Blackwell Companions to Philosophy

A Companion to the Philosophy of Technology

Edited by
Jan Kyrre Berg Olsen Friis,
Stig Andur Pedersen, and
Vincent F. Hendricks

WILEY-BLACKWELL

Introduction

JAN KYRRE BERG OLSEN FRIIS, STIG ANDUR PEDERSEN AND VINCENT F. HENDRICKS

No major reference work on the philosophy of technology is in existence. The aim of the *Companion to the Philosophy of Technology* is thus to provide an up-to-date review of the philosophy of technology, bringing it into close contact with cutting-edge technology and contemporary technology policy.

The philosophy of technology is highly *interdisciplinary*: it consists of insights from different kinds of technologies, from a variety of epistemological approaches, the humanities, social science, natural science, sociology, psychology, engineering sciences, different philosophical schools of thought, i.e. pragmatism, analytical philosophy, and phenomenology. The philosophy of technology taken as a whole is an understanding of the consequences of technological impacts relating to the environment, the society and human existence. The philosophy of technology is a newcomer in philosophy. As a constituted subject it has existed for about half a century. It is one of the fastest-growing philosophical disciplines. It is also an *intercontinental* philosophical discipline, drawing inspiration and building lasting bridges across the unfortunate divide between Continental and analytic strands of thought in philosophy.

This *Companion* is intended to be the primary navigator for understanding technology and its various roles in the modern complex society. "Technology" refers to many different concepts and phenomena, and it is therefore impossible to give a clear-cut definition of what is to be understood by the term. However, the *Companion* covers the main features of technology, its historical development, its future potentials and risks, etc. With these ambitions in mind, the *Companion* is organized in accordance with the following seven pillars, each covering major areas where technology plays a central role. Each part consists of several short encyclopedia-like case studies, or specialized chapters, describing all issues that add up to actual problems and insights, fleshing out how far technology has come in this particular area or field.

I History of Technology

This part describes technological development in Western culture as well as in other cultures. It brings into focus Islamic technology, Chinese and other developed technological societies. It is of paramount importance to see the extent to which these societies became dependent upon various technologies and what kinds of technologies were preferred. There is an intimate link between our societies today and the choices made in the past.

II Technology and Science

The focal point of this part is the close connection between technology and science – and their independence. Among other things, the old and still-present issue of technology as applied science will be discussed, the differences between epistemologies and methodologies fleshed out. The connection with the previous part is straightforward; modern science grew out of a society that put more and more emphasis on developing technologies to penetrate the core of nature’s secrets.

III Technology and Philosophy

This part reveals the story from the first attempts to create an engineering philosophy of technology to the more influential humanistic philosophy of technology, towards what today is labeled “philosophy *of* technology.”

IV Technology and Environment

Technology has had a tremendous impact on nature. Technologies have been, in the hands of man, a destructive tool. We are today facing the severest consequences imaginable. As forecasts go, it is only going to get worse. Rescue and damage control also lie in our best technologies at hand. Only by developing intricate instruments can we detect pollution and build complex enough models of the forthcoming developments caused by global warming, global dimming and the greenhouse effects. In this part, management, science and technology are intimately joined.

V Technology and Politics

Technology is highly political. Governments, the military, all have high hopes and expectations related to technological innovations. However, technology is also taking center stage in order to secure safety and prosperity for society. Therefore the political and economic dimensions of technology are studied in this part within specific contexts – “European Politics, Economy and Technology”; “Asian Politics, Economy and Technology”; “US Politics, Economy and Technology” – where differences in policy-making, in addition to differences in economic and cultural emphasis on technology, stand out with clarity. This is a tangled web that pulls in issues related to all the previous parts of the *Companion* and also extends to the next part.

VI Technology and Ethics

The development of technology has radicalized classical ethical problems and raised new ones. This part focuses on the responsibilities and values of engineers, scientists, policy-makers and others. Also included are consequences of technologies for the environment. Ethics and technology concern technology in agriculture; within stem cell research; in weapons research, etc.

VII Technology and the Future

Technologies are undergoing constant changes, and they influence all sides of human life. In order to assess new developments in technology it is necessary to discuss the expectations for the future with respect to human prosperity and possible risks involved therein. This part of the *Companion* discusses the extent to which new technologies contribute to the realization of a desirable future or whether it will be harmful or risky. Some steps have already been taken. The political decision-makers in the EU have drawn up "the Lisbon strategy for economic, social and environmental renewal." Here a colossal emphasis has been put on the development of environmentally friendly technologies – cleaner technologies – that can make use of alternative energy sources like hydrogen. Another important area is nanotechnology, with both military and civilian applications.

