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INTRODUCTION

Too many of the younger Germans simply make use of the phrase historical materialism only in order to get their relatively scanty historical knowledge constructed into a neat system as quickly as possible. The materialist conception of history has a lot of them nowadays, to whom it serves as an excuse for not *studying history. . . . Our construction of history is above all a guide to study, not a lever for construction after the manner of the Hegelian.*

—Frederick Engels[1]

Unless one assumes some trans-historical theory of the nature of history, or that man in society is a non-historical entity, no social science can be assumed to transcend history. All sociology worthy of the name is "historical sociology".

—C. Wright Mills[2]

In my understanding of history and sociology, there can be no relation between *them because, in terms of their fundamental preoccupations, history and sociology are and always have been the same thing. Both seek to*

understand the puzzle of human agency and both seek to do so in terms of the process of social structuring. Both are impelled to conceive of that process chronologically; at the end of the debate the diachrony-synchrony distinction is absurd. Sociology must be concerned with eventuation, because that is how structuring happens. History must be theoretical, because that is how structuring is apprehended. Historical sociology is thus not some special kind of sociology; rather, it is the essence of sociology.

—Philip Abrams[3]

What distinguishes social sciences from history? I think we have to reply as Durkheim did . . . nothing—nothing, that is, which is conceptually coherent or intellectually defensible.

—Anthony Giddens[4]

Over two decades ago, Benjamin Nelson observed that the micro-sociological perspectives that dominated the sociology of science had "largely spent themselves," and he expressed the hope that the neglected comparative historical and civilizational perspective pioneered by Joseph Needham would once again be utilized to investigate issues like the "struggles over the new science in nineteenth-century India".[5] Nelson's mixture of hope and prediction of the decline of the microsociological perspective proved to be premature. Barring a few outstanding exceptions, the "new" sociology of science, continues to be dominated by repeated attempts to demonstrate the fact that scientific facts are socially constructed.[6] While analyses governed by such a perspective have no doubt contributed substantially to our understanding of the scientific enterprise, they have also at times engendered extreme ontological relativism bordering on solipsism.[7]

The major contribution of the constructivist perspective has been to question the normative view of science and the scientific enterprise that allowed little if any role for scientists as active agents involved in the production of knowledge. The sociological studies of scientific practice that gathered momentum in the mid-seventies and have continued to profilerate ever since depicted scientists as actively engaged in the process of constructing scientific facts. Detailed ethnographic studies of scientists at work produced a picture that was more complex than some normative accounts of science had allowed.

A number of social factors were implicated in the production of scientific facts, and practitioners of the "new" sociology of science focused on the complex negotiations and power struggles that constituted essential components of the scientific enterprise. Despite their many differences, proponents and followers of various theoretical perspectives within the sociology of science agreed on some version of the "constructivist perspective"—the theory that scientific facts are socially constructed, and social factors influence the very content of scientific knowledge. Drawing on the work of Thomas Kuhn, the new practitioners of the sociology of scientific knowledge characterized their work as inaugurating a "post-Mertonian" phase in the sociology of science. However, as Sal Restivo has argued, it was a questionable interpretation and appropriation of Kuhn's work, and nobody was more surprised than Kuhn himself at the relativist "Kuhnian revolution" that the mainly British sociologists sought to herald.[8] More recently the continuing preoccupation of some sociologists with purely epistemological issues has led Kuhn to count himself "among those who have found the claims of the strong program absurd: an example of deconstruction gone mad."[9] At the same time, as Thomas Gieryn has convincingly argued, Robert Merton, one of the main targets of the "new" sociologists of scientific knowledge, was not as innocent of the social constructivist perspective as the more enthusiastic proponents of the post-Mertonian era have claimed. As Gieryn puts it, "many of the empirical findings of the relativist/constructivist programme, when stripped of polemical manifestos and trendy neologisms, could be expected from Merton's theories, and some are anticipated by his occasional steps into empirical research."[10] While it would be inaccurate to argue that Merton's work exhausted the range of perspectives and topics in the sociology of science, a careful rereading of his writings would reveal that the much vaunted novelty of the post-Mertonian turn was not quite warranted. Perhaps exemplifying the social constructivist program in action, the "new" sociologists of science had constructed and interpreted key Kuhnian and Mertonian texts in line with their own intellectual agendas.

