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SOCIAL ANTHROPOLOGY OF TECHNOLOGY

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At the onset of the 20th century, anthropologists such as Balfour, Marett, and Haddon could readily identify three spheres of strength in anthropological research: material culture, social organization, and physical anthropology (49). The study of technology and material culture, however, was about to be jettisoned, and with stunning finality. By 1914, Wissler (103:447) complained that the study of these subjects "has been quite out of fashion." Researchers were giving their attention to "language, art, ceremonies, and social organization" in place of the former almost obsessive concentration on the minute description of techniques and artifacts, and on the tendency to study artifacts without regard for their social and cultural context. As I aim to show in this chapter, the anthropological study of technology and material culture is poised, finally, for a comeback, if in a different guise. Its findings may significantly alter the way anthropologists analyze everyday life, cultural reproduction, and human evolution.

If this all-but-forgotten field is to play such a role, it must overcome nearly a century of peripheral status. In anthropology's quest for professionalism, material-culture studies came to stand for all that was academically embarrassing: extreme and conjectural forms of diffusionist and evolutionist explanation, armchair anthropology, "field work" undertaken by amateurs on collecting holidays, and the simplistic interpretation of artifacts shorn of their social and cultural context. Malinowski, for instance, condemned the "purely technological enthusiasms" of material culture ethnologists and adopted an "intransigent position" that the study of "technology alone" is "scientifically sterile" (69:460). The study of technology and material culture, a topic that

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was (and is still) perceived as "dry, even intellectually arid and boring" (92, 5), was relegated to museums, where—out of contact with developments in social anthropology and deprived of ethnographic experience—museum scholars lacked the resources to advance the field. For their part, cultural anthropologists argued that studying techniques and artifacts could only deflect anthropologists from their proper role—that is, from studying culture. Kroeber & Kluckhohn, for example, dismissed the term *material culture* out of hand, arguing that "what is culture is the *idea* behind the artifact" (55:65). "Accordingly," Kroeber argued, "we may forget about this distinction between material and nonmaterial culture, except as a literal difference, that is sometimes of practical convenience to observe" (54:296). For anthropology, jettisoning material culture studies was a necessary step in establishing the scientific basis, the intellectual appeal, and the distinctive subject matter of the discipline.

Periodic attempts have been made to revive the seriously ill patient (e.g. 21, 34, 49, 59, 65, 66, 85, and 88), with their pace quickening in the 1980s (43, 44, 62, 63, 72, 73, 84, 92, 96). Yet, arguably, no real resuscitation has taken place, owing largely to the continued insouciance with which Anglo-American anthropologists regard the study of material culture and technology. In a recent restatement of the Kroeber & Kluckhohn view, Bouquet (13:352) condemns the "recent bids to reinstate the 'materiality' of material culture," as if such bids stemmed from some Philistine conspiracy, against which she prefers recognition of the "hegemony of linguistic approaches to the object world." Noting that the excesses of early material-culture scholars were rightly pilloried, Sillitoe laments that the "mud seems to have stuck more to artifacts and their study ... than to the [evolutionists'] wild-guess theories," which have themselves enjoyed a modest comeback (92, p. 6). As it stands, a topic with which anthropology was once closely identified—the cross-cultural study of technology and material culture—has been largely taken up by scholars working in other fields, such as the history of technology and the interdisciplinary field known as science and technology studies (STS), or by anthropologists with marginal appointments in museums or in the general studies divisions of engineering and technical colleges.

Despite the peripheral status of the anthropology of technology and material culture, compelling questions remain: What is technology? Is technology a human universal? What is the relationship between technological development and cultural evolution? Are there common themes in the appropriation of artifacts that bridge capitalist and precapitalist societies? How do people employ artifacts to accomplish social purposes in the course of everyday life? What kind of cultural meaning is embodied in technological artifacts? How does culture influence technological innovation—and how does technological innovation influence culture?

These questions are far from trivial—and, arguably, only anthropology can answer them. No other discipline offers sufficient comparative depth or appropriate methodologies. The challenge still remains, as Malinowski himself put it, to understand the role of technology as "an indispensable means of approach to economic and sociological activities and to what might be called native science" (69:460). And the challenge is even greater now that scholars generally concede that language, tool use, and social behavior evolved in a process of complex mutual interaction and feedback. Summing up the consensus of a conference titled "Tools, Language, and Intelligence: Evolutionary Implications," Gibson concludes that "We need to know more about the ways in which speaking, tool-using, and sociality are interwoven into the texture of everyday life in contemporary human groups" (29:263).

In this chapter, I argue that social anthropology has already discovered a great deal about human technological activity—especially when anthropological findings are interpreted in the context of recent, stunning advances in the sociology of scientific knowledge (11), the history and sociology of technology, and the emergent field known as science and technology studies (STS). Collectively, these fields, without much anthropological involvement, have developed a concept, the *sociotechnical system* concept (48), that refuses to deny the *sociality* of human technological activity. Developed mainly in social and historical studies of industrial societies, the sociotechnical system concept, I seek to show, serves fruitfully to integrate anthropological findings about *pre*industrial societies into a coherent picture of the universals of human technology and material culture. The central objective of this review, then, is to convey the sociotechnical system concept to an anthropological audience, and to show how it resolves key controversies within anthropology. The results should prove of interest to anthropologists working in fields as diverse as cultural ecology, ritual, symbolic anthropology, ethnoarchaeology, archaeology, and human evolution studies.

One reason for the rapid advance of STS is its refusal to accept the myths of science and technology at face value. Mulkay (74), for example, shows that sociology's refusal to develop a sociological analysis of scientific knowledge stems from sociologists' uncritical acceptance of a mythic Standard View of science. I suggest that the achievement of a truly *social* anthropology of technology likewise requires extending anthropology's recent productive venture into reflexivity (18, 70)—specifically, by making the mythic Standard View of technology explicit, and resolutely questioning its implications. For this reason, this essay begins with the Standard View of technology, and although its purpose is to present the sociotechnical system concept and explore its implications for anthropology, it is organized as a series of attacks on the implications of the Standard View.

THE STANDARD VIEW OF TECHNOLOGY

Like the Standard View of science (74: 19-21), the Standard View of technology underlies much scholarly as well as popular thinking. A master narrative of modern culture, the Standard View of technology could be elicited, more or less intact, from any undergraduate class. Occasionally, it is made explicit in anthropological writings (e.g. 39). By suggesting that such a Standard View exists, I do not mean to imply that every scholar who has advanced some part of it necessarily endorses the rest. In what follows, I deliberately use the masculine pronoun to stand for humankind; to do otherwise would strip the Standard View of its gender ideology.

Necessity is the mother of invention. As Man has been faced with severe survival challenges, certain extraordinary individuals have seen, often in a brilliant flash of inspiration, how to address the challenge of Need by applying the forces, potentialities, and affordances of Nature to the fabrication of tools and material artifacts. The power of Nature is there, waiting to be harnessed, to the extent that the inventor can clear away the cobwebs of culture to see the world from a purely utilitarian standpoint. In this we see Man's thirst for Progress.