Philosophers, and other scholars working with issues related to technology, often define technology differently. We come from different cultures and therefore emphasize certain things differently. All existing definitions of "technology" rest upon specific schools of thought. However, for "technology" there cannot be any simple definition pledging allegiance to one or other school. There are "metaphysical" complications that have to be overcome. The structure of the *Companion* will guarantee this diversity. Definitions are always related to the values of a tradition, of a specific group of thinkers, to a school of thought, and of course to whoever provides the definition. The problem is that "technology" is not one "thing" but a complex of practices, methods, hopes, intentions, goals, needs and desires, besides all the actual technologies in hand. The lack of unity is in turn due to the interdisciplinary nature of technology and technology studies. A single definition simply cannot fathom the complexity of technology in its entirety. In sum, a thorough definition of "technology" needs a "companion" – *A Companion to the Philosophy of Technology.*

Putting this companion together would not have been possible if it was not for all the authors and pillar editors who vividly, eruditely and with great expertise advised and contributed on the way. We should like to extend our gratitude to all our contributors, thank Rasmus Rendsvig for taking care of the logistics in the assembly part of the process, and finally thank Blackwell Publishing and in particular Nick Bellorini and Liz Cremona for taking on this project.

Part I
History of Technology

Chapter 1
History of Technology

THOMAS J. MISA

A generation ago, before the much-noted "empirical turn" in philosophy, it was unlikely that an assessment of the philosophy of technology would have prominently featured the history of technology. Put simply, there were relatively few common concerns, since historians of technology rarely engaged in the sort of questions that animated philosophers of technology. Consulting the published volumes of *Research in Philosophy and Technology* and *Technology and Culture* three decades ago suggests two divergent scholarly communities, separated by research methods and background assumptions, and pursuing largely independent investigations. At the time, historians of technology were insisting on technology being an ontologically and epistemologically separate category from science, and vigorously insisting that technology is not merely applied science, while philosophers were ready and more comfortable with sweeping normative assessments about the essential characteristics of technology and its impact on society. In the debates on technological determinism, philosophers of technology and historians of technology were nearly as far apart as possible: while historians of technology adamantly refuted any and all claims of technological determinism, philosophers of technology were as a discipline the most enthusiastic in exploring and embracing the notion that technology determines social and cultural change and that technology develops more or less autonomously of social and cultural influences (Winner 1977; Misa 2004b). In this climate, there was not so very much that the two specialist fields held in common.

In the last ten years or so, however, there has been increasing mutual interest in philosophy and history of technology (Achterhuis 2001; Ihde 2004). It has not been that a hybrid discipline such as the history of philosophy of science has emerged, but rather that some historians and some philosophers have discovered common interests and common concerns. The essays in this volume are testimony to this shared mutual interest, although the individual topics they explore do not really exhaust the range of shared topics and emergent themes (see Misa et al. 2003). The commissioned essays examine the cultural contexts of technology, notably in the specific contexts of Japan, Islam, China and the West, as well as examining the problem areas of defining technology and assessing military technology. These essays develop some of the shared concerns and concepts that are emerging between these two fields. Accordingly, this essay will provide a summary of their main findings but also attempt a wider assessment of these shared concerns and emerging problems. I shall do so by accenting three themes: the challenges of defining the term "technology"; the varied concepts and problems in defining "culture" as well as its relations to and interactions with technology; and the issue of technological determinism, a scholarly and practical problem that, for several decades, has merited philosophical reflection and historical analysis.

Definitions of "Technology"

Historians of technology have for many years pointedly resisted giving a prescriptive definition of the term "technology." This stance, somewhat paradoxically, reflects the disciplinary maturity and confidence of their field. They have frequently observed that no scholarly historian of art today would feel the least temptation to try to define “art,” as if that complex expression of human creativity could be pinned down by a few well-chosen words. And similarly, as the noted historian of technology Thomas Hughes has written (2004: 2), “Defining technology in its complexity is as difficult as grasping the essence of politics. Few experienced politicians and political scientists attempt to define politics. Few experienced practitioners, historians, and social scientists try to inclusively define technology.” Most historians writing on technology have defined the term mostly by presenting and discussing pertinent examples. Many historians studying the twentieth century have focused on large technological systems, such as electricity, industrial production, and transportation, that emerged in the early decades and became more or less pervasive in the West during the second half of that century.

