Part One

Technology-specific Concepts

1

Technology: Discourse and Possibility

J. C. Spender

ESADE and Lund University

Technology is a puzzle despite its evident impact on our lives. It penetrates and structures space and time via the Internet, travel, global warming, the world's rapid financial interactions, in off-shore supply chains, and increasingly within us, as drugs and prosthetics. But we have a hard time identifying precisely what this "it" is, to grasp technology. Is "it" more than artifacts; iPods, offshore drilling rigs, or hybrid cars? Or is it a generic method paralleling the scientific method? Is it an option, an imperative, a distinct mode of human existence or merely peripheral (Heidegger, 1977)? Ellul, for instance, treats technology as an autonomous domain of human activity, sprung free of our control by our Original Sin; now, monster-like, it pursues its own imperatives and shapes us into "mass man" (Ellul, 1967). We now fear the automobile and its impact (Ladd, 2008). Against dark views we have others more comforting; technology as tools to increase our productivity towards our chosen purposes; under our control, ready-to-hand, and morally neutral (Lancaster, 1966; Mansfield, 1996; Mowery and Rosenberg, 1989). More complex are Victorian notions of technology as the means to realize our dominance over the Primitive, to free us from our natural condition; i.e., technology as the construction of our artificial world; genetic engineering rather than the fruits of the field and forest, video-gaming rather than schoolyards (Passmore, 1974; White, 1972). This variety of framings should make us suspicious of simple models; yet in this most technological of ages, it seems essential to clarify technology's nature. Ferre, summarizing, wonders whether technology should be conceived as (a) material (hardware), (b) the embodiment of scientific knowledge, (c) the extension of our natural abilities, (d) the artificial aspects of our world, or (e) man's extension of Nature (Ferre, 1988).

Rather than establish technology's essence, one approach is to explore what it is not. It is not science, nor is it Nature unalloyed, nor abstract thought, and so on. Looking for relevant dichotomies, philosophers of technology distinguish their topic from the philosophy of science (Feenberg, 1996; Ihde, 1979, 1993; Mitcham, 1994), differentiating the abstractions of theory from the practical contextualities of technology's "being-in-the-world" (Heidegger, 1977) noting the different domains of thought and action. But before we go far down this road we must decide whether we are looking for Universalist notions or ones contextualized by our own theories. Organizational and management theorists have long recognized that our definitions of technology may not work for artists, philosophers, engineers, or ethicists whose intellectual enterprise differs from ours. Perhaps technology is just another puzzle behind the unresolved contradictions of our languages that show the cutting edges of our theorizing—economic versus organizational, maximizing versus power exercizing, equilibrium versus non-equilibrium (Cyert and March, 1963; Gibbons, 2005). Perhaps it is just the doing, the practice of bridging these conceptual differences, fitting into, say, transaction cost analysis by bridging contrasting ways of modeling management's world (Williamson, 1975)? On the one hand, technology as capital, a costly tool that leverages productivity, shifts the production function, and is evaluated in terms of ROI in both make or buy modes. This is an economist's "use-based" definition, duly bound by the market demand for the technology-applying organization's output. Or we might define technology as an administrator's tool, limiting others' guile and the "impactedness" of organizational life by collecting and distributing information for decision makers. This would be an organizational theorist's definition, a mechanism for greater control. Or we might strike a "critical" attitude, seeing technology as an investment against people rather than in them that leads to workers becoming "de-skilled" (Braverman, 1974), that its anti-humanist *ethos* accelerates the disenchantment of organizational life. Or, a marketing view, how technology likewise limits the range of products and services, shaping the customer's choices.

The method here is to look at technology via the interactions that are the focus of our theorizing. Technology is then either (a) external, available in a specialized market of productivity or control-enhancing tools, or (b) endogenous, emerging in the workplace, leading to team and organizational-level learning and to novel goods and services (Nonaka and Takeuchi, 1995; Romer, 1990). Noting their patterns of power and motivation, we see how organizations are transformed by technological change; for example, as production is automated and workers establish control, countering senior executives' administrative power. Likewise, external competition is reshaped.

Technology's social context

No doubt many managers think of technology in terms of cost, profitability, control, or product market strategy. But that is not the way technology is framed by contemporaries such as Weick (Weick, 1990) or Orlikowski (Orlikowski, 1992, 2000). They reach beyond concerns with ROI, control, and competitive advantage to ask questions like "why is this technology the way it is rather than otherwise?" or "why is this technology viewed as it is by those whose activity it shapes?" These questions seem deeper, seeing technology as embedded in the world and in people's interactions, especially between those who choose a technology and those whose work is directly shaped by the technology chosen.

