TECHNOLOGY AND SOCIETAL DEVELOPMENT

A principal concern of philosophy of technology is how technological development influences the course of societal interrelationships at different stages of societal organization, as well as how specific stages of societal organization and culture affect technological development. Among philosophical approaches, technological determinism sees technological development as a spontaneous evolutionary process requiring a given society to organize itself so as to make efficient use of the technologies becoming available. It also seizes upon individual technological innovations as immediate and direct causes for fundamental social change. A second approach views technological advance as a consequence of the development of human spirit and culture. The most generally held view is that technological change is the cause of profound societal change at certain points in human history, while at other times societal change stimulates technological development. Followers of this third approach attach widely varying weights to the two sides of this interaction.

The discussion in Sect. 1 of this interaction between technology and society will be organized around the historical sequence of key stages of human societal development. The aim here is not to unfold a chronology of technology, but to examine the intricacies of the interrelationships between technology on the one hand, and the complex of science, culture, and socioeconomic organization on the other.

1.1 Role of Technology in Human Evolution

The interconnections between technology and society begin with the evolution of the human species. It is therefore appropriate to begin this section with the three-way interaction of technological, societal, and biological interactions that have led to the emergence of the modern human species *Homo sapiens.*

The unique character of human toolmaking and tool use along with the uniqueness of bipedality suggests these two factors as the primary stimulus for the evolution of the modern human being.

The evolutionary line of the modern human species, *Homo sapiens,* can be traced backward through at least two earlier species of the genus *Homo,* namely *Homo habilis* and *Homo erectus,* to the bipedal genus *Australopithecus*, originating in Africa some five million years ago, branching off from the family of the primates from which the modern chimpanzee descends (Hood, 1993). Bipedality frees the hands for many activities, including using tools. The first fossil evidence for tools appears later—some 2.5 million years ago—stone choppers, scrapers, and sharp flakes, probably used for stripping meat and skin from bones (Napier, 1993, pp. 43–44; Howells, 1993, p. 118; Isaac, 1976, p. 487), leading some scholars to suggest that the development of the brain was a more important factor in human evolution (Lovejoy, 1993). On the other hand, the tools that we observe among pongids like the chimpanzee today such as stripped branches for prodding termite nests or stone anvils for cracking open hard fruits (Candland, 1987; Goodall, 1968) are not likely to leave a fossil trail, so that it is not unreasonable to assume (even without evidence) that the early bipedal hominids not only did not lag behind the pongids in toolmaking, but also had begun to advance in their use of tools.

Apart from structural changes favoring bipedal locomotion, the fossil trail from the australopithecines to *Homo sapiens* is marked by significant increases in brain size (Falk, 1993, p. 64); changes in the bone structure of the hand (Napier, 1993); a lowering of the larynx so as to increase the space between the larynx and the back of the nasal cavity, thereby enhancing the possibility for articulate speech (Laitman, 1993); and a decrease in the size of the canine teeth (Skelton et al., 1993). Toolmaking, development of the hand, socialization of food consumption, increasing differentiation in vocal communication, and mental development move forward in the evolutionary process as an integrative whole, a development in one area contributing to the development of the others.

1.2 Hunting and Foraging Cultures

The term *hunting and foraging* is generally used to characterize both the level of technological development and form of societal organization within which this technology is applied. The first evidence of hunting, probably by *Homo sapiens*, appears some 100,000 years ago in northwestern Germany, where a fossil elephant with a wooden spear nearly eight feet long between its ribs was found. Apart from the weapons themselves, the earliest symbolic representations of their use are the cave paintings with hunting scenes in northwestern Spain and southwestern France painted perhaps some 10,000 to 30,000 years ago.

To overcome the lack of information about the technological culture of ancient hunting and foraging societies, it is necessary to consider recent and contemporary hunting and foraging cultures, such as the Mbuti people in the Ituri rain forest in Zaire. These people lived until the 1980s much as they had thousands of years ago, with a cultural form that is essentially pre-stone age. The primary economic standard is one of adequacy, the mobile lifestyle mitigating against accumulation of private property. The adult men, women, and unmarried youth all participate in the hunt. Mbuti net hunters establish their symbiotic relationship with the forest ecology by a culture of minimal hunting, spending a daily average of only four to five hours away from camp (Turnbull, 1983, p. 138).

The close cooperation of women and men in the hunt and the division of labor between them are reinforced in their hunting songs, which are always sung in round form, utilizing a technique that recreates the cooperative patterns required by the hunt. The other major types of song, the foraging song and the death song, also reinforce the appropriate patterns for the corresponding activity. Except for the lullaby, none of the songs can be produced by a single singer. The ritualistic character of the singing suggests that this art form is viewed as a necessary component of the hunt itself.