While research resulting from the early phase of the constructivist program played a significant role in demystifying and deconstructing the idealized image of scientific practice, the recent work of some practitioners of the sociology of scientific knowledge comes close to exemplifying what Kuhn termed "deconstruction gone mad."[11] Quite clearly, any attempt to subject scientific knowledge to sociological scrutiny is likely to involve an epistemologically relativist stance toward scientific facts. Otherwise one could simply adopt the normative, idealized image of what the practice of science is supposed to be. However in recent years, the sociological critique of the "essentialist"[12] or "standard"[13] view of science, has taken a rather curious turn. If the original impetus for revising the "essentialist" view of science was to argue that scientists were engaged in much more than passively describing and

recording the natural world, then research demonstrating that factors other than "nature" were implicated in the construction of scientific facts was indeed helpful in opening up the "black box" of science. In keeping with the spirit of establishing the fact that scientific knowledge was influenced by social factors and therefore amenable to sociological analysis, the early post-Mertonian, relativist sociologists of science downplayed the role of the natural world in the construction of scientific facts. However most sociologists, even while engaged in research driven by "epistemic relativism" cautioned against the adoption of a position of "ontological relativism."[14] While insisting that scientific facts are socially constructed, few wanted to argue that the natural world had no role in this process. As Barnes put it more than two decades ago: "Occasionally, existing work leaves the feeling that reality has nothing to do with what is socially constructed or negotiated to count as natural knowledge, but we may safely assume that this impression is an accidental by-product of over-enthusiastic sociological analysis, and that sociologists as a whole would acknowledge that the world in some way constrains what is believed to be."[15] In a similar vein, Michael Mulkay, while arguing that there is "nothing in the physical world which uniquely determines the conclusions of the scientific community," felt it necessary to add that "it is of course self-evident that the external world exerts constraints on the conclusions of science."[16]

There have always been critics of the position that allowed the natural world some role, however minimal, in the constitution of scientific facts. One of the most strident of these critics continues to be Steve Woolgar who has consistently taken most sociologists of science to task for not being relativist enough. Thus proponents of the "strong program" are criticized by Woolgar for being "uncertain about taking issue with a further key assumption, that the world exists independently of, and prior to, knowledge produced about it."[17] Much of the existing work in the sociology of science is criticized by him for being "epistemologically relativist and ontologically realist." As Woolgar sees it, this state of affairs seems rather "curious given that a major thrust of postmodern critiques of science is to suggest the essential equivalence of ontology and epistemology: How we know *is* what exists."[18] Woolgar's aim is to introduce a radical ontological relativism that questions the idea that the natural world has any role in the formulation of scientific facts or in adjudicating the choice between rival theories. His main objective is to invert the "presumed relationship between representation and object" and to argue and defend the proposition that "the representation gives rise to the object."[19] For Woolgar, the scientific laboratory and the culture of scientific research comprise a "moral order of entities" or "technologies of representation," where "the objects of the natural world are constituted in virtue of representation."[20] Dispensing with the note of caution injected by the sociologists who inaugurated the constructivist tradition in the sociology of science, Woolgar and his colleagues have now embarked on a "reflexive" project that aims to deconstruct not just the concept

of science and technology but also what are perceived to be the scientific pretensions of the sociology of science.

While the issue of reflexivity is an important one for sociology, Woolgar and his colleagues' understanding of the term and its significance for sociology are quite different from the way it was conceptualized by Gouldner, Bourdieu, or Giddens. Woolgar's argument is that while sociologists of science have successfully demonstrated the socially constructed nature of scientific facts, they have failed to apply the same tools of "deconstruction" to their own accounts of scientific activity. While such a critique of the existing work in the sociology of science is fair to a degree, it is not clear whether such a mode of analysis has contributed much to the understanding of the interface between science, technology, and society. Despite repeated attempts to allay the fears of those who fear the worst, the reflexive project seems to be well on its way toward deconstructing science and technology out of existence. Indeed recent work informed by the reflexive perspective or the general "linguistic" turn has precious little to say about science and technology and is overburdened by discussions of the ideas of fellow sociologists of science—real, constructed and sometimes completely imagined.[21]