Form follows function. To be sure, Man decorates his tools and artifacts, but artifacts are adopted to the extent that their form shows a clear and rational relationship to the artifacts' intended function—that is, its ability to satisfy the need that was the raison d'être of the artifact's creation. Thus, a society's material culture becomes a physical record of its characteristic survival adaptation; material culture is the primary means by which society effects its reproduction. The meaning of human artifacts is a surface matter of style, of surface burnish or minor symbolization.

By viewing the material record of Man's technological achievements, one can directly perceive the challenges Man faced in the past, and how he met these challenges. This record shows a unilinear progression over time, because technology is cumulative. Each new level of penetration into Nature's secrets builds on the previous one, producing ever more powerful inventions. The digging stick had to precede the plough. Those inventions that significantly increase Man's reach bring about revolutionary changes in social organization and subsistence. Accordingly, the ages of Man can be expressed in terms of technological stages, such as the Stone Age, the Iron Age, the Bronze Age, and so on. Our age is the Information Age, brought on by the invention of the computer. Overall, the movement is from very simple tools to very complex machines. It was also a movement from primitive sensorimotor skills (techniques) to highly elaborate systems of objective, linguistically encoded knowledge about Nature and its potential (technology).

Now, we live in a material world. The result of the explosion of technological knowledge has been a massive expansion of Man's reach, but with lamentable and unavoidable social, environmental, and cultural consequences: We live in a fabricated environment, mediated by machines. Technology was more authentic when we used tools, because we could control them. Machines, in contrast, control us. Thus one can identify a Great Divide or Rupture when Man lost his authenticity as a cultural creature, his Faustian depth as a being living in a world of cultural meaning, and gave himself over to a world ruled by instrumentalism and superficiality. This Rupture was the Industrial Revolution, which launched the Age of the Machine. As the primacy of function over aesthetics rips through culture, we increasingly live in a homogenous world of functionally driven design coherence. Our culture has become an inauthentic one in which reified images of technology predominate. We can define ourselves only by purchasing plastic, *ersatz artifacts made far away. To retain some measure of authenticity the young must be brought into direct contact with the great works of art and literature.*

The Standard View of technology appears to be a pillar of Modernism, a cultural, literary, and artistic period noted for its extreme ambivalence toward technology. According to most scholars (e.g. 40), Modernism reached its apex between the two World Wars. In essence, Modernism represents a struggle to find a stable ground of being within the promise and peril of science and technological development. Like Siva in Hindu iconography, technology is seen through the Modernist lens as both creator and destroyer, an agent both of future promise and of culture's destruction. Echoed perfectly in the Standard View of technology, Modernism amounts to

> an extraordinary compound of the futurist and the nihilistic, the revolutionary and the conservative, the romantic and the classical. It was the celebration of a technological age and a condemnation of it; an excited acceptance of the belief that the old regimes of culture were over, and a deep despairing in the face of that fear (15:46).

Modernism is an almost unavoidable response, as Bradbury & McFarlane put it, to the "scenario of our chaos" (15:27). Accordingly, any attempt to grasp the role of human technological activity must begin by questioning the Standard View's assumptions, which could, if left unexamined, color anthropological thought.

"NECESSITY IS THE MOTHER OF INVENTION"

The Standard View puts forth a commonsense view of technology and material culture that accords perfectly with our everyday understanding. All around us are artifacts originally developed to fulfill a specific need—juicers, word processors, vacuum cleaners, and telephones; and apart from artifacts that are decorative or symbolic, the most useful artifacts—the ones that increase our fitness or efficiency in dealing with everyday life—are associated each with a specific Master Function, given by the physical or technological properties of the object itself. Extending this commonsense view one quickly arrives at a theory of technological evolution (parodied by 4:6): People need water, "so they dig wells, dam rivers and streams, and develop hydraulic technology. They need shelter and defense, so they build houses, forts, cities, and military machines … . They need to move through the environment with ease, so they invent ships, chariots, charts, carriages, bicycles, automobiles, airplanes, and spacecraft."

The New Archaeology, which sought to put archaeology on a firm modernist footing, puts forward a view of technology and artifacts firmly in accord with the Standard View and its presumption of need-driven technological evolution. Culture, according to Binford (7), is an "extrasomatic means of adaptation"; thus technology and material culture form the primary means by which people establish their viability, given the constraints imposed upon them by their environment and the demands of social integration. It follows, as Binford argued in 1965 (8), that every artifact has two dimensions, the primary, referring to the instrumental dimension related to the artifact's function, and the secondary, related to the artifact's social meaning and symbolism. Echoing this view, Dunnell makes explicit the connection that is assumed between an artifact's function and group survival: The artifact's function is that which "directly enhances the Darwinian fitness of the populations in which they occur" (23:199). Style, in contrast, is something added on the surface, a burnish or decoration, that might play some useful role in symbolizing group solidarity but is decidedly secondary. In the Modernist view, there are universal human needs, and for each of these there is an ideal artifact. For the primitive technologist, discovering such an artifact is like discovering America: It was there before the explorers finally found it—and to the extent that anyone bothers to look, it will be found, and inevitably adopted (although it might be resisted for a time). The tale of Man's rise, then, is the story of increasing technological prowess, as digging sticks develop into ploughs, drums into telephones, carts into cars.

The Standard View of technology offers a seemingly "hard" or "tough-minded" view of artifacts and technological evolution, but there is ample evidence that its "hardness" dissolves when examined critically. What seems to us an incontrovertible need, for which there is an ideal artifact, may well be generated by our own culture's fixations. Basalla (4:7–11) demonstrates this point forcefully with respect to the wheel. First used for ceremonial purposes in the Near East, the wheel took on military applications before finally finding transport applications. In Mesoamerica, the wheel was never adopted for transport functions, given the constraints of terrain and the lack of draught animals. Even in the Near East, where the wheel was first invented, it was gradually given up in favor of camels. Basalla comments, "A bias for the wheel led Western scholars to underrate the utility of pack animals and overestimate the contribution made by wheeled vehicles in the years before the camel replaced the wheel" (4:11). Against all Modernist bias, Basalla's view echoes the findings of recent social anthropologists who have argued that it is impossible to identify a class of "authentic" artifacts that directly and rationally address "real" needs (2, 22:72; 87). Culture, not nature, defines necessity. One could reassert that a "hard" or "tough-minded" approach requires the recognition, after all, that people must eat, and so on, but it is abundantly evident that a huge variety of techniques and artifacts can be chosen to accomplish any given utilitarian objective (91).