SCOT (Social Construction of Technology) (Bijker, Hughes, and Pinch, 1987) and ANT (Actor Network Theory) (Law and Hassard, 1999) theorists surface the social and institutional influences over seemingly pure engineering (MacKenzie and Wajcman, 1999). The SCOT angle is that technologies reflect the economic, social, and political contexts in which they come into being, combined with the science they appropriate. ANT bears more directly on sociology, arguing that society emerges between individuals whose interactions are technologically mediated; so society cannot be understood independently of the technologies that shape its practices. The general conclusion is that technology cannot be analyzed without considering the non-technological aspects of its context; it is "in-the-world" and contextualized, not abstract. Brought into the social realm, technology is inevitably "institutionalized"—"infused with meaning beyond the strict technical requirements at hand" (Selznick, 1957, p. 17)—which happens because the relationship between the technology and its users is disjoint, under-determined, with a degree of "interpretive flexibility", its practical meaning remaining "up for grabs". Technological choices lead to collisions of interests, challenging managers to "align" their technological appropriations with the organization's goals, processes, routines, and culture. Even then, the technology's inherent flexibility remains a threat to management's control.

Weick, pursuing his "sense-making" agenda, points to the perceptual and psychological phenomena that might help managers and theorists grasp how a technology acquires its meaning and practical impact. Technology is not self-evident; on the contrary it is "equivocal". Lacking any essential meaning, it means nothing except to those who interact with it. Weick's special interest is in how a technology may surprise users into errors, some catastrophic (Weick and Sutcliffe, 2001). What it means may be more to do with these interactions, and the emotions they generate in users, than with what the equipment or system's designers or selectors had in mind. Orlikowski likewise borrows from Giddens' structuration theory to theorize the interplay as technology impacts practice and practice impacts technology, and focuses on why managers' projects succeed or fail. But to argue that situations are under-determined and might therefore not turn out as planned is not the same as trying to explain, *ex post*, why they turned out as they did—and therein, of course, lies managers' struggle with technology. Unlike the philosophers, concerned with technology's impact on society generally, managers intend to harness it to their organization's goals; but what of the employees? Admitting different people might have different views about a technology they are interacting with raises questions about "who wants to know?" rather than "what is this technology?" Orlikowski's notion of "technology-as-practice"—how a technology eventually presents as a stable and institutionalized way of being—moves towards identifying the relevant agents, whether physical, individual, or group. But which of these can explain or predict success or failure? Is this technological relativism with all explanations equally valid or "up for grabs"? Likewise, though the notion of practice is intriguing, things get horrid as we extend the notion of the practicing agent from individuals to the organization's objects, procedures, equipment, institutions, and so forth, the full panoply of ANT (Latour, 1996; Law and Hassard, 1999).

Giddens' "structuration" theory attributes "interpretive flexibility" to society itself as various social arrangements are enacted and the consequences perceived lead to new arrangements (Bryant and Jary, 1991). Organization theorists like Weick and Orlikowski adopt these dialectical notions, suggesting the interactions of a technology's human and non-human aspects, its history and perceived future, give it "transience", leaving it without any deep fundamental nature, never more than what it appears to be at a particular time, a temporary synthesis. Then our obsession with causality tempts us to grant technology or society higher status as an independent variable. Social constructionists grant society higher status, without explaining how society came to be the way it is,

even while granting technology the power to shape it as, say, rice-growing in a constricted geography is said to have shaped Japanese culture. The contrary is to grant technology higher status, politics, and self-interest than colliding with technology's scientific truths. Thus the QWERTY keyboard, we are told, is a triumph of convenience and institutionalization over technical efficiency.