The precise role the natural world plays or does not play in the construction of scientific facts will continue to be debated vigorously, and it is quite unlikely that a consensus on the issue will ever emerge.[22] While the key assumption of the constructivist perspective, that scientific facts are theory-laden and acquire stability as a consequence of the activity of scientists, is a truism for most contemporary sociologists of science, and while most practicing scientists will hardly be surprised by this approach, extending this perspective to argue for ontological relativism as Woolgar and some proponents of the "strong program" do is inherently problematic. The program of ontological relativism, which denies any role whatsoever to the natural world, has been questioned by a number of sociologists. Most recently, Kyung-Man Kim has argued that such an "ontologically nihilistic sociology of science can never provide us with a plausible causal scenario as to the belief change process of scientists and hence cannot cope with the problem of explaining theory change in science."[23] Kim has convincingly questioned "strong programmer" David Bloor's theory that "any negative experimental results can be reinterpreted at will so that they fit the social conventions of one's preferred theory" and has argued for a theory that emphasizes a "process of constant modification through interaction with the natural world."[24]

In a similar vein, Roy Bhaskar has distinguished between the "intransitive objects of scientific inquiry" that exist and act independently of our knowledge of them, and the "transitive dimension," or epistemology, that enables us to make sense of the natural world. Such a distinction does not mean that Bhaskar is the naive realist as caricatured by Steve Woolgar and others.[25] Bhaskar's distinction between the two dimensions of scientific inquiry enables

him to conceptualize science "as a social process, irreducible to an individual acquisition, whose aim is the production of the knowledge of the mechanisms of the production of phenomena in nature, the intransitive objects of inquiry."[26] Bhaskar's "critical realist" perspective retains the distinction between epistemology and ontology that Woolgar, by arguing that "how we know *is* what exists" tries to erase. Unlike Woolgar, Bhaskar's perspective offers a non-anthropocentric account of the natural world and its role in the development of scientific knowledge. And contrary to the caricatures of this position, constructed mainly by the radical constructivists, Bhaskar's critical realism construes the natural world as "a presupposition of our causal investigations of nature, but our knowledge of it is socially and laboriously constructed—with the cognitive resources at our disposal, on the basis of the effects of those investigations."[27] Bhaskar's critical realism offers a perspective that incorporates the constructivist position without lapsing into the epistemological and ontological idealism advocated by Woolgar and other reflexivists.

A perspective quite similar to Bhaskar's has been offered by the sociologist of science Steven Yearley. Yearley has argued for "moderate constructionism," a theoretical perspective, which, together with elements of Bhaskar's "critical realism," informs the present study. Yearley does not discount many of the insights offered by the constructivist perspective, but, like Bhaskar, he is not willing to accept ontological idealism. As he puts it, "science and technology are not *mere* social constructions; but constructions they are all the same."[28] What is useful for the purposes of this study is Yearley's attempt to combine what he terms "a social construction view and a political economy view." While proponents of the first perspective reject the idea that scientific knowledge and technological developments unfold in a pre-set, asocial manner, they usually do not move beyond the microsociological level of analysis. The political economy perspective, on the other hand, draws attention to the larger institutional structures to examine how the development of scientific and technical knowledge is influenced by political and economic priorities. Yearley's attempt to combine both these perspectives offers a powerful theoretical tool for questioning the view that science and technology are asocial institutions whose development is driven by the unfolding of an internal logic. Together with the recent writings of Chandra Mukerji,[29] Stephan Fuchs,[30] and Donald MacKenzie,[31] among others, Yearley's perspective contributes to "bringing sociology back in" to a field that has been dominated by discussions of epistemological and philosophical issues leading to endless, labored demonstrations of some version of the constructivist thesis.

One of the unintended consequences of the proliferation of various "relativist" and "constructivist" programs has been a total neglect of what Thomas Gieryn has termed "the constitutive historical question of the sociology of science: what explains the origins of modern science in the seventeenth century, and its ascendance in four centuries to a position of cognitive monopoly over

certain spheres of decisions?"[32] Such historical questions which informed the early work of Robert Merton,[33] Joseph Needham, and Edgar Zilsel,[34] among others, are rarely posed by contemporary sociologists of science.[35] While historians of science have incorporated many sociological concepts and analytical tools in their analyses, sociologists have been much more reluctant to reciprocate.