The egalitarian character of Mbuti society is characteristic of most hunting and foraging societies, generally marked by the absence of hierarchical structures. Group members make decisions collectively or through councils of elders. The prestige of certain individuals is based on respect for their achievements as outstanding hunters or foragers. The individual function of the chief stands out; he gives leadership in dealing with conflict with other groups of people. A second individual function is that of the shaman, who is believed to have special powers in connection with the group's religious beliefs or mythology, and a third is one with skills in rituals practiced by the group, such as a dancer or singer (Coudert, 1991, p. 398). Although a certain degree of social division of labor, partly based on levels of skill, emerges in hunting and foraging societies, the society is essentially free of social conflicts, the disputes and tensions that do arise do so as conflicts among individuals and are frowned upon by the other members of the society. It is for this reason that many social philosophers reject the sociobiological views asserting that humans are genetically conditioned to be aggressive and acquisitive.

1.3 Transition from Mobile to Sedentary Cultures: Crop Cultivation, Animal Domestication, and Social Differentiation

The first major revolution in social organization associated with technological developments appears to have occurred toward the end of the Ice Age in the period 12,000 to 10,000 B.C. in the Near East. Sedentary settlements and the subsequent development of crop cultivation and domestication of animals were accompanied by relatively rapid technological changes in comparison with the preceding millennia, resulting not only in the increase in production above the subsistence level, but also in the emergence and deepening of social stratification within the population. This process, culminating in the formation of great city-states, occurred in Mesopotamia, Egypt, China, India, Mesoamerica, and the Andes.

Donald O. Henry (1989, p. 4), on the basis of suggestions from Binford (1980) and Gould (1982), sees the first signs of technological change as involving a transition from *simple foraging* to *complex foraging*. Henry summarizes simple foraging as “a high mobility and movement to resources” and *complex foraging* as a “collecting strategy in which greater residential permanence is maintained through storage and logistical acquisition of resources.”

The increased productivity that resulted from this transition led both to population increase and social differentiation. The new technology involved not only a new level of foraging activity, but also qualitative changes in the handling of the products as a result of the increased quantity of goods and people. Administrative problems seem to arise when more than two hundred people engage in coordinated activity. Structures that appear to have been communal storehouses suggest the need for administering and redistribution of the goods stored. Similarly, ceremonial structures suggest leaders (Henry, 1989, p. 212), and some central management may have been needed for housing the larger population.

A widely accepted model of social development through several stages of the social reorganization that began with the production of a food surplus has been put forward by Fried (1967). Fried suggests that the domestication of animals and plants initiated a series of changes in social organization from the egalitarian societies of hunters and foragers to the formation of what he calls rank societies, then into stratified societies, and finally to the formation of the state.

The rank society is characterized by the emergence of an individual, such as a chief, whose principal function is the redistribution of the products derived from the technological activity. According to Fried, in a stratified society, essential basic resources become the private property of a ranked segment of the community. Fried makes a distinction between what might be called the personal property of an individual or family, that is, objects of immediate use or consumption, and the basic resources that are needed to produce them (pp. 193–96).

The state emerges as an institution that stabilizes the stratification through control over the productive resources and products. Haas (1987, p. 2) defines the state society "as a type of society in which rulers have control over production or procurement of basic resources and as a result exercise coercive power over their respective populations."

Stone-walled dwellings and storage pits are evidence of sedentary settlements; stable storage of food was necessary beyond that immediately consumed (Henry, 1989, p. 19). The production of such a surplus is needed since life cycles of plants and, to a large extent, animals are tied to the seasons of the year. Stored supplies can be exchanged among different communities or even be produced specifically for exchange.

Once the technology to produce a surplus is available, the possibility for continual accumulation of a wealth of products arises, although this potential has not been realized uniformly everywhere, since subsistence-level economies persist to this day. Therefore, Fried's model of social evolution must be viewed as a tendency rather than a specific sequence of stages through which every coherent community of people must pass.

The change from mobile to sedentary cultures involves a division of labor in two distinct areas: the organization of production and the associated infrastructures for production and storage on the one hand, and the administration of the process of redistribution for consumption on the other. The managerial/administrative functions are often combined with the role of leader in ritualistic functions, since the rituals to a large extent are considered necessary components of the technology. The increase in the storable surplus also creates the conditions for the separation of the product from the producers through increasing bureaucratization of the administrative/managerial function. Those appropriating the product ultimately must establish state institutions based on a morality justifying the social stratification and also set in place means of physical force to enforce the new social morality.

