1 Science and Technology Studies and an Engaged Program

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There is the part of Science and Technology Studies (STS) that addresses and often challenges traditional perspectives in philosophy, sociology, and history of science and technology; it has developed increasingly sophisticated understandings of scientific and technical knowledge, and of the processes and resources that contribute to that knowledge. There is also the part of STS that focuses on reform or activism, critically addressing policy, governance, and funding issues, as well as individual pieces of publicly relevant science and technology; it tries to reform science and technology in the name of equality, welfare, and environment. The two parts, which Steve Fuller (1993) has called the "High Church" and "Low Church" of STS, differ simultaneously in goals, attention, and style, and as a result the division between them is often seen as the largest one in the field.

However, this image of division ignores the numerous bridges between the Churches, so numerous that they form another terrain in which the politics of science and technology are explored. There we find theorists increasingly concerned with practical politics of science, articulating positions with respect to questions about the place of expertise in a democracy, or engaging in studies that directly bear on questions of reform and activism. In particular, constructivist STS has created a space for theoretically sophisticated analyses of science and technology in explicitly political contexts. By way of a scandalously short history of STS, this chapter describes that space.

SCIENCE AND TECHNOLOGY STUDIES IN ONE EASY LESSON

STS in one lesson? Not really. However, one important feature of the field can be gained from one lesson: STS looks to how the things it studies are constructed. The history of STS is in part a history of increasing scope—starting with scientific knowledge, and expanding to artifacts, methods, materials, observations, phenomena, classifications, institutions, interests, histories, and cultures. With those increases in scope have come increases in sophistication, as its analyses assume fewer and fewer fixed points and draw on more and more resources to understand technoscientific constructions. A standard history of STS (as in Bucchi, 2004; Sismondo, 2004; or Yearley, 2005) shows how this has played out.

The metaphor of "construction," or "social construction," was so ubiquitous in the 1980s and 1990s that now authors in STS bend over backward to avoid using the term: other terms, like "framing," "constitution," "organization," "production," and "manufacture," fill similar roles, attached to parts of the construction of facts and artifacts. The construction metaphor has been applied in a wide variety of ways in STS; attention to that variety shows us that the majority of these applications are reasonable or unobjectionable (Sismondo, 1993). We may also, though, pay attention to the central implications of the metaphor, the ones that allow it to be used in so many different ways and about so many different subject matters. Social constructivism provides three important assumptions about science and technology, which can be extended to other realms. First, science and technology are importantly *social*. Second, they are *active*—the construction metaphor suggests activity. And third, they do not provide a direct route from nature to ideas about nature; the products of science and technology are *not themselves natural* (for a different analysis, see Hacking, 1999).

A standard history of STS might start with Thomas Kuhn's *Structure of Scientific Revolutions* (1962), which emphasized the communal basis of the solidity of scientific knowledge, the perspectival nature of that knowledge, and the hands-on work needed to create it. More importantly, the popularity of Kuhn's book and iconoclastic readings of it opened up novel possibilities for looking at science as a social activity.

In this way, Kuhn's work helped make space for another starting point in the field, David Bloor's (1976) and Barry Barnes's (1974) articulation of the "strong program" in the sociology of knowledge. The strong program starts from a commitment to naturalist explanations of scientific and mathematical knowledge, to investigating the causes of knowledge. Much traditional history and philosophy of science retained non-naturalist patterns of explanation by explaining beliefs deemed true (or rational) and false (or irrational) asymmetrically, in so doing importing an assumption that truth and rationality have an attractive force, drawing disinterested science toward them. Such asymmetric treatments of science assume that, *ceteris paribus*, researchers will be led to the true and the rational, and therefore there can be no sociology of scientific knowledge but only a sociology of error. The strong program, then, provides a theoretical backdrop for studying the construction of scientific knowledge and not just error.

The strong program was most immediately worked out in terms of interests: interests affect the positions people adopt and shape the claims that count as scientific knowledge (e.g., MacKenzie, 1981; Shapin, 1975). A current body of work in STS largely compatible with interest-based explanations is feminist work revealing the sexism or sexist origins of particular scientific claims, usually ones that themselves contribute to the construction of gender (e.g., Fausto-Sterling, 1985; Martin, 1991; Schiebinger, 1993). This strand of feminist STS shows how ideology, as starting and ending points, contributes to the construction of scientific knowledge.