However in view of the fact that now, more than ever, modern science is being perceived as a "social problem,"[36] and seems to be directly implicated in the emerging environmental crisis, such historical questions are extremely relevant. Philip Abrams' challenge—"try asking serious questions about the contemporary world and see if you can do without historical answers"[37]—explicitly articulates a view that was always incorporated into the work of classical sociologists and is particularly relevant for understanding the role of modern science and technology in the contemporary world.

This study departs from the currently dominant tendencies within the sociology of science by investigating the complex social processes involved in the introduction and institutionalization of Western science in colonial India. The point of departure lies not in the rejection of the insights of the constructivist perspective, but rather in the attempt to articulate it with an explicitly institutional and historical dimension. The colonial encounter between India and Britain represents an important and fascinating but relatively unexplored chapter in the historical constitution of Western science and technology. India constitutes an interesting area for such a study because, like many other cultures, it has a distinct legacy of indigenous science and technology. In fact, as Joseph Needham has amply demonstrated through his monumental studies, "before the fourteenth century A.D., Europe was almost wholly receiving from Asia than giving, especially in the field of technology."[38] Although Needham is referring mainly to China, his multivolume *Science and Civilization in China*[39] incorporates numerous discussions of particular scientific and technological innovations diffused from India to China through the spread of Buddhism. In view of the proliferation of distinctive indigenous forms of scientific knowledge and technology at various times in India, the introduction of Western science and technology in such a milieu in the late eighteenth and nineteenth century is a neglected topic that deserves further investigation. As demonstrated in this study, the colonial encounter in the sphere of science had significant conseqences not just for science in India but also for the development of Western science and technology.

The introduction of Western science and technology in British India was by no means a smooth and uncontested process. In the initial stages of the consolidation of colonial rule, there was no discernable science and technology policy. More often than not, the perception of local conditions and circumstances by colonial administrators led to the utilization of scientific and technological expertise available among the British servants of the East India

Company in India. In fact during the early phases of colonial rule, the Court of Directors of the East India Company, based in London, was not always willing to authorize funds for the scientific projects planned by British administrators in India. For a trading company, the prospect of unnecessary expenditure without any promise of immediate returns, was not a desirable policy. It was only after an initial period of conflict and disagreement between London and Calcutta that the Court of Directors realized the significance of the application of science and technology for the expansion of colonial rule and the augmentation of revenues from India. At the same time, a number of amateur scientists employed by the Company, perceived India to be a vast, unexplored territory that held out the promise of totally new flora and fauna, and the consequent possibility of developing their careers as "scientists." These amateur scientists were actively seeking out patronage for exploration and research, and over a period of time, their scientific interests overlapped with the pecuniary and administrative interests of the East India Company.

By the mid-nineteenth century, colonial India constituted the site for one of the largest, state-sponsored scientific and technological enterprises undertaken anywhere in modern times. During the course of colonial rule, India literally constituted a "social laboratory" where a number of "experiments" in institution building were planned and executed.[40] The experience of developing scientific institutions in British India contributed to a fund of information that was later utilized in Britain. At the same time, specific colonial policies led to the decline and then withdrawal of patronage for indigenous scientific and educational institutions. In the context of rapid structural transformation, initiated in part by colonial policies, the interests of the emergent elites within India were intertwined with the evolving colonial social structure. Under changed social conditions, the elite, urban, and anglicized sections of the Indian population attempted to utilize the existing colonial structures to further consolidate and legitimize their status. These sections of the Indian population were active in demanding the expansion of education in Western science and technology, as it was perceived to be one of the avenues for social mobility in colonial India. This particular configuration of "structure" and "agency" created the conditions for the introduction and institutionalization of Western science and technology in colonial India, a process that constitutes the main focus of this study.

In examining this process, three interconnected issues are explored in detail. First, the manifold ways in which the scientific and technological projects of nineteenth-century British India were intimately intertwined with colonial imperatives. Western science and technology played active roles, both in the expansion of colonial rule and in the exercise and consolidation of colonial power. As will be demonstrated in this study, scientific and technological projects were frequently perceived by British administrators as visible symbols of colonial power and deployed for the legitimation of colonial rule. A second

theme explored here is the impact of colonial rule on indigenous scientific knowledge and institutions, and some of the social and scientific consequences of this cross-cultural scientific encounter. Such a focus includes a detailed examination and analysis of the varied responses of Indians to the introduction of Western science and technology.

