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Beyond Science and Civilization: A Post-Needham Critique[1]

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The contention that science is uniquely Western has never been presented as a thesis to be demonstrated historically—that is, stated explicitly, formulated rigorously, evaluated critically, and documented comprehensively. Instead, throughout much of the twentieth century, variants on this theme frequently appeared in panegyrics for Western civilization ("Science . . . is the glory of Western culture" [Kyburg 1990: 3]), in the forgings of exalted origins for the West in Greek antiquity ("science originated only once in history, in Greece" [Wolpert 1992: 35]), and in accounts that confidently offered purported explanations for the absence of science in other civilizations—accounts thus unencumbered by any require-

[1] This article developed from the concluding chapter of my dissertation which presents a study of Chinese mathematics during the Ming dynasty and a microhistorical analysis of the introduction of Euclid's Elements into China. This article presents a critique of the science and civilizations approach within which much of the received historiography on this episode has been framed. Mario Biagioli, Benjamin Elman, David Keightley, Ted Porter, Haun Saussy, and two anonymous reviewers offered detailed and very helpful criticisms. Versions of this article have been presented at the Fairbank Center for East Asian Research at Harvard University, the Society for the Social Studies of Science, and the Chinese Historiography Studies Group at the Association for Asian Studies. Students in a seminar on Chinese science at Stanford University offered perceptive comments. I would like to thank all those who offered suggestions. An earlier version has been published as "On the Problem of Chinese Science," in *The Science Studies Reader*, edited by Mario Biagioli (New York: Routledge, 1999).

ment to examine sciences already known to be absent.[2] As presented, these were hardly simple assertions of differential developments of specific sciences in particular geographic areas during particular historical periods. Instead they asserted a Great Divide between the imagined community the West and its Other.[3] One particularly dramatic formulation was Ernest Gellner's "Big Ditch," symbolizing the enormous differences separating "traditional" societies from the scientific "Single World or Unique Truth" produced by "one *kind* of man" (Gellner 1979: 145–47; Gellner 1982: 188–200). Such assertions—although apparently about the West—should have depended for their validity on investigations of other cultures. However, the historical evidence accompanying such claims related only to the uncontroversial half of the assertion—the existence of sciences in the West. The substantive half—the assertion of the absence of science in every other culture—rested on little more than the ignorance of the sciences of other cultures, mistaken for the ignorance of other cultures of science. The most important historical counterexample was China—research beginning in the 1940s increasingly provided considerable evidence that there were in China many forms of knowledges and practices similar to those that have been labeled "science" in the West.[4] This, then, is the reason that "Chinese science" became a problem.

Despite this evidence, claims that science is uniquely Western have continued to appear even in the most respected scholarly literature in the history of science;[5] on the other hand, major research projects on Chinese science have

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[2] Several examples will be discussed below.

[3] For examples of debates over this kind of a "Great Divide," see Horton and Finnegan 1973. For criticisms of assertions of a "Great Divide," see Geertz 1989: 19; and Latour 1993: 97–100, discussed below.

[4] The two most important examples are the work of Joseph Needham and Nathan Sivin. For a comprehensive overview of Chinese science, see Needham's multivolume series *Science and Civilisation in China* (Cambridge, Eng.: Cambridge Univ. Press, 1954–). For important correctives of Needham's work, see Sivin 1995. For Needham's publications (up to 1973), see "Bibliography of Joseph Needham" 1973. For Sivin's works, see "The published writings of Nathan Sivin: An annotated bibliography" 1996. For a review of current research, see Sivin 1988; and idem, "Selected, annotated bibliography of the history of Chinese science: Sources in Western languages," in Sivin 1995.

[5] For two important recent examples, see Huff 1993; and the work of A. C. Crombie, especially Crombie 1994, and his "Designed in the mind: Western visions of science, nature and humankind" and "The origins of Western science," both in Crombie 1996. For example, in his review of Huff's book, Crombie, quoting from the introduction to his own multivolume work, presents the following theses: "the history of science as we have it is the history of 'a vision and an argument initiated in the West by ancient Greek philosophers, mathematicians and physicians'"; "it is 'a specific vision, created within Western culture'"; it was based on the Greeks' "two fundamental conceptions of universal natural causality matched by formal proof"; "'from these two conceptions all the essential character and style of Western philosophy, mathematics, and natural science have followed'" (*Journal of Asian Studies* 53, 4 [1994]: 1213–14; quoted from Crombie 1994: 3–5). In

often—up to the present—been framed within these disputes. But rather than returning to take sides within these debates, this article will take the framework that has preconditioned these controversies as itself the object of historical analysis. That is, this article will analyze what these accounts share: the assumption that the imagined communities China and the West are to be fundamental starting points in analyses of the history of science; that to the West and China we can then rigorously assign antithetical pairs of attributes (e.g., scientific versus intuitive, theoretical versus practical, causal versus correlative thinking, adversarial versus irenic, or geometric versus algebraic) that remain valid across historical periods, geographic locales, social strata, gender identifications, economic and technological differentials, and domains of scientific research along with their subdomains and competing schools; and that ultimately, studies of science can contribute to the further assignment of normative attributes in praise-and-blame historiographies of civilizations (e.g., the uniqueness of the West in producing universal science, the xenophobia of China, or the equality of all civilizations).

Civilization and Science

Perhaps it was the ambiguities in concepts as broad as *civilization* and *science* that encouraged such easy answers to questions about their relationship. With the existence of suprahistorical entities called civilizations established by assumption, the central question became to determine what exactly characterized them. What were the essential features that distinguished one civilization from another? Given an assumed Great Divide that separated the West and its Other, this question was often posed in a very specific form: What made the West unique? Yet the very requirements that these essential defining features were supposed to fulfill presented something of a paradox: these features were to be transhistorical, existing across spans of hundreds or thousands of years; they were also to be unique—confined within the boundaries of a single civilization (for example, the West)—and thus their antithesis was to characterize other civilizations, again over hundreds of years.[6] Moreover, although these distinguishing features were to define a single civilization, there was to be a sense in which it remained possible to compare them: all civilizations were by definition in some sense unique, yet the ultimate conclusions reached were often comparisons of civilizations along normative teleologies of moral, political, scientific, or economic progress. Some civilizations were more unique than others.

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comparison, Crombie asserts, "China had no Euclid, and did not adopt his scientific style when that became available" (p. 1214). It should be noted, however, that the number of adherents to such viewpoints is decreasing.

[6] To be sure, transhistorical continuity was often constructed through metaphors of growth and development; uniqueness was often defended through claims of propensities and emphasis.