Other historians even of the twentieth century, however, would strongly prefer to examine technologies from the perspective of “everyday life” or from a user’s perspective. Even what might on the surface be considered the same technology can look quite different when viewed “from above” using a manager’s or a business executive’s perspective or, alternately, “from below” using a worker’s or an individual consumer’s perspective. Often, the view from above leaves the impression of large systems spreading more or less uniformly across time and space – as, for instance, maps showing the increasing geographical spread of railways and highways or statistical tables showing the increasing pervasiveness of such electrical consumer goods as irons, refrigerators and televisions. Conversely, locally situated studies of individual technologies, sometimes inspired by consumption studies, often find substantial variability in patterns of use and in the meanings these technologies have for subcultures that form around them. As studies inspired by the productive "user heuristic" have shown, there is a great deal of creativity and inventiveness that is uncovered when paying close attention to these local processes (Oudshoorn and Pinch 2003; Hippel 2005). Farmers invented new uses for Henry Ford's classic Model T automobile when adapting it for use on the farm as a source of power. Even the widely popular invention of email was at the start "unplanned, unanticipated, and most unsupported" by the original designers of the Internet (Abbate 1999: 109). Japanese teenagers created new uses for mobile pagers and cell phones, and created a new culture in doing so (Ito et al. 2005). Many times these activities, not originally conceived by the system designers, can be taken up by the producers of these devices and systems and transformed into economically lucrative marketing strategies. This finding of substantial diversity has implications beyond merely complicating any tidy definition of technology; this diversity, especially the agency of users in divining and defining new purposes for a certain technology and new activities around it, also keeps open the question whether technologies can meaningfully be said to have "impact" on society and culture. Normative evaluations of technology, then, cannot assume that the meanings or consequences of technology can be easily comprehended; nor, as was once the case in the early days of the technology-assessment movement, can these characteristics be predicted from the technology's "hardware" characteristics. Indeed, all assessments of technology need to grapple with these epistemological and methodological problems.

Indeed, recent research has productively treated the term "technology" as an emergent and contested entity. Technology is not nearly as old as we commonly think, especially if we have in mind the several technologically marked historical epochs, such as the Bronze Age or the Iron Age. Jacob Bigelow, a medical doctor and Harvard professor, is often credited with coining the term in his book *Elements of Technology* (1829). “The general name of Technology, a word sufficiently expressive … is beginning to be revived in the literature of practical men at the present day,” he wrote (Bigelow 1829/1831: iv–v). “Under this title it is attempted to include … an account … of the principles, processes, and nomenclatures of the more conspicuous arts, particularly those which involve applications of science, and which may be considered useful, by promoting the benefit of society, together with the emolument of those who pursue them.” Earlier than this, the term “technology” in English, as well as its cognates in the other principal European languages, referred most directly to the treatises and published accounts describing various technical crafts. Bigelow’s own coinage did not immediately catch on, however. His speech to the Massachusetts Institute of Technology more than three decades later helped recast the term as an aggregate of individual tools and techniques, an agent of progress, and an active force in history. “Technology,” he asserted in 1865, “in the present century and almost under our eyes … has advanced with greater strides than any other agent of civilization, and has done more than any science to enlarge the boundaries of profitable knowledge, to extend the dominion of mankind over nature, to economize and utilize both labor and time, and thus to add indefinitely to the effective and available length of human existence” (Segal 1985: quote 81).

Following Bigelow’s use, “technology” gained something of its present-day associations in the next several decades. Numerous institutes and colleges of technology in the United States took up the name: not only the flagship of MIT (founded 1861) but also other colleges, schools, or institutes of technology such as Stevens (1870), Georgia (1885), Clarkson (1896), Carnegie (1912), California (1921), Lawrence (1932), Illinois (1940) and Rochester (1944). Polytechnics in Europe, often modeled on the pioneering École Polytechnique (founded much earlier, in 1794) in Paris, provided broadly similar educational opportunities. In 1950, the Indian government founded Kharagpur Institute of Technology, the first in a national network of seven technical universities.

As Ruth Oldenziel (1999) has made clear, in these same decades “technology” took on a distinctly male-oriented slant. Earlier terms such as “the applied arts” or “the industrial arts” could be associated equally with the products of women’s work as with men’s; but “technology” after 1865 increasingly came to signify male-oriented machines and industrial processes. Oldenziel sees the emergence of technology in the personification of the (male) engineer as an instance of the gender-coding of the modern world. Eric Schatzberg situates the rise of “technology” as a keyword in the writings of social critic Thorstein Veblen, who drew heavily on the contemporary German discourse around “technik,” as well as of the popular historian Charles Beard. “Technology marches in seven-league boots from one ruthless, revolutionary conquest to another, tearing down old factories and industries, flinging up new processes with terrifying rapidity,” in Beard’s arresting and deterministic image (Schatzberg 2006: 509). Also following Raymond Williams’s method of keywords, Ronald Kline (2006) examines origins of “information technology” in the management-science community of the 1960s and its subsequent spread into the wider discourse.