1.4 Occupational Specialization in the Bronze and Iron Ages

Bronze metallurgy was introduced about 3300 B.C. in Mesopotamia and Egypt. This technological change was not a revolution in the sense of the speed with which it spread, but in the economic, political, and social consequences of the use of metal in weapons and tools. The new technologies significantly increased the level of agricultural production and thereby stimulated larger-scale irrigation projects. The agricultural surplus made possible an increase in the number of people who could separate themselves from agriculture, thus contributing to the growth of urban settlements. The rank societies turned into stratified state societies by the fourth century B.C., with the political and economic control centered in temple-cities ruled by priest-kings. Iron metallurgy appeared about 2200 B.C. and was in widespread use by 1100 B.C.

During the same period, the plow, the horse, and wheeled vehicles were introduced. The workmen involved in the mining, transport, and smelting of ores and in producing tools may have been the first specialists separated from agriculture who did not raise their own food and were not part of the ruling bureaucracy. It therefore appears that by the third millennium B.C. technological development in Mesopotamia and Egypt had reached a level that could sustain the principal types of social stratification we now find in contemporary populations except, perhaps, for a strata of intellectuals. The first intellectuals, the mathematicians of Babylon, may have also emerged in this period, but evidence for their presence does not appear until the second millennium B.C.

1.5 Reckoning Technology, Mathematics, and the origins of Writing in Mesopotamia and the Americas

Along with the first evidence of cultivation of cereals in Syria and Iran, the harvesting or hoarding of grain, and the domestication of animals, occur finds of small clay objects of various geometrical shapes—spheres, cones, disks, and cylinders. Each type of token served as a counter for a definite quantity of a particular food or other basic commodity stored or delivered. These tokens have been found throughout the Middle East, with the earliest dated about 8000 B.C. in the Zagros Mountains of Iran (Schmandt-Besserat, 1992, pp. 40, 168).

After the emergence of city-states in the fourth millennium B.C. , accounting acquired a new importance. The tokens, originally sealed in small clay containers (envelopes) were now impressed on the clay envelopes into which they were placed so that the contents were visible on the envelopes themselves. Ultimately, the tokens became unnecessary, as their shapes and markings were reproduced on clay tablets. A conceptual leap toward abstract thinking then occurred. Quantitative and qualitative aspects of the goods became symbolically separated, so that a token of one shape represented a given commodity, while a second set of tokens represented the quantity. The wedge-shaped impressions developed into the system of writing known as cuneiform (Latin *cuneus,* a wedge).

In the Peruvian Andes in the eighth or ninth century, a period of major state formation, a system of knotted strings called *khipus* (Patterson, 1991, p. 43) was used to keep accounts. The *khipus* did not lead to writing, however. The Mayans later adopted a system of writing from other peoples and refined it with both ideographic and phonetic elements. They used it to record events and dates, deeds involving the nobles, the position of the stars and planets, religious rituals, and calendar reckoning, but there is no evidence of its use for accounting. The failure to develop written accounting and, except perhaps for calendars, the largely noneconomic use of writing were manifestations of different paths of technological development as compared, say, to Mesopotamia. The absence of large domesticated animals restricted the transport of goods, and the resulting fragmentation of the economies further limited technological development (Gille, 1986, p. 424). The Mayan, Inca, and Aztec rulers never developed the technological infrastructure that could tightly link the conquered peoples into vast, geographically expanding empires. The extraction of tribute and the continual pillaging of weaker neighbors by the stronger city-states in the Andes and Mesoamerica evoked resistance that could not be permanently repressed, ultimately allowing a small number of Spanish invaders, with their superior military technology, to form local alliances in order to destroy the Inca, Aztec, and Mayan states (Patterson, 1991).

The first sign of activity that can be called *scientific* (according to our current understanding of scientific knowledge) in antiquity is the development of mathematics in Babylon, known to us from tablets written between 1800 and 1500 B.C. The Babylonian tablets contain lists of conversions of measurement units, multiplication tables, and mathematical exercises. The calculations concerned practical problems such as work quotas, food requirements, and wages for workers; materials for wells and building construction; weights and measures; and inheritance and compound interest (Hooke, 1954, pp. 786–91). Ancient Egyptian mathematics was more geometrically oriented than was Babylonian, its greater sophistication attributable to greater economic complexity and more diverse technological activity. The availability of mathematical methods coordinating elaborate economic projects made it possible to undertake construction projects of increasing complexity (pp. 790–92).

The tokens, *khipus*, and the types of calculations represented on the tablets seem to indicate that mathematics did not arise as an aesthetic intellectual pastime, but was an integral part of the application of technology to the economy. Subsequently, the Greek philosophers of the fourth to first centuries B.C. separated mathematics from technology and integrated it with logic, a process that culminated with Euclid's hypothetico-deductive system of geometry.

1.6 Technological Development and Blockage in Classical Greece

Despite the emergence of Greek science concurrent with the technological advances between the sixth and third centuries B.C., no revolution in production occurred on the scale that might be expected.