To answer to this conundrum, almost any research purporting to discover essential features of the West could be called into service. For some writers fundamental differences were linguistic: alphabetic versus ideographic scripts, the existence versus nonexistence of the copula, scientific versus poetic, theoretical versus practical, or abstract versus concrete; these traits were then linked to the development of rigorous scientific language or efficient bureaucracies (e.g., Goody 1986; Gernet 1985). In some accounts, the fundamental difference was capitalism, which itself ushered in modernity. In yet other accounts, the key was religion: Max Weber improbably connected the differences he alleged to have discovered between Protestantism and Chinese religions to the development of capitalism (Weber [1922] 1951).[7] For others, the fundamental differences were philosophic: conceptions of natural law, causal versus correlative thinking, the ordering of time and space, demonstrative logic versus consensus (e.g., Needham 1951; Bodde 1959; Bodde 1979); China, one translator of Chinese philosophy proclaimed, lacked philosophy altogether (Dubs 1929). For others, the fundamental difference was political—democracy versus Oriental despotism (Wittfogel 1957). This list represents but a fraction of claims for the key features distinguishing the West from the Rest; the search continues to this day (e.g., Huntington 1996).

In the context of this broader literature, "science" was then but one possible solution among many that have been offered to explain the purported differences. Comparative studies, however, rarely even attempted to offer any precise criteria for defining what they might mean by the term *science*. Often, *science* was simply left undefined (this was sometimes rationalized by scientistic claims that *science* was to be a primitive undefined concept); elsewhere *science* was defined by invoking equally amorphous terms such as *reason* or *rationality*.[8] In other accounts, the mere appearance of lexical terms was apparently sufficient to guarantee the existence of science (most often the word *science* itself, under proper translation, in Latin, Italian, or English); and then—again under suitable translation—the lack of the lexical term *science* in Chinese seemed to demonstrate that China lacked science. In still other accounts, it was a scientific methodology that defined science. At their least sophisticated, these asserted methodologies were little more than the familiar ideologies of scientists culled from selective readings of the early Greeks, Galileo, Bacon, or Newton. Elsewhere it was axiomatization that was held to differentiate scientific traditions;[9] sometimes it was deduction or logic, originating with the Greeks, or Descartes, or Galileo; sometimes it was preferred analogies—natural law, the book of nature, or the mechanical universe.

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[7] Weber also included double-entry bookkeeping for good measure.

[8] For example, Lukes's attempt to offer a transcultural definition of *rationality* ends up with little more than the principle of non-contradiction (Lukes 1970).

[9] This claim at least had the merit of specifying a seemingly more concrete, identifiable methodology, and one which apparently can be found in ancient Greece, early modern Europe, and modern mathematics.

There are, however, good reasons to believe that the required definition of *science* cannot in fact be made, for it would require rigorous philosophical criteria capable of demarcating science from non-science—criteria that remained both transhistorically and transculturally valid.[10] First, it has proven impossible to establish criteria to demarcate "science" from "non-science":[11] the term *science* is not a "natural kind,"[12] nor can it be defined by a simple description or disjunction of descriptions; it has been impossible to offer a definition of *science* which could claim both to encompass all of the sciences and to exclude what is not science.[13] The difficulty with defining *science* by some unified methodology is suggested by Feyerabend's criticism that "*the events, procedures and results that constitute the sciences have no common structure;* there are no elements that occur in every scientific investigation but are missing elsewhere" (Feyerabend 1988: 1; emphasis in original). Second, such a definition or criteria for *science* would have to be transhistorical—the definition would have to apply equally well to the present and to ancient Greece (in accounts which place the origin of science there) or seventeenth-century Europe (in the case of modern science).[14] Third, such a definition for *science* would have to be transcultural if it were to avoid the charge of simply circularly invoking the particular sciences in one or several localities (e.g., ancient Greece, early modern Europe) as its essential defining forms.[15]

These writers of the twentieth century, then, sought to provide answers to questions about the relationship between science and civilizations without any particularly clear formulation of either of the concepts that would serve as the framework for their inquiry. But rather than attempting to provide for these authors definitions that they themselves never used—definitions that arguably do not exist—this article will instead chart the history of debates in which it was the

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[10] For recent critiques, see Galison and Stump 1996.

[11] There are enough important philosophical arguments against adopting naive views to warrant demanding a precise definition. Important examples include Wittgenstein [1953] 1969; Feyerabend 1988; Thomas S. Kuhn 1970; Quine 1961; and Quine 1991.

[12] See also Richard Rorty's overview of these arguments (Rorty 1991).

[13] In a more general form, the problem here may be that linguistic terms often lack central, essential meanings, but instead seem to share what Wittgenstein called a family resemblance of uses.

[14] And again, we encounter a more general problem of transhistorical definitions: radical changes often lie behind the apparent nominal continuity of a word. In contrast to the term *science*, it is much easier to offer precise definitions of specific scientific or mathematical terms, such as *calculus*.

[15] There is no reason to assume that political or even linguistic boundaries are congruent with those of the networks of scientific knowledge. And more generally, such a claim would seem to demand some rationale for the choice of geopolitical constructs—terms such as "the West" and "China"—seemingly tangential to the study of questions of cognition and epistemology if it were to escape the charge that it was a transparent attempt at nationalistic glorification.

very ambiguities of these terms that became the locus of ideological contest. How did differing visions of civilizations and their relationships inflect conceptions of *science* and the writing of the history of science? What role did changing accounts of the fundamental defining features of *science* play in narrating the histories of civilizations?

The Scientific West and the Intuitive East

Accounts written in the early twentieth century often portrayed China and an undifferentiated "East" as lacking science entirely.[16] Bertrand Russell, after lecturing in China, wrote in 1922 in a chapter entitled "Chinese and Western Civilization Contrasted," that "comparing the civilization of China with that of Europe, one finds in China most of what was to be found in Greece, but nothing of the other two elements of our civilization, namely Judaism and science. . . . Except quite recently, through European influence, there has been no science and no industrialism" (Russell [1922] 1961: 551). In the 1940s, Filmer Northrop, a professor of philosophy at Yale University, posited suprahistorical differences between "Eastern intuitive" and "Western scientific" philosophical systems representative of entire civilizations, arguing that "a culture which admits only concepts by intuition is automatically prevented from developing science of the Western type" (Northrop 1944, quoted in Hu Shih 1967: 104).[17] Similarly, Wilmon Sheldon, also a professor of philosophy at Yale, contrasted Eastern and Western philosophy, asserting bluntly that "the West generated the natural sciences, as the East did not" (Sheldon 1951: 291, quoted in Hu Shih 1967: 104).[18] Albert Einstein, in a casual letter which was frequently quoted by later historians, stated in 1953 that the "development of Western science is based on two great achievements: the invention of the formal logical system (in Euclidean geometry) by the Greek philosophers, and the discovery of the possibility to find out causal relationship by systematic experiment (Renaissance). In my opinion one has not to be astonished that the Chinese sages have not made these steps.