The supposed functions of artifacts, then, do not provide a clear portrait of a human culture's needs (38), and what is more, one cannot unambiguously infer from them precisely which challenges a human population has faced. The natives of chilly Tierra del Fuego, after all, were content to do without clothing. Accordingly, some archaeologists and social anthropologists would break radically with the Standard View in asserting that material culture does not play a decisive role in shaping a human group's adaptation to its environment. Golson (32) notes that a basic stone toolkit survives intact through "revolutionary" changes in subsistence in both the classic Old World sites and in the New Guinea highlands. A survey of the New Guinea tools, Golson concludes, "revealed none that is indispensable to any form, from the simplest to the most complex, of Highlands agricultural practice, except the stone axe or adze and the digging stick which are not only common to all but also serviceable in other than agricultural contexts" (32:161). Summarizing the evidence from social anthropology, Sahlins (86:81) puts this point well: "For the greater part of human history, labor has been more significant than tools, the intelligent efforts of the producer more significant than his simple equipment." Sahlins' view is echoed by Lemonnier (62:151), who notes that the "search for correspondences between technical level and 'stage' of economic organization does not seem likely to lead to a theory of the relation between technical systems and society, other than one so over-simplified and general that it quickly loses all interest." Material culture alone provides only a shadowy picture of human adaptations.

If techniques and artifacts are not the linchpins of human adaptation, as is so often surmised, then radical redefinitions are in order. It is not mere technology, but technology in concert with the social coordination of labor, that constitutes a human population's adaptation to its environment. In most preindustrial societies, technology plays second fiddle to the human capacity to invent and deploy fabulously complex and variable social arrangements. How, then, should we define technology? Spier (93:2), for instance, defines technology as the means by which "man seeks to modify or control his natural environment." This definition is clearly unsatisfactory. It assumes, a priori, that Man's inherent aim is domination or control of nature; and, anyway, it is wrong, since (as has just been argued) techniques and artifacts are secondary to the social coordination of labor in shaping human adaptations. One could broaden the definition of technology to include the social dimension. But because the term "technology" so easily conjures up "merely technical" activity shorn of its social context (77), I believe it preferable to employ two definitions, the one more restricted, and the other more inclusive. *Technique* (following 62, 63) refers to the system of material resources, tools, operational sequences and skills, verbal and nonverbal knowledge, and *specific* modes of work coordination that come into play in the fabrication of material artifacts. *Sociotechnical system,* in contrast, refers to the distinctive technological activity that stems from the linkage of techniques and material culture to the social coordination of labor. The proper and indispensable subjects of a social anthropology of technology, therefore, include all three: techniques, sociotechnical systems, and material culture.

The sociotechnical system concept stems from the work of Thomas Hughes on the rise of modern electrical power systems (45, 46; for applications of the concept, see 68, 81). According to Hughes, those who seek to develop new technologies must concern themselves not only with techniques and artifacts; they must also engineer the social, economic, legal, scientific, and political context of the technology. A successful technological innovation occurs only when all the elements of the system, the social as well as the technological, have been modified so that they work together effectively. Hughes (45) shows how Edison sought to supply electric lighting at a price competitive with natural gas (economic), to obtain the support of key politicians (political), to cut down the cost of transmitting power (technical), and to find a bulb filament of sufficiently high resistance (scientific). In a successful sociotechnical system, such as the electric lighting industry founded by Edison, the "web is seamless": "the social is indissolubly linked with the technological and the economic" (60:112). In short, sociotechnical systems are heterogeneous constructs that stem from the successful modification of social and nonsocial actors so that they work together harmoniously—that is, so that they resist dissociation (60:166–17)—i.e. resist dissolving or failing in the face of the system's adversaries. One or more sociotechnical systems may be found in a given human society, each devoted to a productive goal.

Extending Hughes's concept, Law (60) and Latour (57) emphasize the difficulty of creating a system capable of resisting dissociation. A system builder is faced with natural and social adversaries, each of which must be controlled and modified if the system is to work. Some of them are more obdurate, and some of them more malleable, than others. In illustrating this point, Law shows that the sociotechnical system concept applies fruitfully to the study of preindustrial technology, in this case the rise of the Portuguese mixed-rigged vessels in the 14th and early 15th centuries. The real achievement, argues Law, was not merely the creation of the mixed-rigged vessel, with its increased cargo capacity and storm stability. Equally important was the magnetic compass, which allowed a consistent heading in the absence of clear skies; the simplification of the astrolabe, such that even semieducated mariners could determine their latitude; exploration that was specifically intended to produce tables of data, against which position could be judged; and an understanding of Atlantic trade winds, which allowed ships to go forth in one season and come back in another. To achieve the necessary integration of all these factors, the system builders had to get mariners, ship builders, kings, merchants, winds, sails, wood, instruments, and measurements to work together harmoniously. The system they created resisted dissociation; they were able to sail out beyond the Pillars of Hercules, down the coast of Africa, and soon around the globe.

Although it is no easy trick to construct a system resistant to dissociation, sociotechnical systems are not inevitable responses to immutable constraints; they do not provide the only way to get the job done. People unfamiliar with technology usually gravely understate the degrees of latitude and choice open to innovators as they seek to solve technical problems (48). More commonly, one sees a range of options, each with its tradeoffs, and it is far from obvious which, if any, is superior. In virtually every technical area, there is substantial latitude for choice. For instance, Lemonnier (62) points to the apparently arbitrary variation of techniques as one moves across the New Guinea highlands; such variation is to be found, Lemonnier notes, even among those "functional" (as opposed to "stylistic") aspects of a tool that are directly implicated in its action upon material (62:160). It would be wrong to attribute a system's "success" (i.e. in resisting dissociation) to the choice of the "correct" technique or social-coordination method.

By analogy to the sociology of scientific knowledge (11), this point can be formulated as a *principle of symmetry.* In the sociology of scientific knowledge, this principle countered an older sociology of science that explained the success of a theory by its conformity to the Truth, while ascribing the failure of another theory to social factors (bias, influence, "interests," etc). The principle of symmetry calls for precisely the same kind of social explanation to be used in accounting for the success as well as the failure of a theory—or, by extension, of a sociotechnical system. Accordingly, it would violate the principle of symmetry to argue that one system succeeds because its builders chose the "right" techniques, the ones that really "work." Of apparently successful systems, we can say only that the system builders have apparently succeeded in bringing to life one out of a range of possible systems that could achieve its goal (e.g. trapping wild pigs, growing rice, or sailing down the coast of Africa). Such a system could be viewed as an adaptation, in line with cultural ecology, but only by abandoning the *post hoc, ergo propter hoc* fallacy of functionalism. That a sociotechnical system develops does not imply that it is the logical system, or the only possible system, that could have developed under the circumstances; social choice, tactics, alternative techniques, and the social redefinition of needs and aspirations all play a role in the rise of sociotechnical systems.

An additional example, south Indian temple irrigation, should help to clarify the sociotechnical system concept and its implications. A marked characteristic of agriculture in medieval south India was the royal donation of wastelands to communities of Brahmans, who in turn were encouraged to organize and supervise agricultural production. They did so by investing the lands in newly constructed temples, which provided a locus of managerial control for the construction, maintenance, and management of complex irrigation systems (42, 67) that successfully resisted drought and led to a majestic efflorescence of south Indian Hindu culture. The heterogeneous quality of such a system is immediately evident. The system linked into a cohesive, successful system actors such as kings, canal-digging techniques, dams, flowing water, modes of coordinating labor for rice production, agricultural rituals, deities, notions of social rank and authority, conceptions of merit flowing from donations, conceptions of caste relations and occupations, conceptions of socially differentiated space, religious notions of the salutary effect of temples on the fertility of the earth, economic relations (land entitlements), trade, temple architecture, and knowledge of astrological and astronomic cycles (used to coordinate agricultural activities). A human sociotechnical system links a fabulous diversity of social and nonsocial actors into a seamless web (47).

