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SURVEY REVIEW

Votes and lab coats: democratizing scientific research and science policy

Wiebe E. Bijker, Roland Bal, and Ruud Hendriks: The paradox of scientific authority: The role of scientific advice in democracies. Cambridge, MA: MIT Press, 2009, 223pp, $32 HB

Mark B. Brown: Science in democracy: Expertise, institutions, and representation. Cambridge, MA: MIT Press, 2009, 354pp, $29 PB

Massimiano Bucchi: Beyond technocracy: Science, politics and citizens. Translated by Adrian Belton. Dordrecht: Springer, 2009, 106pp, €99.95 HB

Michel Callon, Pierre Lascoumes, and Yannick Barthe: Acting in an uncertain world: An essay on technical democracy. Cambridge, MA: MIT Press, 2009, 287pp, $37 HB

Philip Kitcher. Science in a democratic society. Amherst, NY: Prometheus Books, 2011, 270pp, $28 HB

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On December 19, 1984, the US Department of Energy selected, based on a 10-year research project, ten long-term geologic repository sites for 70,000 mt of nuclear waste. A year later, after taking into account expert reports, President Ronald Reagan reduced the candidate sites to three: Hanford, Washington; Deaf Smith County, TX; and Yucca Mountain in Nevada. In 1987, Congress directed the Department of Energy to study only Yucca Mountain. Despite strong opposition from the people of Nevada, environmentalists, and some senators in Congress, President George W. Bush signed a resolution in July 23, 2002 that gave the go-ahead to establish a nuclear waste

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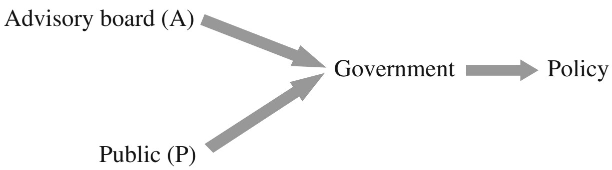
facility at Yucca Mountain. The Department of Energy, the Environmental Protection Agency, and the US Geological Survey experts investigated, and often had strong disagreements about, issues regarding the safety of the facility and the standard levels for radiation emission. In 2006, the project budget was drastically cut. The Department of Energy pushed the date for the opening of the facility back to 2017. In the meantime, the Yucca project became an issue in the presidential election, with Senator John Kerry promising to abandon the project if elected. During his 2008 election campaign, Barak Obama made the same commitment. On April 14, 2011, Congress passed the budget that in effect terminated the project's funding, which had nevertheless already cost 12 billion dollars.

(Extracted from the entry "Yucca Mountain nuclear waste repository" in Wikipedia, http://en.wikipedia.org/wiki/Yucca_Mountain_nuclear_waste_repository.)

The story of the Yucca Mountain nuclear waste repository displays the multifaceted problems and difficult questions that liberal democratic societies face today: What is the proper response to such a close intertwining of techno-science and politics? How are democratically elected governments to decide policies regarding techno-scientific issues, especially when the recommendations of relevant expert advisory boards and agencies clash with public opinion? What are they supposed to do when there is no consensus among the scientific community as to the risks involved? Can the existing political and scientific institutions of contemporary democracies meet the challenges raised by complex techno-scientific issues? Is the public sufficiently knowledgeable about the issues to make informed decisions? Why do people often resist policies that involve scientific and technological innovations? Is it because they are ignorant or misinformed about science, or because public confidence in science is eroding? These and related questions often arise not only around how to dispose of nuclear waste, but also around research and policies regarding a number of issues involving scientific research, including global warming, the treatment and prevention of epidemics, the ethics of stem cell research, and the health benefits and risks of genetically modified (GM) food. In many cases, they involve conflicts among scientific experts, policy makers, businessmen, and the public in ways that paralyze decision making. These issues challenge the existing dominant framework of techno-scientific research and policy making, which, greatly simplified, can be represented as follows:



In this framework, whereas scientific research is the sole purview of scientists, the ultimate decider of a policy is the government, which is democratically elected by the public. Thus, people's role in policy making is indirect and limited to electing their representatives and expressing their will through periodic elections, though of course they can and sometimes do voice their opinions more directly, through public polls and demonstrations. Advisory boards and agencies consisting of scientific experts inform the government about the available ways to pursue ends that have, theoretically, been set by the public. Advisory boards and agencies, though not accountable to the public, have a much greater influence on policy making since they directly advise the policy makers on specific techno-scientific issues. (This is an overly simplified model. In reality, of course, the collective "public" is not a homogenous entity and consists of diverse interest groups with varying degrees of influence. Corporate interests often exert the greatest influence over governments in policy making. We shall say more about this issue toward the end of our article.).

The books reviewed in this article deal with the techno-scientific challenges and conflicts raised by nuclear energy and waste, epidemics like swine flu, Avian flu, and SARS, GM foods, stem cell research, global warming, and the like and discuss the intricate relationships among science, expertise, politics, and the public to which they give rise. Wiebe Bijker et al.'s *The Paradox of Scientific Authority: The Role of Scientific Advice in Democracies* (2009) probes the structure and inner workings of advising expert bodies within democratic societies through a case study of the Gezondheidsraad, the influential Health Council of Netherlands. The other books question the adequacy of the dominant framework within which techno-scientific problems are currently addressed. Massimiano Bucchi's *Beyond Technocracy: Science, Politics and Citizens* (2009) is a short introductory book that touches upon almost every major issue in this context. Michel Callon et al., authors of *Acting in an Uncertain World* (2009), who refer to the dominant framework as "double delegation" (since it involves not only entrusting scientists with the task of acquiring knowledge, but also entrusting elected representatives with the task of making policy choices in light of the knowledge scientists have produced) discuss why the dominant framework is, by itself, insufficient and suggest "hybrid forums," which are forms of public participation in science and science policy making, as mechanisms complementing it. There is naturally considerable overlap between these two books not just because they cover the same topics, but also because the former makes much use of the main ideas of the latter. Philip Kitcher's *Science in a Democratic Society* (2011) extends the ideal of a well-ordered science, which he had developed earlier in his (2001) book and offers an account of how science should be organized in a democratic society. And, finally, Mark Brown's *Science in Democracy* questions the idea of representation implicit in the dominant framework as well as in alternatives like "hybrid forums."

The role of scientific advice in contemporary democracies

The Paradox of Scientific Authority stands apart from the others in that it is an empirical study of a real advisory institution that operates within the dominant framework. The Gezondheidsraad, which consists of about 200 experts, is an independent organization that publishes reports advising ministers and the Netherlands parliament on matters of public health and is sometimes compared to the US National Academy of Science. The Gezondheidsraad itself does not carry out cutting edge scientific research, but rather synthesizes knowledge polled from different disciplines for use in policy making. These reports describe "the state of knowledge and [weigh] the different options that are available for an effective improvement of policies in public health" (Bijker et al., 13).

The Paradox of Scientific Authority uses the ethnographic method in conjunction with "grounded theory" to reveal how the Gezondheidsraad operates: it describes "the backstage" (the making of the report by defining the problem, forming the committees, and the writing of the report), "the frontstage" (the characteristics of the report itself, such as its language and rhetoric, the style of its argumentation, etc.) and, finally, how the Gezondheidsraad, through these reports and their presentation, positions itself in the larger context of democratic governance in what Bijker et al. call "technological cultures." By using the Gezondheidsraad as a case study, *The Paradox of Scientific Authority* addresses two main questions. The first, "the paradox of scientific authority," asks "How can scientific advice have some authority when developments in political culture have eroded the stature of so many classic institutions," including that of science. The second explores how, under these circumstances, "scientific advice [can] still play a role in the democratic governance of technological cultures?" (6).