Recently, the term “technoscience” has found favor in the writings of some, if not all, philosophers of technology and historians of technology. Advocates of the term maintain that the practices, objects and theories of science and technology, even if they once were separate professional communities, have blurred to a point at which they share many important features – indeed, to a point at which their similarities outweigh their differences. The term is not merely a recognition that biologists today frequently enough apply for patents and create start-up companies; it also draws attention to hybrid forms of knowledge and practices. (As such, the appeal to hybridity is an important aspect of the anti-essentialism that is characteristic of much recent technology studies.) With a tone of caution, Barry Barnes (2005: 155) writes of “near consensus on the predominance of technoscience as something characteristic particularly of recent times.” Philosopher of technology Don Ihde’s *Instrumental Realism* (1991) presented an extended analysis of Latour’s *Science in Action* (1987), in which “technoscience” was defined and popularized.[1] And, similarly, Ruth Cowan’s *Social History of American Technology* (1997) takes up “technoscience” in her final chapter, using the examples of hybrid corn, penicillin and the birth-control pill. Overall, historians conceptualize technology as contingent, constructed and contested.

Problems of Culture

In making their assessment of the “anthropological variety” of technology (see Li-Hua), the essays of this section attempt to identify and describe the core qualities that can be associated with Islamic, Chinese, Japanese and Western technology. These essays utilize the familiar method of defining by example and discussion, and there is much to be learned from the rich empirical diversity that such an overview provides. It is worth marking at the onset, all the same, that each of these essays takes up a more-or-less bounded and non-problematic analysis of the assigned "culture." This is especially the case, somewhat paradoxically, when the essays examine instances of the transfer of technology between regions or cultures. Even the idea of a technological "dialogue" between different cultures (used to good effect by Arnold Pacey [1990]) can still carry the assumption that there exists a fundamental, identifiable and more-or-less essential core to the culture(s) under examination. Recently, anthropologists and social theorists have preferred to jettison such essentialist conceptions of culture, and to prefer performative ones. Here, there is no stable core to a given culture – i.e. its essential features – that is constant across time and then that might "change" under one set of circumstances or another. A performative view postulates that cultures are continually re-created and performed, so that changes can be small and incremental and/or large and dramatic. Performative conceptions of culture are also helpful in identifying cultural hybridities, where cultural productions take up and incorporate novel elements which may have their origins in "foreign" borrowings but also with "domestic" innovations.

On the surface, Japan might seem a reasonable candidate for an essentialist understanding, owing to its geographic separation and strong cultural identity. What we might today consider to be "quintessentially Japanese" came rather late to Japan. As David Wittner shows, Japan for many centuries received transfers and/or engaged in technological dialogue with China and Korea, the sources of wet-field agriculture, of the basic techniques of working bronze and iron, as well as of weaving, silk, paper and more. Wittner suggests that, beginning in the eighth century, Japanese woodworking, printing, metalworking and other crafts diverged from Chinese practices. The rise of urban centers of innovation in the late Heian period (794–1185) led to distinctive Japanese practices in jointless carpentry, as well as in standardized interior spaces signified by uniform-sized tatami mats. Metal-based military innovations came to the fore during the Warring States period (1467–1568), notably in the fields of sword-making and gun manufacture.

Two prototypically “Western” technologies that were introduced into Japan in the mid-sixteenth century provide an apt way of assessing Japan’s remarkable technological sophistication. Gunpowder weapons arrived in Japan in 1543 after a Portuguese ship was wrecked off the coast. It happened that the Portuguese survivors landed on the small island of Tanegashima, that this island was rich in iron ore and consequently also in metalworking skills, and that its local lord commanded one of his artisans to make a copy of a Portuguese gun, achieved in short order, and that this region of Japan was well connected to the mainland through trade and tributary relations (see Lidin 2002). The result was that within three decades Japan was making very large numbers of these muskets, with specially modified firing-lock mechanisms and extra attention to effective waterproofing. Muskets, numbering in the many thousands, played a decisive role in the battle of Nagashino (1875), a turning-point in Japan’s political history that led to the consolidation of power by the Tokugawa shogunate (1600–1868). A battle in 1600 is believed to have featured 20,000 muskets.

Western-style mechanical clocks arrived in Japan in 1551, introduced by Jesuit missionaries. In his essay Wittner rightly stresses the unprecedented mechanical complexity of the mechanical clock, and perceptively suggests that its mastery by Japanese artisans forms an important resource for Japan’s later industrial prowess with mechanized reeling machines and looms. It also should be emphasized that Japanese artisans invented an entirely distinctive type of clock, which married the mechanical regularity of its interior clockwork mechanism with several ingenious schemes for relating this mechanically uniform time to the seasonally varying hours that typified Japanese concepts of time. There were six equal units of Japanese time between local sunrise and sunset, and also six units between local sunset and sunrise, the length of which then varied by the season. To devise clocks, including automatic bell-striking ones, that would vary the effective length of the hour seems a compelling instance of a thoroughly "hybrid" technology, and certainly not merely an adaptation or transfer of a Western one. Japan persisted with its distinctive, non-Western time-keeping system until 1873, when during the modernization of the Meiji era (1868–1912) the country converted to a Western calendar and Western time practices amid a great number of other Western-inspired institutional changes. Indeed, it may be that the development of "Japanese" identity was a cultural response to the coming of modernity (Caldararo 2003: 465).