Any sociotechnical system shows the imprint of the context from which it arose, since system builders must draw on existing social and cultural resources. But it is important to stress that every sociotechnical system is in principle a de novo construct; to make the system work, system builders draw from existing resources but modify them to make them function within the system. In this sense, sociotechnical-system building is almost inevitably *sociogenic* (56): Society is the result of sociotechnical-system building. The distinctive social formation of medieval south India, for instance, is in almost every instance attributable to the achievement of the sociotechnical system of temple irrigation. The system of temple irrigation draws on old ideas of gods, kings, water, dams, castes, gifts, and all the rest, but it transforms every one of these ideas in important ways. In this sense, the sociotechnical system concept is in accord with the structuration theory of Giddens (30): People construct their social world using the social resources and structures at hand, but their activities modify the structures even as they are reproduced.

A sociotechnical system, then, is one of the chief means by which humans produce their social world. Yet sociotechnical systems are all but invisible through the lenses provided by Western economic, political, and social theory, as Lansing (56) discovered in his study of Balinese irrigation. From the standpoint of Western theory, irrigation is organized either by the despotic state, as Wittfogel argued, or by autonomous village communities, as anthropologists argued in reply. Invisible within this discourse, Lansing found, was the Balinese water temple, a key component in a *regional* sociotechnical system devoted to the coordination of irrigation. Lansing discovered that the rites in these Balinese water temples define the rights and responsibilities of subsidiary shrines (and with them, the *subaks,* or local rice-growing collectivities, that line the watershed) through offerings and libations of holy water. By symbolically embedding each local group's quest for water within the supra-local compass of temple ritual, water temples encourage the cooperation necessary to ensure not only the equitable distribution of water but also the regulated flow of inundation and fallowing that proves vital for pest control and fertility. Tellingly, the solidarity that is created is not political; the king has obvious interests in promoting this kind of solidarity but does not actively intervene within it. And neither is this solidarity purely economic; it crosscuts other arenas of economic integration. A sociotechnical system engenders a distinctive form of social solidarity that is neither economic nor political (47); that is why it took so long for these systems to be "discovered" by anthropologists indoctrinated with classical social theory.

Sociotechnical systems have remained equally invisible through the lens provided by the Standard View of technology, which refuses to deal with the ritual dimension of technical activity. According to the Standard View, and to virtually every anthropological definition of technology, a technique is an *effective* act (62:154, citing 71), as opposed to magic or religion. Spier makes this commonsense assumption explicit in excluding from "technology" any "magico-religious means" by which people seek to control nature (93:2). Such a view forestalls any consideration of the crucial role that ritual institutions play in the coordination of labor and the network's legitimation (24, 35, 83, 95,), a point that should already be apparent from the south Indian and Balinese examples already discussed. Among the Montagnards of highland Vietnam (19), agriculture is no mere matter of material culture and manual labor. On the contrary, ritual is a key component of agricultural work; the rites call forth social groups to engage in specific activities, and they provide a metacommentary on the entire productive process. Sociotechnical systems may very well include ritual components with explicit productive goals that we find "false," such as enhancing the fertility of the earth; but to ignore them is to miss the crucial role they play in the coordination of labor. I would therefore argue that the social anthropology of technology, against all common sense, should adopt a principle of absolute impartiality with respect to whether a given activity "works" (i.e. is "technical") or "doesn't work" (i.e. is "magico-religious"); only if we adopt such impartiality do the social dimensions of sociotechnical activity come to the fore (80).

The labor-coordination role of ritual is surprisingly widespread, and for good reason: Ritual works surpassingly well to coordinate labor under conditions of statelessness or local autonomy. Among the Piaroa of lowland south America, for example, shamanic rituals employ scarce mystical knowledge to transfer mystical powers of fertility and increase to people who feel themselves in need of such powers; Granero views such rituals as an *"essential part of the productive practices of Piaroa society"* (35:665, Granero's emphasis). Given their access to what Granero tellingly calls the "mystical means of reproduction," shamans legitimately claim the right to solicit and coordinate agricultural labor, as well as organize trade (1986). Under stateless or locally autonomous conditions, rituals provide the ideal medium for the coordination of labor in that they virtually rule out dissent (9): "you cannot argue with a song." In Sri Lanka, 19th-century civil servants meticulously recorded the rites of the threshing floor, which required economically significant transactions to be conducted with a superstitious scrupulousness of detail, and a special, virtually incomprehensible language. This ritual language required participants to adopt an "odd shibboleth," as one observer termed it, for these vital economic transactions; the limited vocabulary sharply constrained what could be said (79). Thus another key feature of sociotechnical systems is their *silence,* the relatively insignificant role played by human language as against nonverbal communication in ritual (28) as a coordinator of technical activities.

Here we see yet another reason for the invisibility of such systems within the compass of Western social theory, which excessively privileges language over nonverbal cognition and behavior (10).

A successful sociotechnical system achieves a stable integration of social and nonsocial actors, but it is no static thing: Keeping the network functioning requires constant vigilance, and it may also require additional technical or social modification. Every sociotechnical system must cope with what Hughes calls *reverse salients,* areas of obduracy or resistance that prevent the system from expanding or threaten it with dissociation. On reaching the Indies, the Portuguese found that Muslims had monopolized the trade with Hindu princes; the Portuguese response was to work a good deal to make the cannon lighter and more powerful (60:127–28). Sociotechnical systems also betray a characteristic life cycle (46) as they grow from invention, small-scale innovation, growth and development, and a climax of maximum elaboration and scope, followed by senescence and decay, until the system disappears or is replaced by a competing system. Such life cycles may be visible in the myriad cycles of innovation, growth, efflorescence, and decay that characterize the archaeological record.

The sociotechnical system concept, in sum, suggests that mere necessity is by no means the mother of invention, just as production alone is by no means the sole rationale for the astonishing linkages that occur in sociotechnical systems (cf 5). To be sure, sociotechnical-system builders react to perceived needs, as their culture defines them. But we see in their activities the essentially creative spirit that underlies sociogenesis, which is surely among the supreme modes of human cultural expression. Basalla (4:14) puts this point well: A human technology is a "material manifestation of the various ways men and women throughout time have chosen to define and pursue existence. Seen in this light, the history of technology is part of the much broader history of human aspirations, and the plethora of made things are a product of human minds replete with fantasies, longings, wants, and desires." Basalla's point suggests that no account of technology can be complete that does not consider fully the *meaning* of sociotechnical activities, and in particular, the nonproductive roles of technical activities in the ongoing, pragmatic constitution of human polities and subjective selves. Sociotechnical systems can be understood, as I argue in the next section, only by acknowledging that they produce power and meaning as well as goods.