To resolve the paradox, Bijker et al. draw on and develop Thomas Gieryn's concept of "boundary work," which frames attempts by mainstream philosophers of science (such as logical empiricists and falsificationists) and classical sociologists of science (such as Robert Merton) to delineate what science is as efforts to carve out a cultural space uniquely occupied by science having a privileged access to reality and distinct from non-science. This way of formulating "the demarcation problem," which reflects a social constructivist perspective, shifts the focus from finding a set of characteristics essential to science or formulating formal and methodological criteria to distinguish it from non-science to the question of how the boundary between the two is drawn, strategically deployed and monitored (144). Bijker et al. argue that the Gezondheidsraad gains its social authority through simultaneously drawing boundaries between and linking science and non-science, science and policy, science and ethics, science and social context, science and societal interests in a constant double movement that they call "coordination work" (147–148). More concretely, coordination work involves redefining a "scientific" problem, the selection of committee members, hearings, informal contacts between ministries and various stakeholders, press releases, and the like such that different viewpoints and interests (scientific, political, and social) are all incorporated into the ultimate result. Such work enables the Gezondheidsraad to present itself as a value-neutral, non-political advisory body that makes its policy recommendations "scientifically" and authoritatively. It is in this way that the Gezondheidsraad gains and maintains its social stature and the faith of the public.

Here, one might wonder whether there is any paradox to be resolved. As one early reviewer has also noted, Bijker et al. do very little to establish their claim that the authority of science is eroding (Hays 2011, 222). In fact, there is some evidence suggesting that science *retains* its authority in European societies. As Bucchi (6) also emphasizes, the European public seems to place significant trust in scientists even on controversial issues such as new biotechnologies. When asked whether scientists "involved in the various applications of modern biotechnology" were "doing a good job for society," 74 % of those surveyed responded positively, and only 8 % responded negatively (Gaskell et al. 2010, 75–76). Other evidence of the authority of science, particularly relevant to the works under review that argue for more public deliberation, is the European public's views regarding how policy on controversial questions, such as synthetic biology and animal cloning, should be made. On the former issue, 52 % of the European public favor "scientific delegation where experts, not the public decide, and where evidence relating to risks and benefits, not moral concerns, are the key considerations" (Gaskell et al. 2010, 70–71). On the latter issue, support for scientific delegation diminishes, but nevertheless 42 % of the population favor it. Even though these surveys cannot conclusively establish that the authority of science is firmly in place, they nevertheless are sufficient to place the burden of proof on Bijker et al. who unfortunately fail to deliver on that point.

In answering the second question (i.e., the role of scientific advice in the democratic governance of technological cultures), Bijker et al. depart from the descriptive mode and switch to a prescriptive one. They agree that in situations of uncertain and ambiguous risk "there is increasing need for stakeholder involvement (of consumers, patients, or other interest groups)," but claim that in cases where the basic scientific knowledge is relatively certain "democracy is better served by scientific advisory institutions that do not have stakeholder representation but that use their subtle boundary and coordination mechanisms to translate the state of scientific knowledge into serviceable truth input for the policy process, so that society benefits optimally from scientific expertise it has amassed" (164).

The dominant framework of science policy and its discontents

While *The Paradox of Scientific Authority* takes the dominant framework of science policy in today's democracies for granted, Bucchi's *Beyond Technocracy: Science, Politics and Citizens*, Michel Callon et al.'s *Acting in an Uncertain World,* and Kitcher's *Science in a Democratic Society* all question its adequacy on several grounds. First, an increasing number of techno-scientific issues involve uncertainty and risks, which the existing mechanisms of decision making are unable to deal with. Since techno-scientific issues have a direct and serious impact on the lives of people, they are inevitably becoming a public concern. Second, when the recommendations of experts clash with the demands of the public, the existing framework has no way of resolving the conflict, other than by the brute exercise of governmental power, which is bound to alienate at least one side in question. Third, scientific experts who advise the governments are not held accountable for the outcome of their advice even though they exert a great influence on policy making. Fourth, the existing framework assumes that the public has nothing interesting to contribute to science. Fifth, it presupposes the much criticized ideal of a value-free science where scientific decisions are based solely on epistemic-cognitive criteria, having nothing to do with cultural, social, political, and economic considerations. Finally, the current framework assumes a pre-formed public will and ignores how science and technology shape citizens' preferences and identities.