Where does such analysis lead? Nowhere, perhaps, though the story seems interesting. Its principal point is methodological, that as we try to ground definitions of technology—whether abstract, like a compression algorithm, or physical, like aspirin, or tool-like, a ski-lift—within a complex and under-determined web of social interaction, we lose control of the discussion. Having presumed society's influence on the penetration, application, or evolution of "a technology"—whether that is institutional, cultural, scientific, organizational, or otherwise—the theorizing is un-moored until we see a theory of that determining context. More precisely, it is all very well to categorize a technology project's outcomes as displaying "inertia", "application", or "change" but can we ever understand the interpretive, technological, and institutional conditions of the context enough to know what will happen and why (Orlikowski, 2000, p. 422)? Only when we know society completely and can anticipate its changes. Likewise invoking the term "practice" but failing to identify the specific agent of that practice or its limits, we miss how contested are the intentions of the individuals or collectives whose practices intersect in any particular organization, and thus how different the answers might be to the question of "what does this agent mean by 'the technology'?" Attempts to define or analyze technology in terms of the interaction between people and objects or systems leads us into epistemological incoherence; a bait and switch. Exploiting our sense of understanding society, the explanatory base is subtly shifted from technology, the problematic, to a socially framed "technology-in-practice" or psychological cycle of function and arousal. But can the result count as an explanation? What is excluded by these notions? We get no grounding; not only is the explanation "up for grabs", it moves precious close to "anything goes" (Feyerabend, 1993).

Absent a robust theory of society, one alternative to a socially grounded theory of technology is a technologically penetrated theory of social interaction at the macro, organizational, or work-team level. This is more or less where the dispute between Habermas and Marcuse leads (Feenberg, 1996, 1999, p. 151). The former argues that behind all theories of society lies the universality of human rationality—the latter argues that such rationality is socially and historically contingent. Both allow technology as an articulation of rationality, inter-subjective, outside the person that then shapes human interaction. Here we note different rationalities, as Weber contrasted "instrumental rationality" (*zweckrationalität*) with "value-based rationality" (*wertrationalität*). It follows that questions like "why is this technology as it is" go well beyond mere contests of individual intention, interest, and power to embrace society's history and technology's path dependence emphasized by the SCOT or ANT theorists (Arthur, 1989).

Technology's objectivity and language

Clearly technology is more than its artifacts; beige boxes, wind generators, software, etc.—for these have no inherent meaning. Our responses to these artifacts determine their meaning and their impact. Yet we speak about technology as "objective" and independent of us, perhaps to hide how our responses vary. But as alternative rationalities come into view we surface the dialectical struggle between the inter-subjective rationalities we think are embedded in the technology and those of the social life they shape, the contest that so excites Ellul and the other anti-technologists. Technological rationality is advanced against the social practice–based alternatives, the contextualized rationalities advanced to explain why society is the way it is. But can we cut through this muddle?

Instead of presuming a technology can ever shed or be cleansed of the contextualities and interests that brought it into being, technology implies a distinct domain of human activity, one currently privileged (Heidegger, 1977). So the real puzzle about technology is the why and the how of this privileging for it shapes our sense-making. Readers of *Practical Mechanics* or *Radio Electronics* aside, it seems technology has no language of its own. Our failure to understand it springs from and is reflected in the lack of axioms that would underpin its own idiosyncratic language and make it comprehensible. Absent these, technology has borrowed. Engineering language obscures because it is about the properties of materials and the design and production of artifacts, not about using them or understanding their impact on our modes of life. But science gives us language that Edison could not, though grounded in causality and focused on cause and effect rather than social practice. While our forefathers were familiar with the sacred books and might quote extensively from them when discussing social concerns, today's generations are more likely to use the language of physical chemistry to discuss, say, global warming or the Green Revolution, this age's concerns. Our society is remarkable in that technology has moved on from *techne*, the Aristotelian form of knowing demonstrable in practice, to appropriate the language of science as its rhetorical mode, to conceal, perhaps, that it is as socio-historically contingent as any other domain of activity,

economic, religious perhaps, or political. This seizure lies behind the idea of a Technological Age, for the language then dominates the public discourse.

Social studies of science have shown science's practices bear little relation to the classroom mythology of rigor and objectivity (Latour, 1987). Technology is no more solid or rational for its claim to be scientific. Its deeper contingent nature, that it could have been otherwise, gets hidden behind a rhetoric of scientific objectivity, just as the rhetoric of economics has evolved to convince others of the acceptability of its assumptions (McCloskey, 1998). An overly science-driven view of technology makes it impossible for us to understand "pre-scientific technology", a *techne* unframed in scientific language, of which there are many examples—military (stirrup and rifle), marine (lateen sails and compass), medical (acupuncture and the dentistry of Ancient Egypt), and managerial (the organization itself) (De Landa, 1991; White, 1964). So the question remains, "is the transient dynamic stability we treat as a technology anything more than a stabilization of the power discourses that shape social practice?" Here technology is an instrument of social power, to be controlled just as colonialists controlled the language of their subjects. It is crucial to deny it any privileged status; it is just another mode of social discourse, albeit more widespread and influential than, say, 300 years ago when religion dominated. Yet we succumb and treat technological language as objective, secular and authoritative, "evidence-based" and organized using the methods of science rather than the hit-and-miss practices Thomas Edison adopted to develop the incandescent lamp and DC technology for urban electrification.