"THE MEANING OF AN ARTIFACT IS A SURFACE MATTER OF STYLE"

The commonsense Modernism of the Standard View desocializes human technological activity, as has just been argued, by reducing the creativity of sociotechnical-system building to the doctrine of Necessity. In precisely the same way, the Standard View desocializes the meaning of technological artifacts by reducing this meaning to the artifact's alleged function, with a residual and secondary role left for the relatively superficial matter (it is claimed) of style. To recapture the sociality of human artifacts, it is necessary to turn this distinction upside down. I begin, therefore, by arguing that the supposedly "hard" part of the artifact, its function, is in reality the "softest," the one that is most subject to cultural definition.

Archaeologists commonly distinguish function and style, as has already been noted. But as Shanks & Tilley argue,

> It is impossible to separate out style and the function [for instance] in either vessel shape or projectile point morphology. There is no way in which we can meaningfully measure and determine what proportion of a vessel's shape performs some utilitarian end, the remainder being assigned to the domain of style. To take a chair—what proportion of this is functional as opposed to stylistic? No answer can be given; the style inheres in the function and vice versa. Furthermore, ascribing any specific or strictly delimited function to an object is in many, if not all cases, an extremely dubious exercise. A chair may be to sit on, it nominally fulfills this function, but chairs can also be used for standing on, or for knocking people over the head with, as pendulums, rulers, or almost anything else. This is not to deny the banal point that objects have uses and may normally be used in just one way, but it is to suggest that such a position represents, at best, a starting point rather than an end point for archaeological analysis (91:92).

The views of Shanks & Tilley are echoed by Norman (75:9), who calls attention to an artifact's *affordances*. An affordance is a perceived property of an artifact that suggests how it should be used. Affordances are inherently multiple: Differing perceptions lead to different uses. You can drink water from a cup to quench thirst, but you can also use a cup to show you are well bred, to emphasize your taste in choosing decor, or to hold model airplane parts. But is not such a point just so much strained, special pleading? Everyone knows that chairs are *primarily* for sitting in; despite "minor" variations associated with specific historical styles and tastes, isn't the chair's function the pre-eminent matter? Such a distinction between function and style is common sense only to the extent that we ignore a key component of technology, ritual. In the preceding section I stressed ritual's prominent role in coordinating labor in sociotechnical systems. Here, I emphasize the equally prominent role of ritual in defining the function of material culture.

To illustrate this point with a convenient and simple example, I draw on the work of K. L. Ames on Victorian hallway furnishings (1). Ames notes that the hallway was the only space in the Victorian house likely to be used by both masters and servants. Masters and visitors of the masters' class would pass through the hall, while servants and tradesmen would be asked to sit there and wait. Ames calls attention to the contradictory character of these artifacts: They had to be visually appealing to the master class as they passed through the hall; but if they included seats, they had to be austere, without upholstery, and uncomfortable, befitting the lower social status of the messenger boys, book agents, census personnel, and soap-sellers who were made to wait there. Plain and uncomfortable, the bench echoed the design of servants' furnishings, which resembled (in the words of a servant quoted by Ames) the furnishings of a penal colony. With such constant reminders of their status, the servants would have no occasion to compare their status favorably with that of their master and mistress. Peers and people of higher status, Ames notes, were shown past the bench and directly into the house. In short, the Victorian hallway is a special space devoted to the enactment of entry rituals.

As the Victorian hallway bench suggests, style and function cannot be distinguished as easily as the Standard View would claim. What appears in a naive analysis to be the superficial matter of "style" (the bench's austerity) turns out, thanks to Ames' deeper contextual reading of hallway artifacts, to be the very "function" of the artifact (to remind servants of their status)! Note that here the function of the artifact (to be attractive to masters and remind servants of their station) can be known only by comprehending the perceived social role that the artifact is designed to fulfill; this perceived social role, in turn, can be known only from a contextual analysis that fully explores the dimensions of Victorian class sensibilities. I do not mean that the flatness and discomfort of the Victorian hallway bench were intended merely to "reflect" Victorian class sensibilities. When employed in a ritual context, the bench was obviously intended to *construct* Victorian statuses in ways not obvious outside the ritual context. With this analysis in view, one can argue that the dimension of an artifact identified by archaeologists, historians, and collectors as "style" once formed part of a now lost ritual system, and for that reason now stands out oddly and mysteriously against the artifact's supposed "function." In short, the distinction between "function" and "style" is a product of the *decontextualization and dehistoricization of artifacts* (see 43:107–20 for an excellent illustration of this point).

Daniel Miller's work among south Indian potters (72) demonstrates that artifacts play key roles in *framing* ritual activities—that is, in providing cues that establish the cultural significance of the events taking place. In a little-understood process that is unconscious and nonverbal, frames—though inconspicuous—play an important social role, establishing the context within which social action takes on meaning. For Miller artifacts are on the one hand extremely visible and omnipresent; yet on the other hand, they operate silently and invisibly (73:109). As many anthropologists have discovered, people find it difficult and pointless to talk about the meaning of artifacts: When pressed, informants resort to their last-ditch tactic, "Our ancestors did it this way" (62:165). Once again we meet a familiar theme: the silence of human technological activity and its invisibility within the compass of theories that assign excessive privilege to speech and writing.

Miller's work among south Indian potters shows the cross-cultural relevance of my point about Victorian hallway artifacts—namely, that the "style" of an artifact, when restored fully to its cultural context, turns out to be its "function." But what is even more important, Miller's work suggests that this "function" of artifacts may inspire artifact diversity, a key feature of human technology. When many versions of an artifact are available, they can play many roles in social life. Miller concludes: "Technology could be analyzed as the *systematic exploitation of the range of methods used in order to produce patterned variation* (72:201, my emphasis). Pushing this point further, one can argue that a major rationale for the creation of sociotechnical systems, beyond mere Necessity, is the elaboration of the material symbols that are indispensable for the conduct of everyday life. And one can identify here another form of linkage, as yet unexplored: the linkage between the rituals that coordinate labor and the rituals that frame human social behavior by employing material artifacts as cues. It seems likely that such linkages amount to a formidable apparatus of domination, even under conditions of statelessness, thus belying the mythos of egalitarianism in stateless societies.