The usual explanations for this "technological blockage" are based on the economic and social structures of the Greek city-states. Most Athenians were peasants, and played no direct role in the political life. *Citizens* lived in the cities and neighboring villages, were generally landowners, and did not engage in manual labor or crafts. Their economic well-being was based on extensive domestic, craft, and field labor by slaves taken as spoils of war (Anderson, 1974, pp. 29–52; Lilley, 1965, pp. 32–33). It was simpler and cheaper to put slaves to heavy work than to construct machines to do it (Lilley, 1965, p. 32). The mechanical arts, increasingly being left to slave labor, could not be respected by the ruling elite. According to Aristotle, since artisans, historically, were slaves or foreigners, the "best form of state will not admit them to citizenship" (*Politics,* III.5.1278a.5–10). "Some men are by nature free, and others slaves, and that for these latter slavery is both expedient and right" (*Politics,* I.5.1255a.39–41). "For that some should rule and others be ruled is a thing not only necessary, but expedient; from the hour of their birth, some are marked out for subjection, others for rule" (*Politics,* I.4.1254a.20–25). "No man can practice virtue who is living the life of a mechanic or labourer" (*Politics,* II.5.1278a.20–25).

Free men, according to Aristotle, would best realize their nature through the sciences—above all, through politics, "truly the master art" (*Ethics,* I.2.1094a.25). Such ideological blockage could only have led to technological blockage. It has also been suggested that the Greek view that mechanics could be reduced to a rational, closed system based on the five simple machines (lever, pulley, screw, winch, and wedge) failed to leave room for the role of experiment in the development of mechanics, which in effect had been limited to statics (Vernant, 1957, p. 217).

The stagnation discussed here is relative to the far more rapid developments in Europe in the second millennium A.D. The gradual improvement in the technological system that characterized Greek technology after the third century B.C. was continued by the Romans, who acquired through their conquests the technological traditions of Greece, the Near East, and Egypt, absorbing whatever was useful for them from other peoples in their expanding empire. Individual Romans did gather information about technological practices in various parts of the empire, but little attempt to coordinate or codify it was made (Gille, 1986, pp. 320–26). Although the towns grew, the propertied classes maintained their traditional disdain for trade (Anderson, 1974, p. 81). While the Romans did not introduce revolutionary changes in the technological system, they did make important improvements in hand tools, agriculture, architecture, city planning, the use of water-powered grain mills on an industrial scale, and the building of aqueducts, cisterns, irrigation canals, and roads.

1.7 Technology and Society in China

The history of Chinese technology paralleled in time and in some fields even excelled the early technological developments of the classical civilizations of the Mediterranean and the Near East and, later, of Europe (Needham, 1954–1967). Chinese interest in philosophy and science unfolded at about the same time as in Greece. The Chinese had already learned to write by the fourteenth century B.C., well before the Greeks (Haudricourt and Needham, 1963, p. 162). Yet by the second half of the second millennium A.D. European technology moved decisively ahead of Chinese technology.

Needham discusses in detail what he sees as the reasons why China took an early lead in so many areas of technology and then failed to maintain it. The country's topography and agriculture required a vast network of waterworks for flood protection and irrigation, especially for wet rice cultivation, and a far-flung canal system whereby the tax grain could be brought to granary centers and to the capital. A highly centralized system emerged in which the emperor assumed the role of one great feudal lord governing and collecting taxes through a gigantic bureaucracy that became known as the “mandarinate.” The mandarinate collected taxes and mobilized unpaid labor (similar to corvée labor of European feudalism in which a serf is required to perform a day of unpaid labor by a feudal lord) for the water projects. They enjoyed no hereditary succession, and were recruited afresh in each generation through state examinations based on literary and cultural subjects that rarely included what might be called scientific subjects (1969, pp. 195–97). Under this system, referred to by some Chinese scholars as “bureaucratic feudalism” (pp. 177–79), the economy was based on taxation in kind, so that money was not widely used. The mandarinate was not salaried by the state, but supported itself through its administrative powers over agricultural production and whatever wealth it could garner from its bureaucratic functions in the towns.

The value system that favored the development of merchant wealth in the feudal towns of Europe found no parallel in China. While capital accumulation in Chinese society was possible, “the application of [capital] in permanently productive industrial enterprises was constantly inhibited by the scholar-bureaucrats, as indeed any other social action which might threaten their supremacy” (Needham, p. 197). “There is nothing in Chinese history resembling the conception of a mayor or burgomaster, alderman, councillors, masters and journeymen of guilds, or any of those civic individuals who played such a large part in the development of city institutions in the west” (p. 185).

Since Chinese philosophy was not capable of allowing the mercantile mentality a leading place in the civilization, it was not capable of fusing together the techniques of the higher artisanate with the methods of mathematical and logical reasoning that the scholars had worked out, so that the passage from the Vincian to the Galilean stage in the development of modern natural science was probably not possible.

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