The empirical program of relativism (EPOR), mostly due to Harry Collins's work in the 1970s, bears much similarity to the strong program (e.g., Collins, 1985). Symmetry is achieved, as it is for many strong program studies, by focusing on controversies, during which knowledge is undetermined. Controversies display interpretive flexibility: materials, data, methods, and ideas can be given a range of interpretations compatible with the competing positions. For this reason, Collins's methodological relativism asserts that the natures of materials play no role in the resolution of controversies. EPOR goes on to show that there is always a regress in scientific and technical controversies. Judgments of interpretations and of the claims they support depend on each other, as participants in a controversy typically see the work and arguments to support a claim as sound to the extent that they see the claim itself as sound. Case studies support a picture of controversies being resolved through actions that define one position as the right and reasonable one for members of an expert community to hold. Thus, the constitution of scientific knowledge contains an ineliminable reference to particular social configurations.

While they are (literally) crucial components of the construction of scientific and technical knowledge, controversies are also only episodes in that construction, episodes in which groups of experts make decisions on contentious issues. To fully understand controversies, we must study how they have been shaped by cultures and events. In the 1970s a number of researchers—most prominently Harry Collins, Karin Knorr Cetina, Bruno Latour, Michael Lynch, and Sharon Traweek—simultaneously adopted a novel approach of studying cultures of science, moving into laboratories to watch and participate in the work of experimentation, the collection and analysis of data, and the refinement of claims. Early laboratory ethnographies drew attention to the skills involved in even the most straightforward laboratory manipulation and observation (Latour & Woolgar, 1979; Collins, 1985; Zenzen & Restivo, 1982). In the context of such skill-bound action, scientists negotiated the nature of data and other results in conversation with each other (Knorr Cetina, 1981; Lynch, 1985), working toward results and arguments that could be published. Attention to such details is consonant with the ethnomethodological study of science advocated by Lynch, which makes epistemology a topic of detailed empirical study (Lynch 1985, 1993); for ethnomethodology, the order of science is made at the level of ordinary actions in laboratories and elsewhere. In all of this, cultures play an enormous role, setting out what can be valued work and acceptable style (Traweek, 1988). The construction of data, then, is heavily marked by skills and cultures and by routine negotiation in the laboratory.

Not only data but phenomena themselves are constructed in laboratories—*labor*atories are places of work, and what is found in them is not nature but rather the product of much human effort. Inputs are extracted and refined, or are invented for particular purposes, shielded from outside influences, and placed in innovative contexts (Latour & Woolgar, 1979; Knorr Cetina, 1981; Hacking, 1983). Experimental systems are tinkered with until stabilized, able to behave consistently (Rheinberger, 1997). Laboratory phenomena, then, are not in themselves natural but are made to stand in for nature; in their purity and artificiality they are typically seen as more fundamental and revealing of nature than the natural world itself can be.

In the seventeenth century, this constructedness of experimental phenomena was a focus of debates over the legitimacy of experimental philosophy. The debates were, as we know, resolved in favor of experiment but not because experiment is self-evidently a transparent window onto nature. They were resolved by an articulation of the proper bounds and styles of discourse within a community of gentlemanly natural philosophers (Shapin & Schaffer, 1985) and by analogy to mathematical construction (Dear, 1995). In the analysis of these and other important developments, STS has opened up new approaches to historical epistemology, studying how and why particular styles of scientific work have arisen (Hacking, 1992); the histories and dynamics of key scientific concepts and ideals, like objectivity (Daston, 1992; Porter, 1995); and the rhetoric and politics of method (Schuster & Yeo, 1986). From the construction of scientific knowledge developed an interest in the construction of scientific methods and epistemologies.

Trevor Pinch and Wiebe Bijker's (1987) transfer of concepts from the study of science to the study of technology, under the title "social construction of technology" (SCOT), argued that the success of a technology depends on the strength and size of the groups that take it up and promote it. Even a technology's definition is a result of its interpretation by "relevant social groups": artifacts may be interpreted flexibly, because what they do and how well they perform are the results of competing goals or competing senses of what they should do. Thus, SCOT points to contingencies in the histories and meanings of technologies, contingencies on actions and interpretations by different social groups.

The symbolic interactionist approach treats science and technology as work, taking place in particular locales using particular materials (e.g., Fujimura, 1988). Moreover, objects serve as symbols that enable work and, through it, the creation of scientific knowledge and technical results (Star & Griesemer, 1989). Attention to the work of science, technology, and medicine alerts symbolic interactionists to the contributions of people not normally recognized as researchers or innovators (e.g., Moore, 1997).