So the more tractable questions are about how the language of technology, its rhetoric, has acquired its status and influence, pushing the moral and political issues inherent in all human activity out of sight, only to re-emerge, as they must, as the problematic for new subfields such as CSR (corporate social responsibility), or business or medical ethics. As we sense the power relations behind the language we frame the political struggle between high-tech, low-tech, and "appropriate technology" approaches, and their concern with technological colonization (Hazeltine and Bull, 1999). Partly this is an overhang from 19th-century colonialism and the struggle between those who saw natural science as "pure science" and the social sciences, if sciences at all, as poor cousins. Part is the impact that technology has on our lives, seeming to present the irresistible facts of a situation and squeeze out other discourses. Part is the professionalization and complexity of technology today, the huge educational investments necessary to comprehend what we see and puzzle out its social and moral implications. Ironically, technology has advanced in power precisely as its discourse has become less comprehensible; we marvel at its effects, having lost sight of how it supports or denies our choices—be they of diet, travel, leisure, or communication. Feeling powerless, we concede it higher status.

How can we bring technology and its impacts to heel rather than be trampled beneath them, as Ellul and Marcuse warned? How can we respect its achievements and benefits but tame its power over us? Positivism has not served us well here, for it prioritizes talk of the "real" that positivists presume exists independently of us and into which the natural sciences inquire for its universal truths. Those who treat technology as the real embedded in the social, endlessly interacting with other forms of life in processes of "structuration", try to leverage off the distinction between positivism and interpretivism, between objectivity and subjectivity. From the realist point of view, perhaps, the technology project failed because its design was faulty or inappropriate to the task; a redesign is indicated. From an interpretive point of view, perhaps, the project failed because its users made the "wrong" interpretation, suggesting that control and rationality can be restored by better communications, training, or incentives. But these two explanations never converge until we arrive at the Archimedean point of total knowledge of our universe and its causal machinery. Our real condition is elsewhere, so these approaches suggest the wrong questions. They leave us with understanding the "it" of technology as the impact of the fruits of others' explorations of the real on us. Which leaves us out of the analysis, and this is the deficiency that contemporary theorists of technology attempt to correct but cannot without a positivistic theory of the social that can converge with the chosen language of science.

A constructivist approach

Once other epistemologies are brought to bear the questions asked change. The implicit model of the human agent (whether her/his axiomatic attribute be rationality, power-seeking, emotion, self-maximizing, religiosity, etc.) is the key. We cannot critique and escape the rationalist rhetoric that supports technology's present status without also critiquing the axiomatic Model of Man which prioritizes rationality as the basis both for action and explanation in a world presumed to be rationally constructed and, consequently, fully comprehensible. We reveal something utterly dierent about technology from a constructivist position. It presents organizations as socio-economic arrangements under constant reconstruction and technology similarly, dematerializing both. Technology is impact rather than artifact. Instead of organizations having a distinct existence or ontology, they become ongoing patterns of interaction between people and other human or inorganic agents as they produce and consume. Likewise any technology-in-use appears as the social practices of producing

and consuming—not at all the materialist notions that spring first to mind, the beige boxes. As we seize technology within a dynamic discourse of influence that actualizes social power, giving it neither false realism nor privileged access to Nature, we render it every bit as recursive as society itself. We are no longer able to distinguish "technology" from "organization" in any fundamental way, for organization is a hugely important technology too. Technology no longer impacts "the organization"; it merely identifies one class of the many influences over organizing processes.