A third and related focus of this study is the investigation of the active role of scientists, both British and Indian, in the transfer and institutionalization of Western science in India, and the creation of new scientific knowledge and institutions in the process. Prior to the emergence of the modern "world-system," one could, despite the limited scientific exchanges across cultural boundaries, identify specific cultural traditions in science and technology. However, the emergence of the modern colonial empires witnessed the development of certain scientific traditions and institutions that transcended national and cultural boundaries. The introduction of Western science and technology in India constituted one such process facilitated partly by the "active involvement of scientists in creating a transnational culture, developing common communication strategies and, at the same, erasing cultural differences."[41] Of course, total erasure of differences in scientific traditions may never be possible, or necessarily a good thing, but the attempt at such globalization of scientific and technological institutions can lend itself to synthesis and the creation of new patterns of scientific knowledge.

In a way, colonialism, science, and technology constituted the conditions for the development of each other. This process was nowhere as clearly evident as in the case of the British Empire in India, which constitutes a significant, albeit relatively neglected phase in the development of modern Western science and technology. In recent years, some scholars have examined the relationship among science, technology, and empire in India.[42] Although these pioneering studies have contributed to a large fund of knowledge and stimulated further research on the practice of science and technology in colonial India, most of them have offered a rather mechanical interpretation and have not paid much attention to the mutually constitutive interplay of structure and agency, colonial power and scientific knowledge, implicated in the process. The general tendency has been to portray Indian society as a passive entity at the receiving end of scientific interventions by an omnipotent colonial state. Other scholars like Susantha Goonatilake and Claude Alvares[43] have depicted precolonial south Asia as a region of tremendous scientific creativity and originality whose route to further development along a specific cultural trajectory was suddenly disrupted and destroyed by colonial rule. Such arguments tend to substitute empirical evidence and rigorous sociological analysis with a populist third worldism and teleological thinking that is ahistorical and does not stand up to critical scrutiny. The fact that colonial rule led to far-reaching structural transformations and had many negative consequences for India and other societies is obvious. What is required is to go beyond repeatedly stating

the obvious to analyze the complexities of colonial rule and its consequences for the development of science and technology not just in the colonized societies but in Britain, too.

The argument that Western science and technology were nothing more than surrogates for colonialist and imperialist ideology and interests is as limited as George Basalla's simplistic, ahistorical, yet much discussed, three-stage diffusionist model that ascribes a benign, "civilizing" role to colonialism as the main agency for the spread of science and technology from the "core" to the nonscientific "periphery."[44] As this study hopes to demonstrate, neither of these perspectives capture the complexities of the process. Science and technology did indeed contribute to colonial expansion and the legitimation of power, but colonial rule itself led to the creation of new forms of knowledge and institutions that were replicated in Britain and elsewhere. The tension between the structures of colonialism and the agency of scientists, first British and later Indian, provided the conditions for structural transformations that had far-reaching consequences for the trajectory of scientific knowledge and institutions as well as the further development of Indian and British society. It is hoped that this study will contribute to an understanding of these issues and to the growing number of studies that have begun examining the multifaceted, complex, and, at times, contradictory relationship among science, technology, and colonialism.[45]

Ramachandra Guha has recently urged sociologists to "stop waiting for historians to provide them with 'data' from which to generalize, and learn the tools of historical research . . . [because] generalizations are far more convincing when based on more, not less, primary data."[46] Although few generalizations are offered in this study, the arguments presented are based on archival research undertaken at the India Office Library and Records, London. In view of the time span covered, reliance on only primary sources would have been impossible, and, as will be evident from the notes, this study relies heavily on a wide range of secondary sources.

Notes

1. Karl Marx and Frederick Engels, 1974: 689–90.

2. C. Wright Mills, 1980: 162.

3. Philip Abrams, 1984: x, 2.

4. Anthony Giddens, 1984: 357–58.

5. Benjamin Nelson, 1987.

6. Sociological analyses of science informed by the constructivist and relativist perspective are prolific. Some representative studies include: Bruno Latour and Steve Woolgar, 1979; Karin Knorr-Cetina, 1981; David Bloor, 1976. For examples of attempts to push the relativist perspective to extremes, see Woolgar (1988) and Malcolm Ashmore (1989). For a recent critique of this "reflexive turn," see Zaheer Baber, 1992.