Actor-network theory (ANT) further broadens that picture by representing the work of technoscience as the attempted creation of larger and stronger networks (Callon, 1986; Latour, 1987; Law, 1987). Actors, or more properly "actants," attempt to build networks we call *machines* when their components are made to act together to achieve a consistent effect, or *facts* when their components are made to act as if they are in agreement. Distinctive to ANT is that the networks are heterogeneous, including diverse components that span materials, equipment, components, people, and institutions. In ANT's networks bacteria may rub shoulders with microscopes and public health agencies, and experimental batteries may be pulled apart by car drivers and oil companies. All these components are actants and are treated as simultaneously semiotic and material; ANT might be seen to combine the interpretive frameworks of EPOR and SCOT with the materialism of laboratory studies. Scientific facts and technological artifacts are the result of work by scientists and engineers to translate the interests of a wide group of actors so that they work together or in agreement. ANT's step in the history of constructivist STS is to integrate human and nonhuman actors in analyses of the construction of knowledge and things—controversially, because it may reproduce asymmetries (Collins & Yearley, 1992; Bloor, 1999).

For scientific knowledge and technological artifacts to be successful, they must be made to fit their environments or their environments must be made to fit them. The process of adjusting pieces of technoscience and their environments to each other, or of simultaneously creating both knowledge and institutions, is a process of *co-production* (Jasanoff, 2004) or *co-construction* (Taylor, 1995) of the natural, technical, and social orders. Drugs are made to address illnesses that come into being because of the availability of drugs (e.g., Fishman, 2004), classifications of diseases afford diagnoses that reinforce those classifications (Bowker & Star, 1999), and climate science has created both knowledge and institutions that help validate and address that knowledge (Miller, 2004). Part of the work of successful technoscience, then, is the construction not only of facts and artifacts but also of the societies that accept, use, and validate them.

There have been many more extensions of constructivist approaches. Observing that interests had been generally taken as fixed causes of scientific and technological actions, even while interests are also flexible and occasioned (Woolgar, 1981; Callon & Law, 1982), some researchers have taken up the challenge of reflexivity, explaining sociology of knowledge using its own tools (Mulkay, 1985; Woolgar, 1988; Ashmore, 1989). Studies of scientific and technical rhetoric follow the discursive causes of facts and artifacts into questions of genre and styles of persuasion (e.g., Gilbert & Mulkay, 1984; Myers, 1990). The study of boundary work displays the construction and reconstruction of the edges of disciplines, methods, and other social divisions (Gieryn, 1999). Meanwhile, researchers have examined some of the legal, regulatory, and ethical work of science and technology: How are safety procedures integrated with other laboratory practices (Sims, 2005)? How is informed consent defined (Reardon, 2001)? How are patents constructed out of scientific results (e.g., Packer & Webster, 1996; Owen-Smith 2005)? In these and many other ways, the constructivist project continues to find new tools of analysis and new objects to analyze.

The metaphor of construction, in its generic form, thus ties together much of STS: Kuhn's historiography of science; the strong program's rejection of non-naturalist explanations; ethnographic interest in the stabilization of materials and knowledges; EPOR's insistence on the muteness of the objects of study; historical epistemology's exploration of even the most apparently basic concepts, methods, and ideals; SCOT's observation of the interpretive flexibility of even the most straightforward of technologies; ANT's mandate to distribute the agency of technoscience widely; and the co-productionist attention to simultaneous work on technical and social orders. Of course, these programs are not unified, as different uses and interpretations of the constructivist metaphor allow for and give rise to substantial theoretical and methodological disagreements. Yet the metaphor has enough substance to help distinguish STS from more general history of science and technology, from the rationalist project of philosophy of science, from the phenomenological tradition of philosophy of technology, and from the constraints of institutional sociology of science.

THE PROBLEM WITH THE NARRATIVE SO FAR

Unfortunately, the narrative so far is entirely a High Church one, to adopt Fuller's useful analogy.[1] This High Church STS has been focused on the interpretation of science and technology and has been successful in developing sophisticated conceptual tools for exploring the development and stabilization of knowledge and artifacts. While its hermeneutics of science and technology are often explicitly framed in opposition to the more rationalist projects of traditional philosophy and history of science, the High Church occupies a similar terrain.