If no form of domination goes unresisted, then one would expect artifacts to be employed in redressive rituals that are specifically designed to mute or counter the invidious status implications of the dominant ritual system. I therefore see the social use of artifacts, paraphrasing Richard Brown (12:129), as a process of nonverbal communication. In this process, each new act of ritual framing is a statement in an ongoing dialogue of ritual statements and counterstatements. In the counterstatements, people whose status is adversely affected by rituals try to obtain or modify valued artifacts, in an attempt to blunt or subvert the dominant rituals' implications. These statements, and their subsequent *counterstatements,* help to constitute social relations as a *polity.* I therefore call attention to *redressive* technological activities, which are interpretive responses to technological domination, to highlight the political dimension of technology. I call this polity-building process a *technological drama.*

A technological drama (78, 82) is a discourse of technological "statements" and "counterstatements" in which there are three recognizable processes: *technological regularization, technological adjustment,* and *technological reconstitution.* A technological drama begins with technological regularization. In this process, a design constituency creates, appropriates, or modifies a technological production process, artifact, user activity, or system in such a way that some of its technical features embody a political aim—that is, an intention to alter the allocation of power, prestige, or wealth (57). Because a sociotechnical system is so closely embedded in ritual and mythic narrative, the technological processes or objects that embody these aims can easily be cloaked in myths of unusual power. Ford's assembly line, for example, was cloaked in the myth that it was the most efficient method of assembling automobiles—a myth indeed, since Norwegian and Swedish experiments have shown that team assembly and worker empowerment are just as efficient. The myth masked a political aim: Ford saw the rigid and repetitive work roles as a way of domesticating and controlling the potentially chaotic and disruptive workforce of Southern and Eastern European immigrants (94:153). The stratifying role of the Victorian hallway bench, to cite another example, was cloaked in a myth of hygiene, which ascribed its plainness to its function in seating those who had recently sojourned in the filthy streets (1, 27).

Like texts, the technological processes and artifacts generated by technological regularization are subject to multiple interpretations, in which the dominating discourse may be challenged tacitly or openly. I call such challenges *technological adjustment* or *technological reconstitution.* In technological adjustment, impact constituencies—the people who lose when a new production process or artifact is introduced—engage in strategies to compensate the loss of self-esteem, social prestige, and social power caused by the technology. In this process they make use of contradictions, ambiguities, and inconsistencies within the hegemonic frame of meaning as they try to validate their actions. They try to control and alter the discourse that affects them so invidiously, and they try to alter the discursively regulated social contexts that regularization creates. Police whose movements are tracked by surveillance systems, for example, become adept at finding bridges and hills that break the surveillance system's tracking signal. They can then grab a burger or chat with another cop without having their location logged. Adjustment strategies include appropriation, in which the impact constituency tries to gain access to a process or artifact from which it has been excluded (e.g. 17). Before the personal computer, computer enthusiasts and hobbyists learned how to hack their way into mainframe systems—as did the youthful Bill Gates (now the CEO of Microsoft Corporation), who was reputed to have hacked his way into systems widely thought to be impregnable. In technological reconstitution, impact constituencies try to reverse the implications of a technology through a symbolic inversion process I call *antisignification.* Reconstitution can lead to the fabrication of counterartifacts (e.g. 51), such as the personal computer or "appropriate technology," which embody features believed to negate or reverse the political implications of the dominant system.

Following Victor Turner (97:91–94, 98:32), I choose the metaphor of "drama" to describe these processes. A technological drama's statements and counterstatements draw upon a culture's root paradigms, its axioms about social life; in consequence, technological activities bring entrenched moral imperatives into prominence. To create the personal computer, for example, was not only to create new production processes and artifacts, but also to bring computational power to the People, to deal the Establishment a blow by appropriating its military-derived tools, and to restore the political autonomy of the household vis-à-vis the Corporation. Here we see the dimension of desire that Basalla (4) emphasizes: To construct a sociotechnical system is not merely to engage in some creative or productive activity. It is to bring to life a deeply desired vision of social life, often with a degree of fervor that can only be termed millenarian.

In any explanation of the motivations underlying sociotechnical-system building and artifact appropriation the role of such activities in the subjective processes of self-definition deserves emphasis (22). In the grip of what Miller calls the mass culture critique, we tend to treat contemporary acts of artifact appropriation in capitalist society "as so tainted, superficial, and trite that they could not possibly be worth investigating." Materialistc people, in addition, are seen as "superficial and deluded, and are unable to comprehend their position" (73:166). Yet, as Miller stresses (73:86–108) there are good grounds for arguing that artifacts play a key role cross-culturally in the formation of the self: Artifact manipulation and play, for example, provide the conceptual groundwork for the later acquisition of language (100). We learn early, argues Miller (73:215), that artifacts play key roles in a "process of social self-creation" in which artifacts are "directly constitutive of our understanding of ourselves and others." In this sense contemporary societies, despite the rise of the Consumer Culture, possess much in common with preindustrial societies (2, c.f. 14:228–9): Artifacts are multiplied, elaborated, appropriated, and employed in framing activities as a form of self-knowledge and self-definition, a contention supported by the dizzying and unfathomable array of spectacular artifacts now collecting dust in ethnological museums. Miller's point leads directly to a consideration of a third contention of the Standard View, the doctrine that technological evolution has proceeded from simple to complex, and has deprived modern Man of his authenticity.

"A UNILINEAR PROGRESSION ... FROM SIMPLE TOOLS TO COMPLEX MACHINES"

It would be idiotic to deny that contemporary humans know a great deal more about technology than did our predecessors. History shows cumulative trends in virtually every field of technological endeavor. But the sociotechnical system concept leads to the equally inescapable conclusion that an enormous amount of human knowledge about building sociotechnical systems has been utterly and irretrievably lost. I argue here that the extent of this loss can be appreciated only by understanding the heterogeneous nature of sociotechnical systems and by radically questioning the Standard View's assumption that the evolution of technology may be described as the shift from Tool to Machine. Such an analysis will raise equally radical questions about the Standard View's notion of Rupture.

In a preindustrial society, people do not often talk about the technical knowledge they possess. In studying weavers in Ghana, for instance, Goody was surprised by the insignificant role of questioning and answering in the teaching of apprentices (33). Although highly elaborate systems of ethnobotanical classification may play key roles in subsistence systems, an enormous amount of technological knowledge is learned, stored, and transmitted by experiential learning, visual/spatial thinking, and analogical reasoning. Bloch

(10:187) describes the nonlinguistic learning that takes place, a form of learning very incompletely understood in the cognitive sciences:...

> Imagine a Malagasy shifting cultivator with a fairly clear, yet supple mental model, perhaps we could say a script, stored in long-term memory, of what a 'good swidden' is like; and that this model is partly visual, partly analytical (though not necessarily in a sentential logical way), partly welded to a series of procedures about what you should do to make and maintain a swidden. This Malagasy is going through the forest with a friend who says to him, 'Look over there at that bit of forest, that would make a good swidden.' What happens then is that, after a rapid conceptualization of the bit of forest, the model of 'the good swidden' is mentally matched with the conceptualized area of forest, and then a new but related model, 'this particular place as a potential swidden,' is established and stored in long-term memory.

Bloch argues that the linguistically derived theory of human cognition is insufficient because it cannot account for the speed with which we perform daily tasks such as identifying a 'good swidden.' It cannot account, as Miller notes (73:102), for our ability to absorb almost instantly the social implications of a furnished interior "consisting of a combination which is not only almost certainly in some degree unique, but some of whose basic elements may also be new to us." As we use technology for practical and social purposes, then, we draw on a nonverbal form of human cognition whose capabilities clearly form an enormous, but heretofore little recognized, component of our species' everyday intelligence. The portion of technical knowledge that people can verbalize represents only the tip of the iceberg.