[16] These claims were part of a literature of the period asserting Chinese absence of modernity, capitalism, science, and philosophy. For related examples of claims that China lacked mathematics, see Hoe 1977: 7–8.

[17] A shorter version of Hu's article appeared in *Philosophy East and West* 9, nos. 1 and 2 (1959): 29–31. See also Northrop 1946: chaps. 8–10. Northrop asserted a "unity of Oriental culture" (a "single civilization of the East" which included China, Japan, and India) and distinguished an entire Western scientific philosophy from an Eastern intuitive philosophy (p. 312).

[18] The assertions by Northrop and Sheldon are criticized by Hu, who presents the views of two Chinese philosophers, Wang Chong (27–ca. 100) and Zhu Xi (1130–1200). However, Hu never cites evidence from Chinese scientific treaties.

The astonishing thing is that these discoveries were made at all."[19] These accounts then offer no analysis of Oriental sciences, presumably because there were not supposed to be any to analyze.

It was to disprove such claims that Needham began his *Science and Civilisation in China*, which soon developed into a multivolume series documenting the developments in China in chemistry, mathematics, astronomy, physics, and other sciences.[20] Needham too shared the assumption that civilizations were to be a fundamental starting point in studies of the history of science: in place of science versus non-science, he offered his own set of four major contrasts between China and the West (organic versus mechanical philosophies, algebra versus Euclidean geometry, wave versus particle theories, and practical versus theoretical orientations) (Needham [1963] 1969: 20–23);[21] his "grand titration" was to redistribute credit for scientific discoveries among civilizations;[22] he proposed to restore for China its pride, correcting its slighting by making it an equal contributor among the tributaries that flowed into the river of modern science; ultimately, he sought to discover the social and economic reasons that Chinese civilization was more advanced than the West before the sixteenth century and later fell behind.[23] Needham's project was from its inception formulated not as one component of, but rather in opposition to mainstream history of science which asserted that

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19 Quoted in Wright 1957: 918; and Wolpert 1992: 48. Cited in Gillispie 1960: 9; and Hartwell 1971: 722–23.

20 *Science and Civilisation in China* presently comprises the following volumes: vol. 1, *Introductory Orientations*; vol. 2, *History of Scientific Thought*; vol. 3, *Mathematics and the Sciences of the Heavens and the Earth*; vol. 4, *Physics and Physical Technology:* pt. 1, *Physics*, pt. 2, *Mechanical Engineering*, pt. 3. *Civil Engineering and Nautics*; vol. 5, *Chemistry and Chemical Technology:* pt. 1, *Paper and Printing*, pt. 2, *Spagyrical Discovery and Invention: Magisteries of Gold and Immortality*, pt. 3, *Spagyrical Discovery and Invention: Historical Survey, from Cinnabar Elixirs to Synthetic Insulin*, pt. 4, *Spagyrical Discovery and Invention: Apparatus, Theories, and Gifts*, pt. 5, *Spagyrical Discovery and Invention: Physiological Alchemy*, pt. 6, *Military Technology: Missiles and Sieges*, pt. 7, *Military Technology: The Gunpowder Epic*, pt. 9, *Textile Technology, Spinning and Reeling*; vol. 6, *Biology and Biological Technology:* pt. 1, *Botany*, pt. 2, *Agriculture*, pt. 3, *Agro-Industries and Forestry*; vol. 7, pt. 1, *Language and Logic*. More volumes are forthcoming.

21 Needham (like G. E. R. Lloyd) affirms these oppositions with some reservations, for example stating that he does "not want to disagree altogether with the idea that the Chinese were a fundamentally practical people" (Needham [1963] 1969: 23). See also the comments and discussion on Needham's article in the Crombie 1963 volume.

22 Needham proposed a retrospective competition between the West and China, fixing dates of discovery through a "grand titration" that compared "the great civilizations against one another, to find out and give credit where credit is due" (Needham 1969: 12).

23 Needham sought to "analyse the various constituents, social or intellectual, of the great civilizations, to see why one combination could far excel in medieval times while another could catch up later on and bring modern science itself into existence" (Needham 1969: 12).

science was unique to Western civilization. Yet Needham's project adopted many of the features of these histories of (Western) science of the period: against catalogs of scientific achievements claimed for the glory of the West, he offered achievements now claimed for the Chinese; against exaggerated claims of Western contributions to other civilizations, Needham asserted Chinese influence where the evidence was incomplete.

Historians of (Western) science, for their part, also often perceived Needham's research not as one part of a larger project of the study of the history of science, but in opposition to their own work. In the late 1950s and early 1960s they continued to insist that science was exclusively Western: in response to studies of the sciences of other civilizations (and Needham's in particular), the criteria defining *science* changed; however, the defining boundaries of science as exclusively Western did not. For example, in A. C. Crombie's account, the Orient became differentiated into distinct civilizations, but the "achievements" of these distinct civilizations were undifferentiatedly dismissed as technologies. Western science was no longer defined solely in stark opposition to Oriental intuition. In its place, *Western science* was defined by an incongruous amalgam of "essential elements" culled from the tradition claimed for the West, including noncontradiction, empirical testing, Euclid, and logic:

> Impressive as are the technological achievements of ancient Babylonia, Assyria, and Egypt, of ancient China and India, as scholars have presented them to us they lack the essential elements of science, the generalized conceptions of scientific explanation and of mathematical proof. It seems to me that it was the Greeks who invented natural science as we know it, by their assumption of a permanent, uniform, abstract order and laws by means of which the regular changes observed in the world could be explained by deduction, and by their brilliant idea of the generalized use of scientific theory tailored according to the principles of noncontradiction and the empirical test. It is this essential Greek idea of scientific explanation, "Euclidean" in logical form, that has introduced the main problems of scientific method and philosophy of science with which the Western scientific tradition has been concerned. [Crombie 1959: 81, quoted in Needham (1963) 1969: 41–42][24]

In another account—even though the defining features of the "mainstream" of science were different—the defining boundaries of science as Western remained stubbornly constant. For de Solla Price, this "mainstream" was the emblem of

[24] Needham's response to this view is discussed below. For a detailed presentation of Crombie's views, see Crombie 1994.

scientific modernity—mathematical astronomy; instead of attributing the development of science to a scientific method, he appealed to "inspiration" as historically causal. Thus mathematical astronomy differentiated "our own high civilization" from its Other:

> What is the origin of the peculiarly scientific basis of our own high civilization? . . . Of all limited areas, by far the most highly developed, most recognizably modern, yet most continuous province of scientific learning, was mathematical astronomy. This is the mainstream that leads through the work of Galileo and Kepler, through the gravitation theory of Newton, directly to the labours of Einstein and all mathematical physicists past and present. In comparison, all other parts of modern science appear derivative or subsequent; either they drew their inspiration directly from the successful sufficiency of mathematical and logical explanation for astronomy, or they developed later, probably as a result of such inspiration in adjacent subjects. [de Solla Price 1961: 2–5, quoted in Needham (1963) 1969: 42]

Primitive versus Modern Science

The two views presented above—those of Crombie and de Solla Price—were in response to the discoveries of the sciences of other civilizations, and Needham's work in particular; these views themselves elicited a response from Needham, "Poverties and Triumphs of the Chinese Scientific Tradition" ([1963] 1969).[25] Needham noted that the increasing discoveries of the sciences of other cultures resulted not in the rejection of claims of European uniqueness but rather in the deprecation of the sciences of other cultures: "As the contributions of the Asian civilizations are progressively uncovered by research, an opposing tendency seeks to preserve European uniqueness by exalting unduly the role of the Greeks and claiming that not only modern science, but science as such, was characteristic of Europe, and of Europe only, from the very beginning. . . . The counterpart of this is a determined effort to show that all scientific developments in non-European civilizations were really nothing but technology" (p. 41).

However, as attention to Needham's phrase "not only modern science, but science as such" suggests, this criticism was not Needham's central thesis. Needham presented two problems that became the central "Needham questions" defining the field of the history of Chinese science:

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[25] Needham ([1963] 1969) also presents similar views from J. D. Bernal and C. C. Gillispie.

> Why did modern science, the mathematization of hypotheses about Nature, with all its implications for advanced technology, take its meteoric rise *only* in the West at the time of Galileo? This is the most obvious question which many have asked but few have answered. Yet there is another which is of quite equal importance. Why was it that between the second century B.C. and the sixteenth century A.D. East Asian culture was much *more* efficient than the European West in applying human knowledge of nature to useful purposes? [p. 16, emphasis in original][26]

Critics who saw in Needham an exaggerated attempt to rehabilitate Chinese science ignored his ultimate reaffirmation of modern science as uniquely Western—Needham did not dispute the radical break between the scientific and nonscientific, but only the manner in which the boundary was drawn. For Needham, this break derived directly from accounts which asserted a radical divide in the West between the ancient and modern by appending to "science" the even more amorphous term "modern" (pp. 14–16): "When we say that modern science developed only in Western Europe at the time of Galileo in the late Renaissance, we mean surely that there and then alone there developed the fundamental bases of the structure of the natural sciences as we have them today, namely the application of mathematical hypotheses to Nature, the full understanding and use of the experimental method, the distinction between primary and secondary qualities, the geometrisation of space, and the acceptance of the mechanical model of reality" (pp. 14–15). And indeed Needham's central concern is this supplemental term "modern": "Hypotheses of primitive or medieval type distinguish themselves quite clearly from those of modern type. Their intrinsic and essential vagueness always made them incapable of proof or disproof, and they were prone to combine in fanciful systems of gnostic correlation. In so far as numerical figures entered into them, numbers were manipulated in forms of 'numerology' or number-mysticism constructed *a priori*, not employed as the stuff of quantitative measurements compared *a posteriori*" (p. 15).[27] Thus against schemes that posited a radical difference between civilizations East and West, Needham insisted on preserving the uniqueness of modern Western science by claiming the premodern world—including China and Greece—"must be thought of as a

[26] Needham proposed the following solution: "Only an analysis of the social and economic structures of Eastern and Western cultures, not forgetting the great role of systems of ideas, will in the end suggest an explanation of both these things" (p. 16).

[27] Needham's characterization of "primitive" (i.e., premodern) science is not true for either all of the early Greek or early Chinese sciences.

whole" (p. 16); the radical break for Needham was the boundary between the modern and the primitive.[28]

Despite Needham's brief list of the characteristics of modern science—experimentalism, mathematization, geometrization, and mechanism—these were hardly the central features that animated his discussion of modern science. Instead, for Needham the central distinction between primitive and modern science was the latter's universality: "Until it had been universalized by its fusion with mathematics, natural science could not be the common property of all mankind. The sciences of the medieval world were tied closely to the ethnic environments in which they had arisen, and it was very difficult, if not impossible, for the people of those different cultures to find any common basis of discourse" (p. 15). Needham then incorporated science into this universal teleology: "the river of Chinese science flowed, like all other such rivers, into this sea of modern science" (p. 16). And by the concluding paragraph, Needham's "science" has become nothing more than an impoverished signifier in a teleology purely utopian: "Let us take pride enough in the undeniable historical fact that *modern* science was born in Europe and only in Europe, but let us not claim thereby a perpetual patent thereon. For what was born in the time of Galileo was a universal palladium, the salutary enlightenment of all men without distinction of race, colour, faith or homeland, wherein all can qualify and all participate. Modern universal science, yes; Western science, no!" (p. 54, emphasis in original).

Scientific Revolutions and *The* Scientific Revolution

The most important response to the two Needham questions—why China was more proficient at technology before the sixteenth century and why modern science arose only in the West—was a series of criticisms presented by Nathan Sivin.[29] Against the former, Sivin argued that in the period from the first century B.C. to the fifteenth century A.D., science and technology were separate and thus Chinese superiority in technology was not indicative of more advanced science (Sivin 1982: 46); he also criticized attempts to compare the science and technology of civilizations in their entirety.[30] In response to the latter—Needham's

28 Needham states, "Galileo broke through its walls"; "the Galilean break-through occurred only in the West" (p. 15).

29 Sivin's criticisms of the Needham questions begin on the first page of his first book (see Sivin 1968: 1). Some of Sivin's most important critiques appeared in several articles: Sivin 1973; Sivin 1975; Sivin 1976; and Sivin 1982. Revised versions of these essays have been collected in Sivin 1995(the page references in the citations below are to Sivin 1995). See also Sivin 1985.

30 Sivin argues that although before the fifteenth century Europe was technologically less advanced, Chinese astronomy even in the fourteenth century was less accurate than Ptolemaic astronomy, which predated it by a thousand years (Sivin 1982: 46–47).