But there is also a Low Church, less concerned with understanding science and technology in and of themselves, and more with making science and technology accountable to public interests. The Low Church has its most important origins in the work of scientists concerned with ties among science, technology, the military, and industry. For them, the goal is to challenge the structures that allowed nuclear physics to contribute to the development of atomic weapons, that allowed chemistry to be harnessed to various environmentally disastrous projects, or that gave biology a key place in the industrialization of agriculture. Activist movements in the 1940s and 1950s produced the *Bulletin of Atomic Scientists* and organizations like Pugwash, in which progressively minded scientists and other scholars discussed nuclear weapons and other global threats. Put differently, science and technology often contribute to projects the benefits, costs, and risks of which are very unevenly distributed. In recognition of this fact, and in the context of a critique of the idea of progress (Cutliffe, 2000), 1960s activists created organizations like the Union of Concerned Scientists and Science for the People.

Especially in the academy, the Low Church became "Science, Technology, and Society," a diverse grouping united by its combination of progressive goals and orientation to science and technology as social institutions. In fact these two have been connected: For researchers on Science, Technology, and Society, the project of understanding the social nature of science has generally been seen as continuous with the project of promoting a socially responsible science (e.g., Ravetz, 1971; Spiegel-Rösing & Price, 1977; Cutliffe, 2000). This establishes a link between Low and High Churches and a justification for treating them as parts of a single field, rather than as two completely separate denominations. So the second of the elements that distinguish STS from other disciplines that study science and technology is an activist interest.

For the Low Church, key questions are tied to reform, to promoting science and technology that benefit the widest populations. How can sound technical decisions be made through genuinely democratic processes (Laird, 1993)? Can innovation be democratically controlled (Sclove, 1995)? How should technologies best be regulated (e.g., Morone & Woodhouse, 1989)? To what extent, and how, can technologies be treated as political entities (Winner, 1986)? What are the dynamics of public technical controversies, and how do sides attempt to control definition of the issues and the relevant participants (Nelkin, 1979)? As problems of science and technology have changed, so have critical studies of them. Military funding as the central focus has given way to a constellation of issues centered on the privatization of university research; in a world in which researchers, knowledge, and tools flow back and forth between academia and industry, how can we safeguard pure science (Dickson, 1988; Slaughter & Leslie, 1997)?

An assumption behind, and also a result of, research on Science, Technology, and Society is that more public participation in technical decision-making, or at least more than has been traditional, improves the public value and quality of science and technology. So, for example, in a comparison of two parallel processes of designing chemical weapons disposal programs, a participatory model was a vast improvement over a "decide, announce, defend" model; the latter took enormous amounts of time, alienated the public, and produced uniform recommendations (Futrell, 2003). In evaluations of public participation exercises it is argued that these are more successful to the extent that participants represent the population, are independent, are involved early in the decision-making process, have real influence, are engaged in a transparent process, have access to resources, have defined tasks, and engage in structured decision-making (Rowe et al., 2004).

The democratization of science and technology has taken many forms. In the 1980s, the Danish Board of Technology created the consensus conference, a panel of citizens charged with reporting and making (nonbinding) recommendations to the Danish parliament on a specific technical topic of concern (Sclove, 2000). Experts and stakeholders have opportunities to present information to the panel, but the lay group has full control over its report. The consensus conference process has been deemed a success for its ability to democratize technical decision-making without obviously sacrificing clarity and rationality, and it has been extended to other parts of Europe, Japan, and the United States (Sclove, 2000).

Looking at an earlier stage in research processes, in the 1970s the Netherlands pioneered the idea of "science shops," which provide technical advice to citizens, associations, and nonprofit organizations (Farkas, 1999). The science shop is typically a small-scale organization that conducts scientific research in response to needs articulated by individuals or organizations lacking the resources to conduct research on their own. This idea, instantiated in many different ways, has been modestly successful, being exported to countries across Europe and to Canada, Israel, South Africa, and the United States, though its popularity has waxed and waned (Fischer et al., 2004). Thus, the project of Science, Technology, and Society has had some impressive achievements that are not part of the constructivist project, at least as represented in this chapter's earlier narrative of the history of STS. Nonetheless, these two projects have been better linked together than the two Churches analogy would suggest.