Collectively taken, these considerations point to a "democracy deficit" in science and science policy making rather than to the public's "science deficit" as it is often assumed. For that very reason, all of the books under review devote considerable attention to the question of how science and science policy making can be made more democratic. The intricate relationships among science, expertise, politics, and the public have been receiving increasing attention especially from the practitioners of science, technology, and society studies (STS) in the last decades, but given its importance it should be of interest to concerned scientists, sociologists, political philosophers, and philosophers of science as well. As Bucchi (ix) argues, techno-scientific challenges and conflicts "are symptomatic of major—perhaps even epochal—changes in the role of science, and generally in the production of scientific knowledge" and "such changes concern the nature … of contemporary politics and democracy." How those changes should be conceptualized and theorized is itself a matter of controversy, which we will discuss in due course. At this point, it would be useful to begin with what Bucchi calls "the technocratic response" to the challenges and conflicts in question, especially common among scientists and not absent among policy makers.

The technocratic response

Bucchi's amusing slogan "all power to the experts (with the blessing of citizens provided they are well educated)" captures the gist of the technocratic response, which rests on the following tenets (1):

> Public opinion and political decision makers are extremely misinformed about science and the issues raised by its development. This misinformation is fueled by inadequate and sensationalist media coverage of techno-scientific topics. This situation is exacerbated by poor training in basic science and a general disinterest—among the institutions and the cultural intelligentsia– in scientific research. Consequently, citizens and political decision makers fall prey to irrational fears which stoke hostility and suspicion towards entire sectors of research and technological innovation (nuclear energy, GM foods, and stem cells).

These complaints naturally give rise to a technocratic solution: techno-scientific problems should be left entirely to the experts, but in order to enjoy social support, the knowledge gap between experts and non-experts should be narrowed by increasing "public understanding of science" (2–4). In short, experts know best and the disagreements would disappear as soon as the public's science deficit is taken care of. However, Bucchi argues that the technocratic response rests on a number of false or unsupported assumptions and therefore would not work. First, there is no empirical support for the assumption that increasing science communication and education increases public's awareness of techno-scientific issues, nor is it true that people's attitudes come to be more in line with those of scientists when they are better informed. In fact, there is evidence to think that at least so far as agro-food biotechnologies are concerned, the more knowledgeable people are, the more resistant they tend to be (5–6). Second, to speak of people's ignorance about science *tout court* does not make much sense: of course, in absolute terms, people know very little about the current state of science, but this is equally true of any scientist outside her own (increasingly narrow) field of expertise (cf. Collins and Evans 2007). Moreover, people's attitude toward sciences is more nuanced than categorical hostility. For example, while people in Europe, and especially in Italy, tend to resist agro-food biotechnologies, they are much more receptive to medical biotechnologies (6). Finally, the media cannot be accused of covering science issues insufficiently or misinforming the public about them; especially in the last 50 years, one can recognize in Europe a significant (and positive) increase in media coverage of science issues (9).

Hybrid forums and public participation in science and science policy

If the existing dominant framework of scientific research and policy making is inadequate, and if the technocratic response will not do, what is the alternative? While acknowledging that there is no simple answer to that question, both Bucchi's *Beyond Technocracy* and *Acting in an Uncertain World* by Michel Callon et al. emphasize the role of public participation in scientific research and policy making regarding science and issues involving techno-science in helping to overcome the limitations of the existing framework. Bucchi (50–51) defines public participation in this context as "the diversified set of situations and activities, more or less spontaneous, organized, and structured, whereby non-experts become involved in, and make their own contributions to, agenda setting, decision making, policy formation, and knowledge and innovation production processes in the techno-scientific field." What follows are some examples that will more concretely illustrate what is meant by this definition and, certainly, more can be produced (cf. Wynne 1996; Irwin and Wynne 1996).