"Scientific Revolution problem"—Sivin critiqued several assumptions underlying the question of why China lacked a scientific revolution and pointed out fallacies of historical reasoning that discovered conditions that were asserted to have inhibited the growth of Chinese science (pp. 51–59). Sivin's ultimate response, however, was to assert that "by conventional intellectual criteria, China had its own scientific revolution in the seventeenth century" (p. 62). This revolution was not, Sivin argued, as sweeping as the Scientific Revolution in Europe.[31]

Sivin's claim was part of his criticism of the received accounts of the rejection by a xenophobic, conservative, traditional China of modern Western science introduced by the Jesuits.[32] Against portrayals of the Jesuits as having introduced modern science, Sivin argued that the Jesuits withheld the Copernican system, instead presenting the Tychonic system as the most recent and misrepresenting the history of Western astronomy to disguise this.[33] Against claims that the lack of Chinese acceptance of early modern science was due to intellectual, linguistic, or philosophical impediments, Sivin argued that it was contradictions in the Jesuit presentation of Western astronomy—including these misleading characterizations of Copernican astronomy which the Jesuits were by decree forbidden to teach—that made it incomprehensible.[34] And against caricatures of the Chinese as xenophobic and conservative, Sivin argued that the Chinese did ac-

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[31] In his analysis of the introduction of European astronomy into China by the Jesuits, Sivin asserts that Wang Xishan, Mei Wending, and Xue Fengzuo were responsible for what Sivin terms a scientific revolution—a fundamental conceptual change from numerical to geometric methods in astronomy. Sivin states, "They radically and permanently reoriented the sense of how one goes about comprehending the celestial motions. They changed the sense of which concepts, tools, and methods are centrally important, so that geometry and trigonometry largely replaced traditional numerical or algebraic procedures. Such issues as the absolute sense of rotation of a planet and its relative distance from the earth became important for the first time. Chinese astronomers came to believe for the first time that mathematical models can explain the phenomena as well as predict them. These changes amount to a conceptual revolution in astronomy" (Sivin 1982: 62).

[32] For example, George C. Wong (1963) argued that Chinese scholar-officials opposed Western science because of their traditional beliefs; see also Sivin's critical response (Sivin 1965).

[33] Sivin asserts that the cosmology presented by the Jesuits from 1608 to 1642 was written from an Aristotelian point of view: Schall, Schreck, and Rho did not mention Galileo. Sivin states that Schall's "quasi-historical treatise" *On the Transmission of Astronomy in the West* included Copernicus and Tycho with Ptolemy in the ancient school; the modern school comprised Schall, Rho, and their collaborators; the summary of Copernicus's *De revolutionibus* did not mention the motion of the earth; and Schall's conclusion asserted that astronomy had not progressed beyond Ptolemy. For the Jesuits in China, Sivin notes, "heliocentricism was unmentionable" (Sivin, 1973: 19–22).

[34] European cosmology was discredited, Sivin argues, by its internal contradictions, and only in the mid-nineteenth century were contemporary treatises introduced that resulted in acceptance of the heliocentric system; "European cosmology had been discredited by its incoherence" (Sivin 1973: 1, 50).

cept Western astronomical techniques, resulting in a "conceptual revolution in astronomy" (Sivin 1982: 62).

Sivin's response, however, incorporated many of the assumptions within which the claims he critiqued had been framed.[35] Seventeenth-century European astronomy remained "modern science" posed against "traditional" Chinese science,[36] for example in Sivin's assertion that Wang Xishan and his contemporaries did not succeed "in a mature synthesis of traditional and modern science" (Sivin 1976: 163). The West remained the source of modern science for the Chinese: "The character of early modern science was concealed from Chinese scientists, who depended on the Jesuit writings. Many were brilliant by any standard. As is easily seen from their responses to the European science they knew, they would have been quite capable of comprehending modern science if their introduction to it had not been both contradictory and trivial" (Sivin 1973: 1). The limited extent of the transformation of the scientific revolution in China remained the result of distorting, nonscientific influences, blamed now not on the Chinese but on the Jesuits: "In short, the scientific revolution in seventeenth-century China was in the main a response to outmoded knowledge [transmitted by the Jesuits] that gave little attention to, and consistently misrepresented, the significance of developments in the direction of modern science" (Sivin 1976: 166 n "n").[37] And ultimately, in Sivin's critiques this episode remained framed as an "encounter in China between its cognitive traditions and those of Europe" ("Wang Hsi-shan," in Sivin 1995: 1).

The key to Sivin's argument was thus his redistribution of "scientific revolutions" among civilizations: by asserting that there was not one but two scientific revolutions—one Chinese and one European—Sivin implied that differences

[35] And like Needham, Sivin also incorporated into his criticisms many of the assumptions of teleological histories of Western science. For example, although Sivin in his work emphasizes the importance of studying science in cultural context, his analysis often implicitly assigns to internalist scientific criteria an explanatory causal role. The inevitability of the acceptance of Western astronomy is naturalized by appeal to anachronistic modern scientific criteria such as accuracy and explanatory power: it was the power of Western models not only to predict but also to exhibit inherent patterns, he asserts, that attracted the Chinese. Social context is then incorporated into Sivin's account primarily as a distorting factor to account for error: European cosmology was rendered incomprehensible by the misleading characterizations of Copernican astronomy which the Jesuits were forbidden to teach, and was ultimately discredited by its internal contradictions. This naturalizing of scientific truth, and the sociology of error, are elements of a conventional teleology of scientific development implicit in his account.

[36] See also Sivin's study of the thought of Shen Gua from which he concludes that there was no unified conception of science (Sivin, 1982: 47–51).

[37] Sivin notes that this thesis is documented in his article "Copernicus in China" (Sivin 1973).

between China and Europe were of degree rather than kind (Sivin 1982: 65).[38] However, by the criteria he used for scientific revolutions—shifts in a disciplinary matrix—there certainly have been many others.[39] Sivin's account adopted from the histories of Western science the conflation of scientific revolutions in this technical sense with the mythologies of *the* Scientific Revolution—a difference that Sivin implicitly notes in his use of a capitalized "Scientific Revolution" for Europe (Sivin 1982: passim). This conflation was itself rooted in attempts by these histories to offer scientific revolutions as the historical cause of the radical break between the ancient and modern that *the* Scientific Revolution emblematized.[40] This radical break had then been translated into a radical difference between the modern scientific West (unique among civilizations in having had the Scientific Revolution) and traditional China. Sivin documented a scientific revolution in China—a change in the disciplinary matrix in Chinese astronomy which was itself a limited copy of the Scientific Revolution of Europe. But he denied to this scientific revolution the miraculous transformative powers claimed in the mythologies of the Scientific Revolution of the West.

Praise-and-Blame Histories of Civilizations

Much of the scholarly literature on the question of Chinese science written during the period when Sivin and Needham were publishing their work offered no study of any aspect of it. Instead, these works (sometimes presented against Needham by borrowing from earlier claims that science was uniquely Western, and sometimes following Needham's call to find the social causes that modern science was uniquely Western) purported to offer explanations for the absence of science in

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[38] Sivin also mentions a third scientific revolution "that didn't take place in Archimedes' lifetime."