But switching to a constructivist epistemology seems to do little more than take us back to the relativism of competing rationalities until we see the human agent as also being constructed. Just as organizing processes are shaped by technology, so are agents (Vygotsky, 1978). People become what they do as the recursive processes link agents—with technology-as-language as the medium. Society means some agents have the power over others and that is how technology enters the social. The pseudo-objective language of science masks this. Consider the CAFE standards, the legalities government uses to pressure the automobile industry to advance their "mileage and emissions technology". The resulting computer-controlled combustion and catalytic exhaust management technology makes no social sense abstracted into the science lab where engines can be built that offer staggeringly high mileage and low emissions—the impression we might get of the CAFE initiative. On the contrary, "fleet mileage" and emissions targets apply to the driving conditions that exist in practice, those deeply implicated in U.S. society, in what people need and expect of their transportation (Kay, 1997). To recognize how much we have been shaped by the automobile industry's decisions is to be shocked at how much power it has over our lives and who we have become. Thus each technology's artifacts are "boundary objects" to these social processes (Star, 1991). They act as the symbols, sacred objects, and ritualized processes of a science-based belief system we have privileged, suggesting some truth beyond priestly power.

Once we see the language of technology is not about "reality" or science, but is an exercise in social power, we are led to think how its rhetoric is constructed and warranted. Aristotelian rhetoric was based on the alternative modes of human persuasion—*logos*, *ethos*, and *pathos*; the first is an appeal to rationality, the second to the social relations between speaker and audience, and the third an appeal to the emotion that is the spur to action. In our hyper-rationalist age *ethos* and *pathos* are hidden, suggesting the language of technology arises at the junction of the three fundamental rational modes of human knowing. For Habermas these are indicated as the objective physical world, the social world of people, and the subjective world of feelings (Feenberg, 1999, p. 158). There are other variants; Barnard assumed the physical, social, and psychological (Barnard, 1968) while Luhmann posited the social, psychological, and the present (Luhmann, 1995). Yet a rationality-based model of the individual is implicit in all. Weick's analysis is rich in that it lies within this three-way framework, implying the meaning of a technology emerges recursively through the interaction of the social and the physical, mediated by the agent's emotion—nothing much to do with the quasi-causal models that some find in Giddens' structuration.

Adopting a constructive epistemology displaces Rational Man from this discourse. Instead we call on Agentic Man, one who constructs both world and self. Explanations of power and process are then grounded in the interacting agents' intents. For instance, ANT networks stabilize as the various agents' intents and practices coalesce into transient quietude rather than as their quasi-scientific rationalities play out to an equilibrium solution. Technology can then be captured as interplaying agents, constrained by history and material and social circumstance; perhaps physical, like carbon fiber, or social norms, important to the SCOT history of bicycles. A constructive explanation's grounding always lies in the particular agents, how they see themselves and the world they imagine—flying Wright brothers, Roosevelt's Panama Canal, the "computer for the rest of us". Technology deployed as an instrument of power to hide the intentions of the agents providing and choosing it, only appears based on rationality when others' interests have been silenced. Deconstructing the rhetoric around a technology that shapes and facilitates our practice helps us recapture our agency, bringing it into our life-world (Critchley, 1999). To speak of being driven by technology is to legitimate silencing others' agency. While one might protest and say, hey, antibiotics are real, they cure, that is just science. That we use them, that is power.

So what is the "it" of technology? This chapter argues that at its most basic "it" is the appearance of a culturally legitimized discourse around how some shape the lives of others through artifacts and ritualized processes, a seemingly de-politicized modernist form of power. The appeal is not to a transcendent Being, but to Nature and the extended possibilities revealed by, say, bronze weaponry, Salk's vaccine, or Microsoft's Vista. Technology as the rhetoric of its impacts on and meanings for us, rather than as the scientific objectivity in artifacts and systems that stand apart from us, brings it into the networks of social, economic, psychological, and political power that dynamically shape our condition. Of course, all language, being inter-subjective and standing outside us, has a mask of objectivity, leaving its practical implications problematic. But ultimately technology's meaning comes from us and not, as some would assert, from any correspondence to the positivist's real.

Bibliography

Arthur, W. B. (1989). "Competing technologies, increasing returns, and lock-in by historical events." *Economic Journal*, **99**, 116–131.

Barnard, C. I. (1968). *The Functions of the Executive* (30th Anniversary Edition). Cambridge, MA: Harvard University Press.

Bijker, W. E., Hughes, T. P., and Pinch, T. J. (Eds.). (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Braverman, H. (1974). *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century*. New York: Monthly Review Press.

Bryant, C. G., and Jary, D. (1991). *Giddens' Theory of Structuration: A Critical Appreciation*. London: Routledge.

Critchley, S. (1999). *The Ethics of Deconstruction: Derrida and Levinas*. Edinburgh, U.K.: Edinburgh University Library.