A RECONSTRUCTION OF THE DISTINCTION

This chapter does not attempt a religious reconciliation. Easier is to argue that the religious metaphors are out of place. There is undoubtedly considerable distance between the more "theoretical" and the more "activist" sides to STS, but there are plenty of

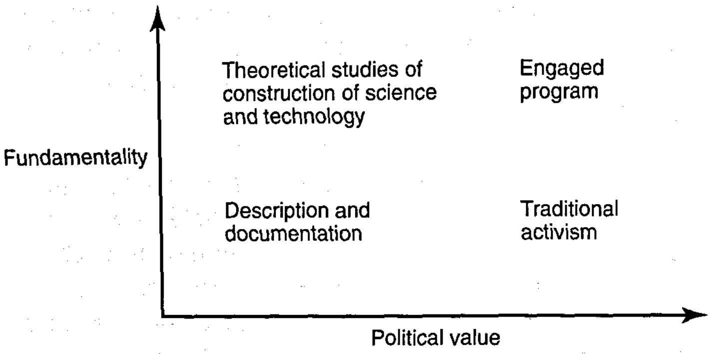

Figure 1.1

overlaps between theory and activism (Woodhouse et al., 2002). There are any number of engaged analyses drawing on constructivist methods and insights, constructivist analyses engaging with policy or politics, and abstract discussions of the connections between theory and the democratization of science and technology. In particular, we can see valuable extensions of constructivist STS to study technoscientific politics, extensions that bridge normative and theoretical concerns.

We might better view the distinction between High Church purely academic work and Low Church political or advocacy work in terms of a double distinction. (There are other revisions of it, around positive and negative attitudes toward science and technology, as well as three-way contrasts among theory, activism, or public policy—see Cutliffe, 2000; Woodhoue et al, 2002; Bijker, 2003.) Let us ask two questions of different pieces of STS scholarship. First, do they aim at results of theoretical or fundamental or wide importance for understanding the construction of science and technology? Second, do they aim at results of political or practical value for promoting democratic control of and participation in science and technology? If we ask these two questions simultaneously, the result is a space defined by two axes: high and low levels of "fundamentality" and high or low levels of "political value." While these axes do not tell a full story of STS, they both distinguish STS from other ways of studying science and technology and capture important dimensions of the field (see figure 1.1). At the lower left of the figure are studies that describe and document. Such studies are not by themselves relevant to either the theoretical or activist projects of STS, though perhaps they may be made so by the right translations. They would typically be left out of the standard characterizations of the field (Cutliffe, 2000; Bucchi, 2004; Sismondo, 2004; Yearley, 2005). At the lower right are studies that aim to contribute primarily to one or another activist project. At the upper left are studies that aim to contribute to theoretical understanding of the construction of science and technology, typically focusing on high-status sciences and technologies and often focusing on their internal dynamics. At the upper right are studies that aim to contribute both to some version of activist projects and to general theoretical perspectives. For ease of reference, this region of intellectual space needs a name: the "engaged program" of STS.

The modest move of the engaged program is to address topics of clear political importance: nuclear energy rather than condensed matter physics, agricultural biotechnology rather than evolutionary systematics. But in so doing the engaged program makes a more sophisticated move by placing relations among science, technology, and public interests at the center of the research program. The engaged program studies science and technology when they are or should be engaged, and as a result, interactions among science, technology, politics, and public interests have become topics for STS and not just contexts of study. Politics has become a site of study rather than a mode of analysis.

The two-dimensional framework allows us to see not a conflict between the goals of theoretical interest and activism but a potential overlap. That overlap is well represented, and increasingly so, in the STS literature. Some of the recent chapters in the history of STS involve the extension of the constructivist program to public sites, with a focus on interactions at the interface of science, technology, law, and government. Without programmatic announcements or even fanfare, the center of gravity of STS has moved markedly toward the terrain of the engaged program. Much of the Low Church has always been there, since many of its representatives intend to contribute to general analyses of the politics of science and technology, treating their subject matters as important case studies. Some strands of feminist STS have also always been there, wherever feminist research met constructivist concerns. So has much symbolic interactionist research, which has been often articulated with attention to issues of power (e.g., Cussins, 1996; Casper & Clarke, 1998). But recently it has become almost the norm for constructivist STS to study cases of public interest, and it has become common to study the interactions of science, technology, and public interests. Consequently, the nature of the politics of science and technology appears to be at the very center of the field. Recent issues of *Social Studies of Science,* certainly one of the highest of High Church central journals in STS, contain any number of articles on a wide variety of topics clearly located in the engaged program.[2] Books on science and technology in an explicitly political context attract attention and win prizes.[3] Indeed, the natures of democracy and politics in a technoscientific world, and the political orders of technoscience, are among the central topics of STS. That movement makes the distinction between two Churches increasingly irrelevant.