[39] The term *disciplinary matrix* is introduced in Kuhn's postscript to *The Structure of Scientific Revolutions* to mean that which is shared by practitioners and accounts for the unanimity of their judgment; the term replaces his earlier concept of *paradigm*. Kuhn's disciplinary matrix consists of four major components: (1) symbolic generalizations (statements which can be formalized into logical or mathematical symbols, functioning to define terms and express relations); (2) the metaphysical conceptions involved in scientific interpretations and models which provide preferred analogies; (3) values that are shared by a wider community than one group of scientific practitioners; and (4) "exemplars"—concrete solutions to scientific problems. See Thomas S. Kuhn 1970: 182–87.

[40] Perhaps the most dramatic emblem of the radical shift between the worldviews of the ancients and moderns is the shift from the geocentric to the heliocentric picture of the solar system; see Thomas S. Kuhn 1957. Alexandre Koyré (1957) offers a similarly dramatic symbolization of the radical break between the "closed world" of the ancients and the modern "infinite universe." Kuhn's example of the duck/rabbit diagram is yet another example of an emblem of this radical shift (Kuhn 1970: 114).

China—philosophical, social, linguistic, logical, and political.[41] For example, Mark Elvin (1973: 234) offered the metaphysical thought developed from Wang Yangming as "the reason why China failed to create a modern science of her own accord." Joseph Levenson (1968: chaps. 1, 2) explained the purported absence of a Chinese scientific tradition as the result of an "amateur ideal." Alfred Bloom (1981) asserted that the Chinese language had inhibited the ability of the Chinese to think theoretically. Robert Hartwell (1971: 723) argued that the major impediment was the absence of the formal logical system embodied in Euclidean geometry. And Wenyuan Qian (1985: 26) provided a "politico-ideological" explanation.

Yet this literature was not about science. Levenson failed to cite a single primary source on Chinese science in his bibliography; instead he drew his conclusions on the nondevelopment of science and modernity by universalizing the ethics of Ming painting as exemplary of all of Ming culture, and comparing this with stereotypes of Western science and modern values (Levenson 1968: 204–9). Bloom made no pretense of citing historical materials, much less scientific materials from China or the West, in justifying his leap from measuring the testing skills of students in present-day China—presented in the language of the Sapir-Whorf hypotheses—to the development of Chinese science in the past. Elvin cited one scientist.[42] Hartwell's explanation of the nondevelopment of Chinese science was appended to a study of trends in Chinese historiography.[43] And Qian's dialogic narrative contained its own admissions of the historical falsity of central theses of the book (Qian 1985: 12–14, 96–97).[44] These accounts—because the absence of (modern) science in China was known—could ignore the technical details specific to the sciences themselves and instead derive lessons on topics deemed more vital—whether political despotism, philosophical orthodoxy, linguistic inadequacies, or cultural stagnation.

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[41] For an overview of the literature predating this work, see Sivin 1982: 54 n 7. Elsewhere, Sivin also repeatedly criticizes sinologists for ignoring scientific texts (Sivin 1973: 13).

[42] Elvin's example is Fang Yizhi (1611–71). See Elvin 1973: 227–34.

[43] Hartwell's thesis is that historical analogism "was dominant among policy makers during most years of the eleventh, twelfth, and thirteenth centuries" (Hartwell 1971: 694); it was displaced by "an orthodoxy of the Zhu Xi classicist-moral-didactic compromise" from the fourteenth to nineteenth centuries (p. 717).

[44] As Sivin notes, Qian's book is "a shallow 'answer' to the Scientific Revolution Problem uninformed by acquaintance with the primary literature" ("Selected, annotated bibliography," in Sivin 1995: 7).

Reiterating the Differences

The focus on comparisons of science in China and the West has resulted in enough research that several recent works have been written that attempt to synthesize or reevaluate the theses presented in this literature (e.g., Huff 1993, and Bodde 1991). The most important recent comparative study is G. E. R. Lloyd's *Adversaries and Authorities* (1996).[45] Lloyd seeks to relate differences in the philosophy and science of China and Greece to fundamental differences in their respective cultures. He begins his analysis by reexamining differences in their social and political context, following one variant of the conventional view: "my starting point is . . . a common view of a fundamental contrast"—the view of Burckhardt and others—that "the Greeks exhibited highly developed agonistic traits in every part of their culture . . . philosophy and science included"; in contrast, "it has often been claimed that the Chinese were irenic rather than polemical and rejected aggressive adversariality of any kind" (p. 20). His approach is to present evidence for this conventional view, subject it to a "severe critique,"[46] refine it, and finally seek explanations for the differences (p. 21). Lloyd then analyzes the differences in the science of early Greece and China by reexamining several contrasts: techniques of demonstration (especially Greek axiomatization and deduction); "cause-oriented Greek culture and a correlation-oriented Chinese one" (p. 93); the use of dichotomies in Greek and Chinese thought; Chinese and Greek views of the infinite; the Greeks' emphasis on geometrical models and strict proof in astronomy contrasted with the Chinese political demand for accuracy in the prediction of portents (p. 184); and views of the body and the state. These too are for the most part conventional theses, and in each case Lloyd essentially follows an approach similar to that described above—offering an outline of the thesis, a critique, a refinement, and finally relating the contrasts to differences in cultural context. Although Lloyd emphasizes "in the strongest possible terms, the difficulties and dangers of generalisation," his ultimate conclusion on whether there is a fundamental difference between the science of early Greece and China is "clearly yes" (p. 209); and his ultimate explanation for the

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45 An eminent historian of early Greek science and medicine, Lloyd has devoted recent years to learning classical Chinese and has conducted numerous seminars at Cambridge University in preparation for his comparative work.