In the early 1950s, spinal muscular atrophy (SMA) was an "orphan" disease ignored by specialists, health institutions, and pharmaceutical companies. Together with other parents whose children were suffering from the disease, the Kepper family, after losing a son to this disease, founded the *Association Française contre les Myopathies* (AFM) in 1958, and the organization has since managed to place spinal muscular atrophy on the research agenda of scientists and contributed to research on the disease. In collaboration with scientists, the AFM has collected clinical data on the disease and set up a genetic data bank. It has also organized public awareness campaigns, raised funds, and eventually established the Genethon Institute, which boasts enviable resources and facilities devoted to SMA research (Bucchi, 49–50; Callon et al., 71–74, 141–143).

In the early 1980s, residents of Woburn, Massachusetts observed an unusually high incidence of infantile leukemia. The families, who suspected that this was caused by industrial waste contamination, were assured by the health authorities that there was nothing to worry about. The families were not convinced and thus began collecting data on the frequency of the disease and its symptoms, hired specialists, filed lawsuits, and organized public campaigns. Eventually, the data they collected facilitated the discovery of "trichloroethylene syndrome," a disease caused by the polluting chemicals dumped near Woburn (Bucchi, 51; Callon et al., 77).

The most famous example of public participation in science, of course, is the AIDS activism of the 1980s and the early 1990s that had a profound impact on AIDS research, as meticulously documented in Steven Epstein's superb study, *Impure Science* (1996). By becoming "lay experts" in virology, immunology, and biostatistics, AIDS activists contributed to the clinical research protocols and treatment of AIDS, if not to its etiology, in a number of ways. They developed arguments, which eventually found a place in scientific journals, that challenged the practice of preventing patients from enrolling in more than one trial; they persuaded scientists to include women and members of racial minority groups into the clinical trials and thereby help produce more generalizable results and even change the very definition of "AIDS", and finally, they mobilized different scientific communities to cooperate with one another in new ways. The activists' impressive efforts were recognized officially when they gained representation on the advisory committees of influential institutions like the National Health Institute, the Food and Drug Administration, and the president's National Task Force on AIDS Drug Development, all of which in turn gave them more credibility and power (Epstein 1996, 330–340; cf. also Bucchi, 51; Callon et al., 83–86 and 181–188).

These and similar examples show that, in some cases, ordinary citizens can contribute significantly to the development of science, influencing the direction of scientific research by setting new agendas and raising funds, collecting useful data, stimulating cooperation among different research groups, creating new ways of disseminating scientific knowledge, and even contributing to the reformulation of scientific methodology in medical science. These contributions of ordinary citizens upend the categorical distinction between knowledgeable experts and ignorant lay persons who have nothing to offer the former, showing that ordinary citizens and experts can fruitfully interact in scientific agenda setting, knowledge production, and dissemination under certain circumstances. "Hybrid forums," as Callon et al. call them, provide such circumstances in which knowledge is coproduced; they enable ordinary people, scientists, policy makers, and possibly other stake holders to come together and discuss, deliberate, and collaborate on specific techno-scientific issues or policies and thereby make public participation in techno-science possible. They are (18)

> forums because they are open spaces where groups can come together to discuss technical options involving the collective, hybrid because the groups involved and the spokespersons claiming to represent them are heterogeneous, including experts, politicians, technicians, and laypersons who consider themselves involved. They are also hybrid because the questions and problems taken up are addressed at different levels in a variety of domains, from ethics to economic and including physiology, nuclear physics, and electromagnetism.

Research carried out in hybrid forums is called "research in the wild," which is to be contrasted with "secluded research" carried out in artificial conditions (labs) using highly idealized models. The former is not meant or expected to replace the latter; rather, the two are complementary.