The notion that technology is applied science—that it represents the practical use of logically-formulated, linguistically-encoded knowledge—is very misleading. A sociotechnical system is much better described as an *activity system,* a domain of purposive, goal-oriented action in which knowledge and behavior are reciprocally constituted by social, individual, and material phenomena (64, 102). As Janet and Charles Keller have emphasized, and as Bloch's example so tellingly illustrates, an activity system constantly fluxes between being and becoming: "Action has an emergent quality which results from the continual feedback from external events to internal representations and from the internal representations back to enactment" (52:2). Crucial to this process is an equally flexible cycling among alternative cognitive modes, including visual/spatial thinking and linguistic/classificatory thinking (53). Visual/spatial thinking is widespread in all technological activity systems, including today's high technology. (25, 26, 101, 99). But visual/spatial thinking is silent. Competent producers and users rarely mention it. This kind of knowledge is lost, sometimes irretrievably, in the wake of technological "progress." Recreation of a system that has been lost is virtually impossible. We have no idea how some preindustrial artifacts were made, let alone how highly effective activity systems were so successfully coordinated under preindustrial conditions.

When one views a sociotechnical system as a complex heterogeneous linkage of knowledge, ritual, artifacts, techniques, and activity, it is apparent that much more than visual/spatial knowledge about manufacture can be lost when a system dissociates. A human sociotechnical system involves the coordination of a massively complex network; in the case of Portuguese naval expansion this network consisted of such entities as kings and queens, ships, crews, winds, cannons, maps, sails, astrolabes, Muslims, and gold. Viewed as an activity system, a sociotechnical system must include all the conceptual, visual, experiential, tactile, and intuitive knowledge necessary to modify these diverse elements so that they work together harmoniously. Even in the most "primitive" sociotechnical systems, such as those of contemporary hunters and gatherers living in marginal environments (e.g. 61), the scope of knowledge integration involved is phenomenal. The complexity of any human sociotechnical system is belied by the simplicity of its tools (32).

All human sociotechnical systems, whether "primitive" or "preindustrial," are enormously complex and inherently heterogeneous. Through recognition of this fact one can begin a critique of the notion of Rupture that figures so prominently in the Standard View. According to the Standard view, tool use is *authentic* and fosters *autonomy;* one owns and controls one's own tools and isn't dependent on or exploited by others. When we use machines, in contrast, we must work at rhythms not of our own making, and we become ensnared in the supralocal relations necessary for their production, distribution, and maintenance. To the extent that we become dependent on machines we do not own, the stage is set for exploitation. We become divorced from nature, and our conceptions of the world become pathological, through a process called *reification* (a malady frequently asserted to occur only in industrial societies). According to the doctrine of Rupture, reification occurs because we employ objects as a means of knowing ourselves. When these objects are no longer our own authentic products, as is the case with industrially produced artifacts, our attention is deflected from critical self-awareness to the incompletely understood Other who generates the artifact (73:44).

The concept of sociotechnical systems enables us to see to what degree the doctrine of Rupture overstates the consequences of the transition from Tool to Machine. Although one would be foolish to deny the significant consequences of the machine's rise, preindustrial sociotechnical systems were themselves complex and exploitive—frequently more so than the Standard View acknowledges. A preindustrial sociotechnical system unifies material, ritual, and social resources in a comprehensive strategy for societal reproduction. In the course of participation in such a system, many if not most individuals find themselves playing dependent and exploited roles. By no means is reification restricted to industrial technology. As Lansing notes for Bali,

> Water temples establish connections between productive groups and the components of the natural landscape that they seek to control. The natural world surrounding each village is not a wilderness but an engineered landscape of rice

> terraces, gardens, and aqueducts created by the coordinated labor of generations. Anthropomorphic deities evoke this residual human presence in an engineered landscape … . Each wier is the origin of an irrigation system, which has both physical and social components. The concept of the deity of the wier evokes the collective social presence at the weir, where free-flowing river water becomes controlled irrigation water (56:128).

It would appear, then, that preindustrial sociotechnical systems have much in common with today's machine-based technological systems: Both rely extensively on nonverbal cognition, both show enormous complexity and elaboration, and both seem to generate reified notions rather than "authentic" self-awareness. Moreover, the conditions of freedom in preindustrial societies are falsely represented by focusing on the allegedly nonconstraining nature of tool (as opposed to machine) use. Any sociotechnical system, ancient or modern, primitive or industrialized, stems from the efforts of system builders who attempt to create a network capable of resisting dissociation. As previously argued, the use of ritual to coordinate productive activity in preindustrial sociotechnical systems amounts to a form of domination and control, even under stateless conditions. One can suggest, in fact, that both modern devices and preindustrial systems of ritual coordination are machines, as Latour (57:129) defines the term: "A machine, as the name implies, is first of all a machination, a stratagem, a kind of cunning, where borrowed forces keep one another in check so that none can fly apart from the group." Latour refers here to the role that machines play in uniting the constituent elements of modern sociotechnical systems: Machines tie the assembled forces to one another in a sustainable network (see 57:103–44 for telling discussions of the diesel engine, the Kodak camera, and the telephone). To argue thus is not to deny that the rise of the machine has brought about important, if as yet incompletely understood, alterations in human sociotechnical activity. It is to stress that the Standard View, with its division of human history into the Age of the Tool and the Age of the Machine, substantially overstates the political and subjective implications of the rise of machines (50:174).

What can the sociotechnical systems concept tell us about another kind of rupture, the kind produced when a modern industrial technology or artifact is adopted by a "traditional" society? A variant of the Standard View, perfectly expressed in the film "The Gods Must Be Crazy," alleges that the world-wide distribution of industrial artifacts will inevitably tear out the foundations of "authentic" traditional cultures and draw all the peoples in the world within the grip of consumer ideology. Implicit in this view is a strong version of technological determinism, the doctrine that because there is only one way to make or use a material artifact, every culture that adopts it will be forced to develop the same social and labor relations. Because social information is so crudely encoded in artifacts, however, it is extremely unlikely that a transferred artifact will succeed in bringing with it the ideological structure that produced it. For example, Hebdige (41) shows how motor scooters were deliberately developed in Italy to signify the feminine as opposed to the masculine motorbike: The motor was covered and quiet, the curves were soft and the shapes rounded, and so on. In Britain in the 1960s, however, the motor scooter was adopted by Mods, male and female, for whom it signified a European ("soft") image, as against the Rockers, who appropriated the motorcycle to signify an American ("hard") image.

Thus the "recipient" (appropriating) culture can reinterpret the transferred artifact as it sees fit. No less should be expected of people in so-called "traditional societies." According to the sociotechnical systems model, no such thing as a "traditional society" exists. Every human society is a world in the process of becoming, in which people are engaged in the active technological elaboration, appropriation, and modification of artifacts as the means of coming to know themselves and of coordinating labor to sustain their lives. New resources are unlikely to be ignored if they can be woven into an existing or new activity system. An artifact's determinative implications for labor in one context may be nullified if it is adopted to fulfill an essentially expressive function, as is the case for many "showpiece" industrial installations in Third World countries.