46 Lloyd finds the arguments supporting the conventional theses on Greek/China comparisons so misconceived that in the first chapter he generalizes the mistakes he hopes to avoid, basing his approach on what he terms "anti-generalisation" (the requirement to respect differences in historical periods, geographical areas, domains of science, and different schools within domains), and "anti-piecemeal" (the requirement not to seek simple equivalents of prominent Greek theories in China and vice versa) (pp. 3–9).

difference in sciences is the fundamental difference (encapsulated in the title of his book) between the adversarial Greeks and the authority-bound Chinese.[47]

The most important of the contrasts between Chinese and Greek science that Lloyd analyzes is the "three interrelated concepts of axiomatisation, certainty and foundations" exemplified by the Euclidean tradition of mathematics with "its insistence not just on deduction, but on axiomatic-deductive demonstration" (pp. 211–12): of the conventional views, this is both the most commonplace and the most plausibly significant;[48] it is also this contrast that Lloyd emphasizes in his concluding chapter (pp. 211–12, 214–15). Even here Lloyd's argument remains filled with numerous qualifications and caveats: he notes that axiomatics in Greek mathematics is a style that is a "recurrent, but not a universal, one" (p. 212); often, what in Greek geometry was claimed to be incontrovertible "turns out to be a proposition that is anything but" (p. 63); and on the other hand, Chinese mathematics also offered proofs (p. 212). Yet there is much more wrong with the conventional view than Lloyd's critique suggests. Rigorously defined, axiomatization was not possible outside of geometry;[49] it makes little sense to identify axiomatization with the science of an entire civilization—whether the West or ancient Greece. Lloyd's remaining contrasts fare no better. He notes that the Greeks "were no strangers to correlative thinking" (p. 94), and "Chinese interest in the explanation of events is certainly highly developed in such contexts as history and medicine" (p. 109). What all of Lloyd's careful analysis, caveats, and reservations suggest is reevaluating the assumption that Lloyd does not question—that "Greece" and "China" are appropriate categories from which to generalize about science. For as long as it is assumed that it is "the divergent early histories of philosophy and science in those two ancient civilisations that are our chief *explanandum*" (p. 223), the solutions can only lie in debates over which of the antithetical attributes asserted to characterize entire civilizations are the most significant.

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47 Lloyd argues against a "simplistic contrast" noting its "shortcomings"—adversariality and respect for authority can be found in both societies, but not equally (p. 44).

48 For several examples already mentioned in this article of conventional views on the importance of Euclid and axiomatic deduction, see the views of Einstein, Crombie, Needham, and Hartwell noted above.

49 Even in mathematics, the axiomatization of arithmetic was not possible until the late nineteenth century.

Science and the Postmoderns' West

Research in critical studies, particularly in the past twenty years, has questioned these grand narratives of both science and civilizations. However, in many post-structuralist works, it was often a cross-disciplinary credulity toward the West—equated with reason, science, logic, and rationality—that provided these critiques with their inflated urgency. For example, without this intensified essentialization of the West, the Derridean deconstruction of Western logocentrism becomes little more than a critique of the application of structuralist readings to literary and philosophical texts (see, e.g., Derrida 1981). In a deflationary view, Foucault's archaeology of madness silenced by the language of Western reason becomes no more than a genealogy of psychiatric practices traced to eighteenth-century moral therapies.[50]

If two central lacunae of poststructuralist analyses (as exemplified by the works of Derrida, Foucault, and Bourdieu) were science and non-Western cultures, more recent work in the cultural, gender, and social studies of science has turned toward the critique of science contextualized in culture. Against the view of science as coherent, teleological, and universal, recent microhistorical analyses in science studies have characterized the sciences as disunified, local practices inseparable from cultural context (Shapin and Schaffer 1985; Biagioli 1993; Galison and Stump 1996; Lenoir 1998; on the historiography, see Shapin 1996); the tautological equation of good science with good culture was little more than the ideologies of the historical actors themselves in their advocacy of their own particular political programs, incorporated into earlier Whig accounts as historical conclusions (see esp. Shapin and Schaffer 1985). However, one result of these studies of the relationship of science to culture and of culture to science has been the further identification of science with Western culture—studies of non-Western cultures have often focused not on non-Western science but rather on Western science in colonial settings (Pyenson, 1993; Pyenson 1985; Pyenson 1989).[51] Indeed, perhaps the most important critique of the assumptions about cultures in recent work in science studies is Bruno Latour's provocative *We Have Never Been Modern*. Although Latour criticizes assertions of the Great Divide between the West and its Other,[52] he ultimately accepts the divide itself and

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50 A more precise statement of a central thesis of his book is given by Foucault himself: "What we call psychiatric practice is a certain moral tactic contemporary with the end of the eighteenth century, preserved in the rites of asylum life, and overlaid by the myths of positivism" (Foucault 1988: 276).

51 For an overview of this literature, see Pyenson 1990: 920–33.

52 Latour states: "'We Westerners are absolutely different from others!'—such is the moderns' victory cry, or protracted lament. The Great Divide between Us—Occidentals—and Them—everyone else, from the China seas to the Yucatan, from the Inuit to the Tasmanian aborigines—has not ceased to obsess us. . . . [Westerners] do not claim merely that they differ from others as the Sioux differ from the Algonquins, or the Baoules from

questions only what constitutes it;[53] he asserts that the differences are only of size (of networks), yet to explain these differences Latour returns to claims of a fundamental difference in worldviews.[54] Thus Latour's work, still framed within the assumption of a fundamental division between the West and its Other, can offer no alternative other than to posit yet another antithesis as an explanation.[55]

Similarly, recent work in cultural criticism has questioned conceptualizations of nations and civilizations as "imagined communities" constructed through complex historical and political processes (see Spivak 1987; Bhabha 1994; Duara 1995; Appadurai 1996; Lydia H. Liu, in press).[56] Yet cultural criticism

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the Lapps, but that they differ radically, absolutely, to the extent that Westerners can be lined up on one side and all the cultures on the other, since the latter all have in common the fact that they are precisely cultures among others. In Westerners' eyes the West, and the West alone, is not a culture, not merely a culture" (Latour 1993: 97). Science, Latour notes, is central to the representation of the uniqueness of the West—the West claims to mobilize Nature through the science it invented.

[53] Latour advocates a triply symmetric anthropology that (1) offers the same explanation for truth and error, (2) studies the human and nonhuman simultaneously, and (3) "refrains from making any a priori declarations as to what might distinguish Westerners from Others" (Latour 1993: 103). The distinction itself, then, does remain, and in the end, the Great Divide remains reaffirmed even in Latour: "We are," he declares at one point, "indeed different from others" (p. 114).

[54] Latour (1993) provides for his networks an economistic "scale of the mobilization" (p. 105) to measure civilizations: his principle of symmetry aims at not just "establishing equality" but also "registering differences" (p. 107) now conceptualized not as qualitative but as differences "only of size" (p. 108). Yet elsewhere the difference is not just one of size: "Moderns do differ from premoderns by this single trait: they refuse to conceptualize quasi-objects as such" (p. 112). The dual process of purification and translation (which creates hybrids and networks) becomes not just constitutive of the representations of the moderns but the explanation for the difference between Us and Them, as Latour outlines in the three central hypotheses of his book: (1) for the moderns, purification makes hybrids possible; (2) for the premoderns, conceiving of hybrids excluded their proliferation; and (3) the nonmodern present must "slow down, reorient, and regulate the proliferation of monsters by representing their existence officially" (p. 12). For a succinct summary of the purported differences in worldviews, see his diagram 4.3 (p. 102).