CONSTRUCTIVISM AND THE POLITICS OF EXPERTISE

We can see the engaged program converging on the democratization of technoscience. Approaching the problem from the direction of liberal democratic theory, Stephen Turner (2001, 2003a) argues that there is a genuine conflict between expertise and democracy because expertise creates inequalities that undermine citizen rule. As knowledge societies have developed, decisions are increasingly made by or directly responsive to experts and expert commissions. Turner is cautiously optimistic about this new version of democracy, "Liberal Democracy 3.0," arguing that some forms of expertise are effectively democratically accepted, that judgments of expertise are conferred contingently and are always open to challenge, and that therefore the importance of expertise in modern liberal societies is in principle compatible with democracy (Turner, 2001). How best to manage the conflict remains an open theoretical and political project, though.

One set of implications of the (social) constructedness of scientific knowledge is that there is always a way of cashing out knowledge in social terms: that its meaning always includes a social component, and that assumptions about the social world that produced it are embedded in knowledge. When scientific knowledge enters the public arena, those embedded assumptions can come under scrutiny. An interested public may be in an excellent position to see and challenge assumptions about such things as the residence of expertise, the relative values of different interests, and the importance of risks; Steven Yearley (1999) identifies this as one of the key findings in studies of science meeting the public. Constructivism, then, also provides grounds for increasing public participation in science and technology.

Laypeople can develop and possess technical expertise in many ways. Steven Epstein's (1996) study of AIDS activism and its effects on research provides a striking example. Activists were able to recognize that the standard protocols for clinical trials assumed, for example, that research subjects should be expected not to supplement experimental treatments with alternatives or not to share drugs with other research subjects. The protocols effectively valued clean results over the lives and hopes of people living with AIDS, and thus activists were able to challenge both the artificiality of and the ethics embedded in clinical trials. Moreover, it is clear that there are many forms of expertise and that scientists and engineers may lack relevant forms of expertise when their work takes them into public realms. In a somewhat different situation, French muscular dystrophy patients have contributed to research on their disease by organizing the research effort, engaging in their own studies, participating in accredited researchers' studies, and evaluating results (Rabeharisoa & Callon,1999). Because of its considerable resources, l'Association Française contre les Myopathies has become exemplary of a kind of cooperative research between laypeople and scientists (Callon, 1999). Brian Wynne's (1996) study of Cumbrian sheep farmers potentially affected by the 1986 Chernobyl accident is one of the most-discussed pieces of research in STS, precisely because it is about the fate of expertise in a public domain. The farmers were easily able to see that Chernobyl was not the only potential source of irradiation, as the British nuclear power plant Sellafield was already viewed with suspicion, and were also able to see lacunae in government scientists' knowledge, especially about sheep-farming. Thus, they developed a profound skepticism about the government advice.

Outsiders may challenge the seamlessness of scientific and technical expertise. There are competing epistemes in science and law, and when science is brought into the courtroom the value of its forms of knowledge is not straightforwardly accepted (Jasanoff, 1995). Lawyers and judges often understand that scientific expertise contains its own local and particular features. As a result, science can be challenged by routine legal maneuvers, and it may or may not be translated into forms in which it can survive those challenges. Similarly, science typically does not provide the definitive cases for particular policies that both scientists and policymakers hope for, because the internal mechanisms by which science normally achieves closure often fail in the context of contentious policymaking (Collingridge & Reeve, 1986).

THREE PROGRAMMATIC STATEMENTS

Through studies like the above, STS, and particularly that part of the field that we can see as working within the broad constructivist metaphor and as having a High Church history, has turned the politics of science and technology into a topic, indeed, *the* topic. This is not simply to analyze technoscience politically but to analyze technoscientific politics. What follows are three articulations of core substantive issues and normative responses. We can see each of these articulations as attending to the construction of political orders of science and technology and following paths begun in the history of constructivism.

A Normative Theory of Expertise

In a widely discussed paper, H. M. Collins and Robert Evans (2002) identify what they call a "problem of extension": Who should legitimately participate in technical decision-making? That is, given constructivist STS's successful challenge to claims that science has privileged access to the truth, how open should technical decision-making be? In expansive terms, Collins and Evans claim that a version of the problem of extension is "the pressing intellectual problem of the age" (2002: 236).

