual meal, he placed several large chunks of his food near the fence of his pen. The coyote then hid. Soon several chickens began to peck at the food. Eventually, a chicken selected the morsel closest to the coyote. Patiently waiting until the chicken was engrossed in its meal, the coyote pounced, seizing the chicken by its neck. Still ignoring the food remaining in his dish, the coyote began to eat his preferred dinner! [MacMahan 1978:51-52]

The other half of this illustration returns to our own species. Traditional China had a profoundly humanistic view of the
world, so its answers to problems also tended more toward the humanistic than the technological. Specifically, how has Chinese civilization kept together over the last thousand years, in spite of civil wars and dynastic disruptions?

What the mandarins needed was not technical proficiency for governmental functions but a claim to authority that no one would dare to attack. To give them such authority was the purpose of their endless studies and difficult tests. This made the mandarins’ seemingly quite irrelevant training as practical a preparation for the exercise of power as has ever been designed. It was more than a systematic ideological indoctrination. It was above all a profound and immensely successful system of justification of governmental authority, erected upon the only universal and indestructible foundation for any man’s claim to be obeyed by other men: intellectual and moral superiority, demonstrated in impartial tests that only a man who was thoroughly learned could pass. Only the wicked would dare to object to a system of government under which the wisest and best of men were given the highest positions. [Buttinger 1958:292]

Between the mandarin and the coyote one would think that the member of our own species would be easier to comprehend. But not all problem-solutions are technological, at least not in any sense of the word that modern Western civilization would recognize. The coyote’s problem-solution was a technological fix such as we Americans readily understand. The food was used as a lure, a tool; such an action fits our preconceptions. The mandarin, existing in an ontological rather than a technological situation, is outside these preconceptions, so he belongs to the “inscrutable” East. It is an absolute certainty that some of the mechanisms dreamed up by people in other civilizations to maintain links with each other are so thoroughly different from any-
thing we know that even looking squarely at them, we would not recognize them as being there at all. And those most different from our own way may, simply because of those differences, be the very ones that allow us to understand the basic construction of such things. I shall therefore suggest that, even more than usual, we must proceed on the basic assumption that we do not know what is going on. Perhaps that way we shall eventually discover enough variables that the promise of mathematics can actually be applied.

The third observation is a prediction. In the millennia since civilization started, its individual units have become much larger and more complex. Connectivity study suggests there is going to be much more of this process to monitor. At least since the invention of the concept of progress, we historians have had an ingrained tendency to consider our own time as a sort of summit or completion of history, as though prior developments have been some kind of chronicle building up to ourselves. But to lift an observation from William Faulkner, the past is not dead; it ain’t even past. With the advent of the communications satellite and the Internet, the world presses in ever more strongly, to the point that a border dispute in the Persian Gulf was able to create a united world operation in just a few weeks; and Robert Reich, in his *The Work of Nations* (1991), was able to observe that business has become so international that the elites of the great businesses hardly belong to any one country any more. The world is going to be united. It may be united easily, or it may come with a lot of difficulty. But barring a world agreement to abolish computers and satellites, it is going to come. We have a choice only in the means.

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