[55] Latour's divide is conceived not through relativism but instead as differences in in dimension (pp. 12, 114) which resulted from the separation of Nature and Society and the human and the nonhuman by the "Modern Constitution" instituted by the "Founding Fathers" Hobbes and Boyle (pp. 28–29). For the premoderns, "the nonseparability of natures and societies had the disadvantage of making experimentation on a large scale impossible, since every transformation of nature had to be in harmony with a social transformation, term for term, and vice versa" (p. 140). Latour provides no evidence from scientific treatises of "premodern" cultures to justify this common anthropological stereotype.

[56] For criticisms of the civilizations China and the West as "imagined communities" see Roger Hart, "Translating the Untranslatable: From Copula to Incommensurable

has too often been tempted to critique the West in its entirety by equating it with science portrayed now not as universal and liberating but instead as hegemonic, normalizing, and disciplinary. Thus, perhaps because the critiques of science and civilization have too often proceeded separately, two key lacunae in contemporary critical studies are the problem of culture in science studies and the problem of science in cultural criticism.

Conclusions

The history of science is ostensibly a discipline united by the investigation of the single subject of science irrespective of geopolitical boundaries that construct cultures and civilizations. Yet much of the research literature on Chinese science has taken as its starting point a credulity toward the imagined communities China and the West, and the Great Divide that constitutes them.

This article has analyzed debates about Chinese science which were framed within this broader context. In the first half of the twentieth century, authors asserted an absolute divide between the scientific West and an exoticized, intuitive East. In opposition, Needham proposed to redistribute credit for scientific discoveries among civilizations by a "grand titration"; against the assertions of a radical civilizational divide between China and the West, he revived claims of a radical temporal break between primitive science (which included that of China and equally ancient Greece) and modern science, which for Needham remained culturally universal yet uniquely Western in origin. Sivin criticized many of the excesses in Needham's rehabilitation, and further questioned the uniqueness of the West by proposing that China had had its own, albeit limited, scientific revolution. Yet the scientific revolution Sivin discovered for China was the conversion to modern science from the West, incomplete because of Jesuit distortions; the Scientific Revolution Sivin compared it to in the West was itself only an emblem of the purported radical break between the ancient and modern. Other studies of this period, framed within the legacy of assertions of the Great Divide between China and the West, offered explanations—social, political, philosophical, or linguistic—for the assumed absence of science in a China which then became the anthropomorphized subject of a praise-and-blame historiography of civilizations. Most recently, the cultural turn in the history of science has further identified the culture of the West with science; the cross-disciplinary credulity toward the concept of the West—equated with science, reason, and rationality but now critiqued as hegemonic—which provided many poststructuralist and postcolonial critiques with their inflated urgency only further reinforced this identification of science and the West.

Worlds," in Lydia H. Liu (in press). The term *imagined communities* applied to nations comes from Benedict R. Anderson 1991.

Moving beyond science and civilizations as a framework for analysis raises the important question of possible directions for future research. How is the study of sciences and cultures to proceed without civilizations as the central actors animating world history, and without a universal, teleological science to gauge the progress of those civilizations toward modernity? If nations and civilizations are imagined communities, if the sciences are disunified practices, how does one analyze their relationship? There is of course no formulaic solution. But it may be helpful to suggest ways that emerging research—by calling into question particular assumptions associated with the science and civilizations framework—is opening up new areas of study.

First, the rejection of China and the West as analytic categories itself entails several important implications. If essentialized, suprahistorical civilizations are not assumed at the outset, the first question becomes how to determine the appropriate units of analysis. The problem of cultures becomes a general one, requiring the historical analysis of changing cultures, sub-cultures, and sub-sub-cultures that often do not conform neatly to political or linguistic boundaries; political and linguistic identifications become but elements among others in the fashioning of these groupings. And if the performative act of attributing scientific discoveries to civilizations is not naturalized as a given fact, one must then analyze the ideological contests through which artifacts become identified with particular cultures, claimed for civilizations, and the consequences of those claims—including the role those claims themselves play in the formations of cultures. In other words, what role do products of sciences—knowledges, technologies, and ideologies—play in the constitution of cultures, and how do cultures contribute to the constitution of sciences?

A second important direction for research proceeds from the rejection of the notion of a Great Divide that separates cultures. The traditional historiography often posited an insuperable barrier between civilizations (whether imagined through claims of linguistic or conceptual incommensurability or accounts of xenophobic traditionalism) and—through mythologies of its unique origins in the West—placed science on one side of that divide. Translation was then conceptualized as the unidirectional flow of scientific truth from the West across that barrier and its imperfect reception or outright rejection by the non-West; the alternative was the wholesale adoption of this scheme now romanticized as local resistance to the global hegemony of the normalizing West. Studies of translation began with the assumption of the self-same identity of scientific facts (an assumption reinforced by stories of origins and universality) supposed to remain constant in displacements across space and time; the question posed of translation was then one of fidelity—had truth been distorted by mistranslation, incomprehension, or cultural barriers? The alternative was the radical dissolution of truth and the impossibility of translation posited by some recent works in science studies that assert a radical locality of scientific practice. One possible approach that avoids the false dilemmas posed by these sets of alternatives is to analyze the circulations of cultural artifacts through material, discursive, scientific, technological, and ideological fields and cultural ensembles, tracing the proliferation and dissemination of copies and their further copies, transfigurations, and appropriations.

A third direction for research begins by recognizing the enormous historical efficacy of imagined communities and the claims made about science and civilizations, studying them as the ideologies of the historical protagonists and thus the object of analysis rather than as explanatory categories in which history itself is to be framed. That is, if cross-cultural study is no longer a project of forging the radical differences and transhistorical continuities of science used to represent the non-West as the antithesis of the West, the historical question remains of how claims of difference and continuity made by the actors themselves contribute to contests over the formation and legitimation of sciences and communities. A fourth direction is the historical contextualization and self-reflexive critique of this historiography itself—subjecting the project of comparison to analysis. For example, what was the role of narratives about science and civilization in the construction of the academic disciplines, ideologies of nations, and the rhetorics through which world history was narrated?

These directions are but a small sampling of the possible directions of future research, directions made possible by rejecting frameworks with known trajectories for science and civilizations in which historical details too often contributed little more than a reality effect. Instead, this new research seeks to find within historical documents answers to the questions of what constitutes sciences, cultures, and their relationship. The prospect is then for histories that contribute not to grand narratives of the rise and fall of civilizations but rather to a historical understanding of the processes of the mutual constitution of knowledge and community.

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