7. Good overviews and critical discussion of the various perspectives in the sociology of science can be found in Barry Barnes, 1974; Michael Mulkay, 1979; Mulkay and Knorr-Cetina, 1983; Susan E. Cozzens and Thomas F. Gieryn, 1990; Andrew Pickering, 1992; Randall Collins and Sal Restivo, 1983.

8. Restivo, 1984.

9. Thomas Kuhn, 1992: 9.

10. Gieryn, 1982: 280.

11. Two studies come to mind: Ashmore, 1989, and Mulkay, 1985. For critiques of the reflexive turn see: H. M. Collins and Steven Yearley, 1992, and Baber, 1992.

12. Woolgar, 1988: 20–24.

13. Mulkay, 1979.

14. Knorr-Cetina and Mulkay, 1983.

15. Barnes, 1974: 7.

16. Mulkay, 1979: 61.

17. Woolgar, 1988: 53.

18. Ibid., 54.

19. Ibid., 65.

20. Ibid., 83; 102.

21. See Ashmore, 1989, and Ashmore, Myers, and Potter, 1995. However, the reflexivists and advocates of "new literary forms" are showing signs of getting tired of their own stylistic tricks. After promising to revolutionize sociological analysis through his new method, Mulkay has reverted to more "traditional" modes of writing and analysis. See Mulkay, 1993; 1994a; 1994b. For critiques of the reflexive turn and the general route some contemporary sociologists of science have taken, see C. Doran, 1989, and Raymond Murphy, 1994.

22. There is a burgeoning literature on this debate. more recent discussions include: Kyung-Man kim, 1992; 1994a; 1994b; Donald T. Campbell, 1989; Roy Bhaskar, 1989; Gieryn, 1982; Restivo, 1993.

23. Kim, 1992: 446.

24. Ibid., 461.

25. For an explicit critique of Bhaskar's critical realism, see Latour and Woolgar, 1979.

26. Bhaskar, 1989: 180.

27. Ibid., 25.

28. Yearley, 1988: 184.

29. Chandra Mukerji, 1989.

30. Stephan Fuchs, 1992; For a critique of radical constructivism, see Robert Hagendijk in Cozzens and Gieryn, 1990.

31. Donald MacKenzie, 1990.

32. Gieryn, 1982: 281.

33. Robert K. Merton, 1970 [1938].

34. Edgar Zilsel, 1941.

35. An exception is the recent study by Toby E. Huff, 1993.

36. Restivo, 1988.

37. Abrams, 1982: 1.

38. Joseph Needham, 1969... 177.

39. Needham, 1954. For a critical evaluation of Needham's contribution to the sociology of science, see Restivo, 1979.

40. Russell Dionne and Roy Macleod, 1979.

41. Restivo, 1990.

42. Deepak Kumar, 1982; 1990; Satpal Sangwan, 1990; 1991; Susantha Goonatilake, 1984.

43. Goonatilake, 1984; Claude Alvares, 1980.

44. The theme of science and technology as the tools of colonialism dominates the discussion in Daniel Headrick, 1981; a similar argument is advanced by Deepak Kumar, 1990; George Basalla, 1967; the best critical discussion of Basalla's (1967) simplistic model of the role of colonialism in spreading science and technology to nonscientific societies remains Macleod, 1987.

45. Studies in this new but growing field include: Lewis Pyenson, 1985; 1989; 1993; James E. McClellan, 1992; Patrick Petitjean et al., 1992; Paul

Cranefield, 1991; John M. Mackenzie, 1990; David Mackay, 1985; Lucile H. Brockway, 1979; Deepak Kumar, 1991; Teresa Meade and Mark Walker, 1991; Michael Adas, 1989; Edward Ellsworth, 1991. For a recent debate on the issue of science and imperialism, see Paolo Palladino and Michael Worboys, 1993, and Pyenson, 1993.

46. Ramachandra Guha, 1990: xiv–xv.