The technological and cultural variability one confronts in examining China and Islam is even much greater. As Thomas Glick points out, the "Islamic technology" he surveys is really the technological and scientific knowledge characteristic of the classic Islamic Arab civilization. At its peak in the eighth century, and continuing until 1492, the political and cultural influence of Islamic Arabs extended through North Africa and into present-day Spain. This is why one finds Islamic technology in eastern Spain in the form of so-called Persian-style *qanat* irrigation techniques as well as water-raising *noria.* From the thirteenth century, gunpowder weapons, too, were subject to a wide-ranging geographical transfer process as the Mongols transported this Chinese technology westward with devastating effects. Glick appropriately situates his discussion of Islamic technology in the context of wider continent-scale flows of knowledge and techniques, including the movement westward of the Indian style of agriculture (involving a "distinctive roster" of citrus fruits, rice, sugar cane and cotton) and the diffusion to the Islamic world of Greek astronomy and Indian astronomical tables and instruments. One culturally distinctive set of practices involved the computation of special tables to identify the direction of Mecca as well as accurate timekeeping to mark out the five daily prayer times. Yet, as Glick (1996) and others have recently suggested, "Islamic" technology may also be more of a "hybrid" than a brief overview is able to convey. The specific forms of irrigation in medieval Valencia, for instance, may reflect North African influences and models as much as Arab ones.

Compared with the essays on Japan and Islam, Francesca Bray's essay on Chinese technology is certainly less affected by any sort of essentialist assumptions about the core of China's technology or culture. As an anthropologist herself, Bray offers an essay that at once is close to Chinese assessments of technology and situates itself squarely in the context of historiographic debates on China. She is asking the questions "What do we know about China?," "What do the Chinese know about China?" and "How have the tensions and competitions of the Cold War influenced how we conceptualize China?" One consequence of the political climate of the Cold War, with its long-standing obsession with understanding and conceptualizing the supposedly technology-driven process of industrialization, was the framing and persistence of the "Needham question." Joseph Needham, the eminent British scholar, posed the question why, given China's superior attainments in science and technology – having invented gunpowder, the compass, movable-type printing, all well in advance of the medieval West – did China not also experience a large-scale transformation of its society and economy, which we in the West label as our own scientific revolution or industrial revolution.

Characteristically, however, Bray spends much more time on what Chinese people thought about their own relations to the West, rather than attempting to answer the Needham question. Across most of the entire nineteenth century, China was hard-pressed by the Western powers. Following the experience of “humiliating defeats” in the Opium Wars (1840–2, 1856–60) and the loss of sovereignty attending the forced signing of the “unequal treaties” with the Western powers, the Chinese attempted a home-grown modernization known as “self-strengthening.” Despite some successes such as the Jiangnan Arsenal in Shanghai, the efforts to build up China’s economy and technological level as well as achieve a productive accommodation between “Western artifacts and Chinese spirit,” the overall results were disappointing. Japan, fresh from its own Western-inspired modernization, invaded China in 1894 and forced additional territorial concessions. Given these setbacks, it was difficult for Chinese people to see and appreciate their own technological heritage; instead they conceptualized “technology” as a foreign, Western construct. Technocratic Chinese advocates of economic development in the 1930s, according to Bray, strove to emulate Western models. For much of the orthodox Maoist period (1949–78), China oscillated between grand attempts at forced-draft industrialization and the upheavals of the Cultural Revolution, with its anti-technocratic slogan “Better Red than Expert.” More recently, as Bray notes, scholars of China have entirely shifted away from the comparative Needham questions and instead treated China on its own terms rather than as a reflection of the West.

Dilemmas of Determinism

Discussion of the common concerns of philosophers of technology and historians of technology must include mention of “technological determinism.” As noted above, philosophers and historians have not seen eye to eye when examining the problem of whether, if and how technology brings about social and cultural changes. In their more or less essentialistic framing of the problem a generation ago, philosophers of technology were among the most enthusiastic proponents of the notion of technology as a strong and compelling force for change in history, while historians of technology took great pains to attack any and all forms of technological-determinist arguments (Smith and Marx 1994). Differences in the analytical “scale” at which scholars conduct their studies help account for these explanatory differences (Edwards 2003; Misa 2004b). The cases of military technology and Western technology, which are often cited as leading examples in assessments of the power of technology, offer rich material to explore and assess the dilemmas of determinist accounts of technology.