They offer a normative theory of *expertise* as a framework for a solution to this problem. Experts, they argue, are the right decision-makers because (by definition) they possess relevant knowledge that nonexperts lack. STS has shown, and Collins's work (e.g., 1985) is most prominent in showing, that the solution to scientific and technical controversies rests on judgments by experts and judgments of the location of expertise rather than on any formal scientific method; science and technology are activities performed by humans, not machines. Collins and Evans assume, moreover, that expertise is real and that it represents genuine knowledge within its domains. STS has also shown that legitimate expertise extends much further than merely to accredited scientists and engineers, at least wherever science and technology touches the public domain (e.g., Epstein 1996; Wynne 1996; Yearley 1999). In addition, there are different forms of expertise: contributory expertise allows for meaningful participation in the substance of technoscientific controversies, interactional expertise allows for meaningful interaction with, and often between, contributing experts, and referred expertise allows for the assessment of contributory expertise (Collins & Evans, 2002). Thus, the normative theory of expertise would increase opportunities for participation and would promote an egalitarianism based on ability to participate meaningfully. The problem of extension is to identify how far these different forms of expertise legitimately extend.

Technical decisions are the focus of Collins and Evans's position, the key intersection of science, technology, and politics. This leaves their view open to charges of a "decisionism" (Wynne, 2003; Habermas, 1975) that ignores such matters as the framing of issues, the constitution of expertise, and the dissemination of knowledge (Jasanoff, 2003). We might see a parallel issue in the movement in current political philosophy to value deliberative democracy and active citizenship over aggregative democracy and participation through voting. Thus, we might think that Collins and Evans have construed the topic of the engaged program narrowly, leaving aside terrains where science, technology, and politics intersect.

Civic Epistemologies

Problems with decisionism serve as a point of departure for quite different explorations of science and technology in the public domain. Sheila Jasanoff, in a comparative study of biotechnology in the United States, Britain, and Germany, shows how there are distinct national cultures of technoscientific politics (Jasanoff, 2005). Just as controversies are key moments, but only moments, in the construction of scientific and technical knowledge, decisions are key moments in technoscientific politics. The governments of each of these countries have developed strategies to incubate biotechnological research and industry, even to the extent of being aspects of nation-building. Each has subjected that research and industry to democratic scrutiny and control. Yet the results have been strikingly different: the industries are different, their relations with academia are different, and the regulations dealing with them and their products are different. This is the result of national "civic epistemologies" that shape the democratic practice of science and technology (Jasanoff, 2005: 255).

As Jasanoff describes civic epistemologies, they contain these dimensions: styles of knowledge-making in the public sphere; approaches to, and levels of, accountability and trust; practices of demonstration of knowledge; types of objectivity that are valued; foundations of expertise; and assumptions about the visibility and accessibility of expert bodies (2005: 259). In the United States the level of trust of experts is low, their accountability is grounded in legal or legalistic processes, and neatly congruent with this, the most valued basis of objectivity is formal. In Germany, on the other hand, the level of trust in experts is higher, when they occupy recognized roles, and the basis of objective results is reasoned negotiations among representatives of interested groups. It should be no surprise, then, that the politics of biotechnology are different in the United States and Germany.

The above list of dimensions, which might be expandable, suggests programs of research for all kinds of civic epistemologies and not just national ones. Meanwhile, such a historically grounded and locally situated understanding of technoscientific politics demands historically grounded and locally situated normative approaches. No single template will improve democratic accountability in diverse settings and contexts. And similarly, no single template of active technoscientific citizenship will be adequate to these different settings. If the engaged program foregrounds civic epistemologies, its normative work is multiplied.

Bringing the Sciences into Democracy

For Bruno Latour, the modern world sees nature and politics as two separate domains, their only connection being that nature is taken to provide constraints on politics (Latour, 2004). It has been a central achievement of STS to show that this modern picture is mistaken: what is here being called constructivist STS exposes the work of establishing facts of nature, thus showing that the modernist separation of nature from the social world is a piece of *a priori* metaphysics. Latour aims to bring the sciences into democracy by "blurring the distinction between nature and society durably" (2004: 36). In its place, he proposes the instauration of a collective (or many collectives) that deliberates and decides on its membership. This collective will be a republic of things, human and nonhuman. Just as ANT integrated humans and nonhumans into analyses of technoscience, its contribution to the engaged program should be to integrate humans and nonhumans into technoscientific democracy.