Cyert, R. M., and March, J. G. (1963). *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall.

De Landa, M. (1991). *War in the Age of Intelligent Machines*. New York: Swerve Editions.

Ellul, J. (1967). *Technological Society*. New York: Random House.

Feenberg, A. (1996). "Marcuse or Habermas: Two critiques of technology." *Inquiry*, **39**, 45–70.

Feenberg, A. (1999). *Questioning Technology*. London: Routledge.

Ferre, F. (1988). *Philosophy of Technology*. Englewood Cliffs, NJ: Prentice-Hall.

Feyerabend, P. (1993). *Against Method* (Third Edition). London: Verso.

Gibbons, R. (2005). "Four formal(izable) theories of the firm?" *Journal of Economic Behavior & Organization*, **58**, 200–245.

Hazeltine, B., and Bull, C. (1999). *Appropriate Technology: Tools, Choices and Implications*. San Diego, CA: Academic Press.

Heidegger, M. (1977). *The Question concerning Technology*. New York: Harper & Row.

Ihde, D. (1979). *Technics and Praxis: A Philosophy of Technology*. Boston, MA: Reidel.

Ihde, D. (1993). *Philosophy of Technology: An Introduction*. New York: Paragon House.

Kay, J. H. (1997). *Asphalt Nation: How the Automobile Took over America and How We Can Take It Back*. Berkeley, CA: University of California Press.

Ladd, B. (2008). *Autophobia: Love and Hate in the Automotive Age*. Chicago, IL: University of Chicago Press.

Lancaster, K. (1966). "Change and innovation in the technology of consumption." *American Economic Review*, **56**(2), 14.

Latour, B. (1987). *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, MA: Harvard University Press.

Latour, B. (1996). *Aramis or the Love of Technology*. Cambridge, MA: Harvard University Press.

Law, J., and Hassard, J. (Eds.). (1999). *Actor Network Theory and After*. Oxford, U.K.: Blackwell.

Luhmann, N. (1995). *Social Systems* (J. Bednarz and D. Baecker, Trans.). Stanford, CA: Stanford University Press.

MacKenzie, D., and Wajcman, J. (Eds.). (1999). *The Social Shaping of Technology* (Second Edition). Buckingham, U.K.: Open University Press.

Mansfield, E. (1996). "Contributions of new technology to the economy." In: B. L. R. Smith and C. E. Barfield (Eds.), *Technology, R & D, and the Economy* (pp. 114–139). Washington, DC: Brookings Institution.

McCloskey, D. N. (1998). *The Rhetoric of Economics* (Second Edition). Madison, WI: University of Wisconsin Press.

Mitcham, C. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago, IL: University of Chicago Press.

Mowery, D. C., and Rosenberg, N. (1989). *Technology and the Pursuit of Economic Growth*. Cambridge, U.K.: Cambridge University Press.

Nonaka, I., and Takeuchi, H. (1995). *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press.

Orlikowski, W. J. (1992). "The duality of technology: Rethinking the concept of technology in organizations." *Organization Science*, **3**, 398–427.

Orlikowski, W. J. (2000). "Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science*, **11**, 404–428.

Passmore, J. A. (1974). *Man's Responsibility for Nature: Ecological Problems and Western Traditions*. London: Duckworth.

Romer, P. M. (1990). "Endogenous technological change." *Journal of Political Economy*, **98**(5, Supplement), S71–S102.

Selznick, P. (1957). *Leadership in Administration: A Sociological Interpretation*. New York: Harper & Row.

Star, S. L. (1991). "Power, technology and the phenomenon of conventions: On being allergic to onions." In: J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination* (pp. 26–56). London: Routledge.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Weick, K. E. (1990). "Technology as equivoque: Sensemaking in new technologies." In: P. S. Goodman *et al.* (Eds.), *Technology and Organizations* (pp. 1–44). San Francisco, CA: Jossey-Bass.

Weick, K. E., and Sutcliffe, K. M. (2001). *Managing the Unexpected: Assuring High Performance in an Age of Complexity*. San Francisco, CA: Jossey-Bass.

White, L. (1964). *Medieval Technology and Social Change*. Oxford: Oxford University Press.

White, L. (1972). "The historical roots of our ecological crisis." In: C. Mitcham and R. Mackey (Eds.), *Philosophy and Technology: Readings in the Philosophical Problems of Technology* (pp. 259–265). New York: Free Press.

Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*. New York: Free Press.