Bart Hacker frames his essay on “Technology and War” in an interactive framework. “The interplay of military institutions and changing technology has regularly made history,” he maintains. His essay presents a richly textured account, over a very long span of human history, of these interactions. His model is that military institutions are both key sites of technical innovation and critical vectors that transport and transform technical innovations. He finds the rise of organized armies in the Near East, in Mesopotamia and in Egypt in the fourth millennium BCE to be a key turning-point that “decisively divided prehistory from civilization.” Composite bows and horse-drawn chariots contributed to the effectiveness of the emerging armies, but these complex and expensive technologies required deep pockets; thus the new technologies in this way depended on the state’s capability of mobilizing extensive resources. These early states clearly took form through the deployment of military technologies, while these technologies were themselves products of state initiative.

Hacker also provides a detailed account of the rise of feudalism as a social, economic and political form – arising first on the Iranian frontier – and its relation to the (again expensive) technologies of large grain-fed warhorses. Feudalism, with its “centers of local military power that regularly threatened central control,” was certainly not the ideal option for a central power wishing to retain control over its lands, but in Hacker’s estimation it was a social and economic arrangement necessary to field the war-winning military technology of the time. One classic technological interpretation of feudalism that Hacker does not cite in this essay is that of Lynn White (1962). White famously argued that horse stirrups, heavy plows, and mechanical power were crucial to the rise of feudalism in Europe. Even with many scholarly criticisms over the years, White’s overall interpretation retains remarkable persistence among non-specialists (for a recent assessment, see Roland 2003).

A set of “revolutions” related to military technologies rounds out Hacker’s treatment. Gunpowder weapons, invented in China in the late thirteenth century, had dramatic consequences for the states that embraced them. Not only were guns useful in claiming territories from lesser-armed foes; the sizable expenses required to field an army with numerous guns (as well as procuring the extremely costly gunpowder) also worked to centralize both political and economic power. These changes – clearly related to technology but certainly not caused by technology – were most evident in the classic early-modern “gunpowder empires” of the Ottomans in the Near East, the Safavids in Iran, and the Moguls in India. Intense competition between rival states in Europe, with none of them able to consolidate power over the continent, led to a period of vigorous institutional and technological innovation. The resulting "military revolution," Hacker writes, "may well have been the key factor that disrupted in the West's favor the rough parity in technology, economy, and polity that prevailed until the 15th century among civilized communities all across the Old World."

By around 1900, in the wake of military, scientific and industrial revolutions, the West's military capabilities would "achieve an almost uncontested hegemony over most of the world." As noted above, the modernizations embodied in China's "self strengthening" as well as in Japan's Meiji restoration were constructed around the adoption of Western weapons and Western models for military institutions. As Hacker concludes, "in the late 19th and 20th centuries, all armies became Western in organization, in equipment, and in spirit."

If "all armies became Western," then might it be the case that Keld Nielsen's essay on Western technology describes the paradigm toward which the world is conforming? Nielsen himself suggests that Western technology has become more or less pervasive, and can be "found on all continents." There are numerous ways in which Western and non-Western technologies share significant characteristics, but it is Nielsen's ambition to identify a number of "unique" characteristics that typify Western technologies. These include, in somewhat compressed form, the ability to extract mechanical energy from fossil fuels; the creation of integrated systems of mass production linking raw materials, production and consumers; the spread of uniform technical standards; the ability to manufacture tools and products to increasing mechanical precision; the mobilization of large capital and financing; the deployment of scientific knowledge; and a commitment to continuous "renewal" through research and development. Nielsen also allows that these immense technological capabilities have made it possible for humans to alter the world's climate or even destroy its population.

As such, Nielsen's list of unique Western characteristics is an admirable one to have identified but a difficult one to defend. One possible defense would be to assert that Western technology is typified by the *package* of these characteristics, taken together, and operating on a large and/or pervasive scale – and not by the characteristics taken individually. Certainly there is a meaningful difference in the technological capacities of, say, Switzerland and of most of the countries in sub-Saharan Africa, as measured in phone lines or Internet connections per capita, access to patents and technology, and agency in dealing with the global economy. Luxembourg has 199 phone lines per 100 inhabitants; Angola has 1.5. Maps of the global Internet, as well as composite photos of the Earth during night-time hours, also indicate that Africa as a continent is in comparative terms literally "off" the electricity and information networks.