Latour argues that representing nonhumans is no more difficult than representing humans, that there is only one problem of representation, which sometimes appears as a problem of political representation and sometimes as a problem of scientific representation (2004: 55). In both cases, we rely on spokespeople, of whom we must be simultaneously skeptical and respectful. Nonetheless, political philosophy has had enough difficulty dealing with *human* multiculturalisms, with their apparent conflicts over universal rights and national projects, and we might suspect that such conflicts would be more difficult to address if nonhumans were also given consideration.

Perhaps for this reason, Latour's collective would be focused on propositions, determining which propositions belong in a well-ordered common world or cosmos. He divides it into two houses, with separate powers and responsibilities; these houses cut across science and politics, reconceptualizing epistemic processes so that all parties can participate at all stages. An upper house has the power to "take into account," the lower house has the power to "put in order," and both together have the power "to follow up." To effect such powers requires tasks that scientists and politicians would undertake: to be attentive to propositions that might be added to the common world, even if they might challenge members; to determine how to assess propositions that might be included; to arrange propositions in a homogeneous order; to reason toward closure of debates; and so on.

It would be unfair to Latour, given the amount of detail in his descriptions, to say that the organization of the collective is unclear. Nonetheless, Latour's divisions and unities are not described to help us site a new parliament building and populate it with representatives. Rather, he aims to show what a society should do if it took epistemics as central. In effect, Latour's preferred politics of nature is reminiscent of Karl Popper's epistemic liberalism but responsive to research in STS, and specifically to research in ANT. Such a society would not allow propositions to become established without being subjected to the right kinds of scrutiny. It would attempt to institutionalize propositions rationally, yet it would be constantly open to the possibility of revision of its established cosmos. It would not adopt any *a priori* metaphysics, such as that which neatly divides nature and society. And it would be so constituted that these checks and balances would remain in place. So while Latour's politics of nature is intensely normative, it does not make recognizably concrete recommendations.

STS AND THE STUDY OF TECHNOSCIENTIFIC POLITICS

In the above three programmatic statements we can see parallels to programs in the history of constructivist STS. There remain plenty of opportunities to explore further extensions of the field into the terrain of technoscientific politics: constructions of phenomena of interest, natures of interests themselves, histories and uses of civic epistemologies and not only their forms, contingencies of particular understandings of the politics of science and technology, boundary work in political domains, and rhetorical action. As before, these programs need not be unified, as different uses and interpretations of the constructivist metaphor allow for substantial disagreements. Yet the metaphor has enough substance to help guide research in interesting and valuable directions.

Moreover, as the above programmatic statements show, there are opportunities for contributions to a political philosophy that recognize the centrality of science and technology to the modern world. Because it does not separate epistemic and political processes, STS can genuinely study knowledge societies and technological societies rather than treat knowledge and technology as externalities to political processes. This theoretical project is structured so that it already contributes to STS's normative project, providing a broad set of ways of bringing them together.

Notes

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1. Fuller's analogy is to two waves of secularization. STS's Low Church resembles the sixteenth and seventeenth century Protestant Reformation, whereas the High Church resembles nineteenth century radical hermeneutical criticism of the Bible (Fuller, 2000: 409).

2. There are, for example, articles on the rhetoric of commentary on tobacco regulation (Roth et al., 2003), environmental management of small islands (Hercock, 2003), race and scientific credit (Timmermans, 2003), social and ethical consequences of pharmacogenetics (Hedgecoe & Martin, 2003), a debate about the nature of engagement in STS (Jasanoff, 2003; Wynne, 2003; Rip, 2003; Collins & Evans, 2003), and a discussion of the politics of expertise (Turner, 2003b).

3. The Society for Social Studies of Science awards two book prizes each year, the Ludwik Fleck and Rachel Carson prizes. The latter, created only in 1996, is explicitly for a book of political or social relevance, but the former is for a book of general interest in STS. Nonetheless, among the Fleck winners are such books as Helen Verran's *Science and an African Logic* (2001), a book that puts relativism in a multicultural context; Adele Clark's *Disciplining Reproduction* (1998), on twentieth century sciences of human reproduction; Donna Haraway's *Modest_Witness@Second-Millennium* (1997), on feminism and technoscience; Theodore Porter's *Trust in Numbers* (1995), which discusses how the ideal of objectivity arises from the democratization of expertise; and Londa Schiebinger's *Nature's Body* (1993), on gender in Enlightenment biology and anthropology.

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