In a recent important essay, Schaniel (89) has stressed that the adoption of artifacts does not necessarily imply the adoption of the system of logic that produced the technology. Schaniel illustrates this point by discussing the history of Maori appropriation of iron artifacts. In the first phase, the Maori ignored the artifacts, seeing little or no value in them. After some experimentation, the Maori found that hoes and spades could be worked into their indigenous system of agriculture. European observers were shocked to find that the Maori bound their hoes to short handles and used this implement from the squatting position. The favorite implement for levering up the ground remained the digging stick. The Maori later modified the digging stick by affixing to it a short piece of straight iron (89:496). Schaniel concludes that "the process of adopting and adapting introduced technology ... does not imply that introduced technology does not lead to change, but the change is not pre-ordained by the technology adapted ... . The process of technological adaptation is one where the introduced technology is adopted to the social processes of the adopting society, and not vice-versa" (89:496–98).

That said, the appropriation of modern technology, whether for productive or symbolic purposes, may bring with it what Pelto calls "de-localization," the irreversible growth of dependence on nonlocal sources of energy (76:166–68). As Pelto's study of the snowmobile in Lapland suggests, de-localization may expand the geographical scope within which people actively appropriate artifacts, with extensive implications for social and cultural change. It would be wrong, however, to try to predict the trajectory of such change from a technical analysis of the transferred technology, as the extensive literature on the social impact of the Green Revolution attests. According to some studies (36, 37), the Green Revolution invariably leads to "techno-economic differentiation" and the growth of a pauper class because rich farmers disproportionately benefit from the extra-local resources (high-yielding varieties, pesticides, herbicides, and fertilizers). Other studies report that Green Revolution technology does not necessarily produce socioeconomic differentiation, so long as countervailing customs assure the equitable use of agricultural inputs (3, 20, 31). In assessing the social and cultural impact of de-localization, however, it is important to bear in mind that assuming technological determinism is much easier than conducting a fully contextual study in which people are shown to be the active appropriators, rather than the passive victims, of transferred technology (79).

Sharp's famous analysis of steel axes among "stone-age" Australians illustrates the peril of reading too much technological determinism into a single case. Sharp showed how missionaries, by providing stone axes to women and young men, whose status had previously been defined by having to ask tribal elders for these artifacts, brought down a precariously legitimated stratification system. However, any status differentiation system that depends on sumptuary regulations, rules that deny certain artifacts to those deemed low in status, is vulnerable to furious adjustment strategies if such artifacts suddenly become widely available; culture contact and technology transfer are by no means required to set such processes in motion. The process Sharp described is not constitutive of technology transfer per se; a clear analogue is the erosion of the medieval aristocracy's status as peasants freed themselves from sumptuary regulations and acquired high-status artifacts (73:135–36).

Where technological change has apparently disrupted so-called "traditional societies," the villain is much more likely to be colonialism than technology. Colonialism disrupts indigenous political, legal, and ritual systems, and in so doing, may seriously degrade the capacity of local system-builders to function effectively within indigenous activity systems. In colonial Sri Lanka, the liberal British government was obsessed with the eradication of multiple claims to land, which were perceived to discourage investment and social progress. The legal eradication of such claims destroyed the ability of native headmen to adjust holdings to changing water supply levels and undermined the traditional basis by which labor was coordinated for the repair of dams and irrigation canals. Village tanks and canals fell into disrepair as impecunious villagers allowed their lands to be taken over by village boutique owners and moneylenders (79). This example suggests that it is not transferred technology, but rather the imposition of an alien and hegemonic legal and political ideology—arguably, technicism, but not technology—that effects disastrous social change in colonized countries.

It is when sociotechnical systems come into direct competition, as is the case in advanced technological diffusion, that spectacular disintegrations of indigenous systems can occur. The sudden deployment of a competing system may outstrip the capacity of indigenous system participants to conceptualize their circumstances and make the necessary adjustments; their mode of deploying resources, material and human, no longer works. Latour (58:32) comments:

> The huge iron and steel plants of Lorraine are rusting away, no matter how many elements they tied together, because the world [their builders] were supposing to hold has changed. They are much like these beautiful words Scrabble players love to compose but which they do not know how to place on the board because the shape of the board has been modified by other players.

CONCLUSIONS

Against the Standard View's exaggerated picture of technological evolution from simple tools to complex machines, the sociotechnical system concept puts forward a universal conception of human technological activity, in which complex social structures, nonverbal activity systems, advanced linguistic communication, the ritual coordination of labor, advanced artifact manufacture, the linkage of phenomenally diverse social and nonsocial actors, and the social use of diverse artifacts are all recognized as parts of a single complex that is simultaneously adaptive and expressive.

The sociotechnical systems of the Machine Age do differ from their preindustrial predecessors, but the Standard View grossly exaggerates these differences. For example, most modern definitions of technology assert that, unlike their preindustrial predecessors, modern technological systems are systems for the application of science, drawing their productive power from objective, linguistically encoded knowledge (e.g. 16). But on closer examination we see here the influence of Standard View mythology. Historians of technology tell us that virtually none of the technologies that structure our current social landscape were produced by the application of science; on the contrary, science and organized objective knowledge are more commonly the *result* of technology. The principles of thermodynamics, for example, were discovered as scientists sought to determine how devices actually worked and what their operating parameters were (26). The notion that modern technology is efffective because it is founded in objective, "true" knowledge violates the principle of symmetry advanced earlier in this essay, even as it denigrates the achievements of preindustrial sociotechnical systems. As Lansing notes (56), Balinese water temples were more effective managers of irrigation than the all-but-disastrous Green Revolution techniques have been.

By jettisoning material-culture studies in the early 20th century, anthropology lost one means of developing a holistic, multi-disciplinary approach to culture. By reinstating the social anthropology of technology and material culture, we lay the foundation once again for fruitful communication among social anthropologists, ethnoarchaeologists, archaeologists, and students of human evolution. Besides challenging certain myths about technology that social anthropologists often take for granted, I hope this essay helps to raise the level of such interdisciplinary discourse. For example, efforts are now underway to comprehend human evolution in terms of the complex interplay among "tools, language, and intelligence" (29). From the perspective of this essay, such an effort is misconceived: It overprivileges tools and language, and disguises the truly significant phenomena—namely, sociotechnical systems and nonverbal cognition. To grasp the evolutionary significance of human technological activity, I suggest that anthropologists lay aside the myths of the Standard View ("necessity is the mother of invention," "the meaning of an artifact is a surface matter of style," and "the history of technology is a unilinear progression from tools to machines"), and view human technological activity using the concept of the sociotechnical system. Once we do so, we can begin to construct hypotheses about the *universals* of human technology—universals that highlight what is distinctly *human* about activities as diverse as making stone tools and launching space vehicles.

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