The end of the Cold War and the rise of globalization has further blurred lines marking off the "West" and made it more difficult to defend the concept of "Western technology." A Western computer might be designed in Silicon Valley (safely in the West), but software is increasingly written by programmers in India and China, with many components of personal computers manufactured in Taiwan, Hong Kong, China and other formerly "Far Eastern" countries. According to the Basel Action Network, no fewer than 500 large containers (40 feet in length) arrive each month in the port of Lagos, Nigeria, packed with obsolete computers and other electronic equipment. While Lagos has an active market in recycling these components, up to three-quarters of the shipped material is unusable trash, in effect being dumped in Africa owing to cheap global shipping.[2] Apart from the obvious moral issues, there is a puzzle in this example concerning what is "Western" about these computers, and whether they are still fairly considered to be "Western" when manufactured in a Chinese town and then, some months later, disposed of in Africa.

Notes

1. Latour's definition of technoscience (1987: 174–5) is part of the exposition of his worldview and method, and it is not easy to summarize briefly. The relevant passage reads: "To remind us of this important distinction [the Janus-like quality of science-in-the-making compared with ready-made science], I will use the word **technoscience** from now on, to describe all the elements tied to the scientific contents no matter how dirty, unexpected or foreign they seem, and the expression '**science and technology**,' in quotation marks, to designate *what is kept of technoscience* once all the trials of responsibility have been settled. The more 'science and technology' has an esoteric content the further they extend outside. Thus, 'science and technology' is only a sub-set which seems to take precedence only because of an optical illusion."

2. <www.ban.org/BANreports/10-24-05/index.htm> (21 December 2007).

References and Further Reading

Abbate, J. (1999). *Inventing the Internet* (Cambridge, Mass.: MIT Press).
Achterhuis, H. (2001). *American Philosophy of Technology: The Empirical Turn* (Bloomington, Ind.: Indiana University

Press).
Adas, M. (2006). *Dominance by Design: Technological Imperatives and America’s Civilizing Mission* (Cambridge, Mass.: Belknap Press).
Barnes, B. (2005). “Elusive Memories of Technoscience,” *Perspectives on Science,* 13 (2): 142–65.
Beniger, J. R. (1989). *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, Mass.: Harvard University Press).
Bigelow, J. (1831). *Elements of Technology,* 2nd edn (Boston, Mass.: Hilliard, Gray, Little & Wilkins). Originally published 1829.
Bijker, W. and Law, J. (eds) (1992). *Shaping Technology/Building Society: Studies in Sociotechnical Change.* (Cambridge, Mass./London: MIT Press).
Bijker, W., Pinch, T. and Hughes, T. (eds) (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, Mass.: MIT Press).
Brenner, N. (2004). *New State Spaces: Urban Governance and the Rescaling of Statehood.* (Oxford: Oxford University Press).
Caldararo, N. (2003). “The Concept of the Sustainable Economy and the Promise of Japan’s Transformation,” *Anthropological Quarterly,* 76 (3): 463–78.
Clancey, G. (2006). *Earthquake Nation: The Cultural Politics of Japanese Seismicity, 1868–1930* (Berkeley, Calif.: University of California Press).
Cowan, R. S. (1997). *Social History of American Technology* (New York: Oxford University Press).
Edwards, P. N. (2003). “Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems,” in T. Misa et al. (eds) (2003), *Modernity and Technology* (Cambridge, Mass.: MIT Press), pp. 185–225.

Fischer, C. S. (1992). *America Calling: A Social History of the Telephone to 1940* (Berkeley, Calif.: University of California Press).
Glick, T. F. (1996). *Irrigation and Hydraulic Technology: Medieval Spain and Its Legacy* (Aldershot: Variorum).
Hippel, E. von. (2005). *Democratizing Innovation* (Cambridge, Mass.: MIT Press).
Hughes, T. P. (2004). *Human-built World: How to Think about Technology and Culture* (Chicago, Ill.: University of Chicago Press).
Ihde, D. (1991). *Instrumental Realism: The Interface between Philosophy of Science and Philosophy of Technology* (Bloomington, Ind.: Indiana University Press).
Ihde, D. (2004). "Has the Philosophy of Technology Arrived? A State-of-the-Art Review," *Philosophy of Science,* 71: 117–31.
Ito, M., Okabe, D. and Matsuda, M. (eds) (2005). *Personal, Portable, Pedestrian: Mobile Phones in Japanese Life* (Cambridge, Mass.: MIT Press).
Kline, R. R. (2000). *Consumers in the Country: Technology and Social Change in Rural America* (Baltimore, Md.: Johns Hopkins University Press).
Kline, R. R. (2006). "Cybernetics, Management Science, and Technology Policy: The Emergence of 'Information Technology' as a Keyword, 1948–1985," *Technology and Culture,* 47 (3): 513–35.
Kline, R. and Pinch, T. (1996). "Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States," *Technology and Culture,* 37: 763–95.
Latour, B. (1987). *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, Mass.: Harvard University Press).
Lidin, O. G. (2002). *Tanegashima: The Arrival of Europe in Japan* (Copenhagen: NIAS Press).

Misa, T. J. (2004a). *Leonardo to the Internet: Technology and Culture from the Renaissance to the Present* (Baltimore, Md.: Johns Hopkins University Press).
Misa, T. J. (2004b). “Beyond Linear Models: Science, Technology, and Processes of Change,” in K. Grandin et al. (eds) (2004), *The Science–Industry Nexus: History, Policy, Implications* (Sagamore Beach, Mass.: Science History/Watson Publishing), pp. 257–76.
Misa, T., Brey, P. and Feenberg, A. (eds) (2003). *Modernity and Technology* (Cambridge, Mass.: MIT Press).
Oldenziel, R. (1999). *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870–1945* (Amsterdam: Amsterdam University Press).
Oudshoorn, N. and Pinch, T. (eds) (2003). *How Users Matter: The Co-construction of Users and Technology* (Cambridge, Mass.: MIT Press).
Pacey, A. (1990). *Technology in World Civilization: A Thousand-year History* (Cambridge, Mass.: MIT Press).
Roland, A. (2003). “Once More into the Stirrups: Lynn White Jr., Medieval Technology and Social Change,” *Technology and Culture,* 44 (3): 574–85.
Schatzberg, E. (2006). “Technik Comes to America: Changing Meanings of Technology before 1930,” *Technology and Culture,* 47 (3): 486–512.
Schot, J. (2003). “The Contested Rise of a Modernist Technology Politics,” in T. Misa, P. Brey and A. Feenberg (eds) (2003), *Modernity and Technology* (Cambridge, Mass.: MIT Press), pp. 257–78.
Segal, H. P. (1985). *Technological Utopianism in American Culture* (Chicago, Ill.: University of Chicago Press).
Smith, M. R. and Marx, L. (eds) (1994). *Does Technology Drive History?* (Cambridge, Mass.: MIT Press).
Staudenmaier, J. M. (1990). “Recent Trends in the History of Technology,” *American Historical Review,* 95: 715–25.
Verbeek, P.-P. (2005). *What Things Do: Philosophical Reflections on Technology, Agency, and Design* (University

Park, Pa.: Penn State University Press).
Winner, L. (1977). *Autonomous Technology: Technics-out-of-control as a Theme in Political Thought* (Cambridge, Mass.: MIT Press).

Chapter 2
Definitions of Technology

RICHARD LI-HUA

Owing to anthropological diversity, the attempt to define technology seems quite challenging. People may have different interpretations as they are positioned differently. This reminds me of the Chinese parable of the blind men and the elephant.

Megantz (2002) further elaborates in the preface to his book *Technology Management: Developing and Implementing Effective Licensing Programs* that technology is a wonderful, amazing, always changing bag of tricks that helps human beings to live healthier, happier (however, these could take place in other way around) and more fulfilling lives. To a scientist, technology is the end product of one's research. To an engineer, technology is a tool or process that can be employed to build better products or solve technical problems. To an attorney, technology is intellectual property to be protected and guarded. To a business executive, technology may be the most important, yet least understood, company asset. Technology is viewed as competitive advantage against rivals.

Technology means state power to both developing and developed countries. Technology is regarded as a strategic instrument in achieving economic targets and in the creation of wealth and prosperity in the developing countries, while technology is taken as an important vehicle to get large profits in the developed countries. The effective use of technology is perhaps the most important issue faced by both developing and developed countries, and will undoubtedly become even more critical in years to come.

The word “technology” usually conjures up many different images and generally refers to what has been described as the “high-tech,” or high-technology, industries. It has to be understood that limiting technology to high-tech industries such as computers, superconductivity, chips, genetic engineering, robotics, magnetic railways and so on focuses excessive attention on what the media consider newsworthy (Gaynor 1996). However, limiting technology to science, engineering and mathematics also loses sight of other supporting technologies. Actually, technology includes more than machines, processes and inventions. Traditionally, it might concentrate more on hardware; however, in these days, more on soft side as well. There are many manifestations of technology; some are very simple, while others are very complex.

What Is Technology?

But what exactly is meant by the term “technology”? According to Dean and LeMaster (1995, p. 19), technology is defined as “firm-specific information concerning characteristics and performance properties of production processes and product design.” While Contractor and Sagafi-Nejad (1981) describe technology simply as “a bundle of information, rights and services,” Maskus (2004, p. 9) defines technology as “the information necessary to achieve a certain production outcome from a particular mean of combining or processing selected inputs.” However, Maskus (2004) solely distinguishes between embodied and disembodied technology, whereas Kedia and Bhagat (1988) recommend a more detailed classification into process-, product- and person-embodied technology.