Hybrid forums are especially needed, according to Callon et al. because of the increasing uncertainty in our techno-science-dependent world. Uncertainty, however, is not to be confused with risk, a notion associated with rational decision. Rational decisions can be made, more or less mechanically, in cases where risks are involved, provided we (a) have "an exhaustive list of options open to us," (b) are able to "describe the entities constituting the world presupposed by that option," and (c) that "the assessment of the significant interactions that are likely to take place between these different entities" is feasible (19). In other words, in cases of risk, we have knowledge of the possible worlds that our actions can bring about. With uncertainty, on the other hand, we do not have the necessary knowledge of the options open before us, or the possible outcomes, nor do we necessarily know the identity of the actors involved. According to Callon and his collaborators, the institutions of double delegation are unable to deal with uncertainty, specifically uncertainty concerning our knowledge of the world and uncertainty concerning the composition of the collective (119). The system of double delegation gives the task of dealing with the first uncertainty to scientists and deals with the second "by constituting itself as a political body made up of individuals (citizens) endowed with a will and definite known preferences" (121). But "when uncertainties about possible states of the world and the constitution of the collective are dominant, the procedures of delegative democracy are (…) unable to take the measure of the overflows provoked by science and technology. Other procedures of consultation and mobilization must be devised; other modes of decision making must be invented" (225). This is where hybrid forums become relevant: being dialogic, they directly challenge both aspects of the double delegation, providing room for the involvement of laypersons in different stages of research and deliberative space for articulating new identities through discussion with others (158).

Callon et al. point out that hybrid forums have implications far beyond the domain of techno-science because they can be also applied to many social issues, ranging from pension plans and internal security to the cost of health care (262). In this way, hybrid forums enrich traditional representative ("delegative") democracy, giving rise to "dialogic democracy."

Well-ordered science and democracy

The relationship between science and democracy is also the topic of Philip Kitcher's ground-breaking book *Science, Truth, and Democracy* (2001) and its sequel *Science in a Democratic Society* (2011). The most important idea that underlines both books is "well-ordered science," an ideal model of scientific inquiry organized in such a way that it promotes the collective good in a democratic society. This ideal is counterposed to the traditional image of science as a largely autonomous institution which paints scientists as a self-governing community of experts who set up scientific research agendas and determine or influence the allocation of resources to pursue them. The need for the ideal of well-ordered science does not simply arise from such standard arguments as "science is publicly funded, it affects people's lives directly and significantly, and therefore needs to be democratically controlled." It also arises from the nature of "scientific significance." According to Kitcher, science pursues not just truths but "significant" truths, and the latter are shaped through a very intricate system that bears the marks of intrinsic natural curiosity and intellectual challenge, past scientific achievements, and public benefit. This means that it is impossible to insulate scientific inquiry from historical and social contingencies (this is in effect the rejection of the myth of purity, i.e., the value-neutrality of science) and therefore that "all kinds of considerations, including moral, social, and political ideals, figure in judgments about scientific significance" (Kitcher 2001, 86). If this is the case, then they must be open to scrutiny and deliberation by all parties.

Kitcher's "well-ordered science" aims to provide an ideal framework within which this can be accomplished. It requires ideal deliberators, representative of all viewpoints in the society, to debate ideal inquiry, which consists of three phases: (1) agenda setting, (2) the pursuit of research within moral constraints, and (3) translation of the results of research into applications. Ideal deliberators first learn about and discuss the possible theoretical and practical benefits of research programs that might be pursued. In this way, their original subjective preferences become tutored. Next, again through mutual deliberation, they compile a list of the issues, with relative weights assigned to each that they would like these research programs to address. With this list in hand, they consult a disinterested expert who informs them about the probabilities that different lines of inquiry will help them realize the goals they have collectively decided on, together with the level of funding each requires. Finally, the ideal deliberators decide by consensus, or if that is not possible, by simple majority vote, which research projects are to be pursued and how much funding each is to receive. In the next phase of ideal inquiry, scientists pursue the maximally efficient strategies within the moral constraints established by ideal deliberators. The final phase of ideal inquiry reiterates the first in the translation of the results of inquiry into practical applications.

Given all this, science is well ordered if there are "institutions governing the practice of inquiry within society that *invariably* lead to investigations that *coincide* in three respects [1, 2, 3] with the judgments of ideal deliberators" (2001, 122–123). It should be noted that Kitcher does not argue that an actual deliberation of the kind described must take place for a well-ordered science; rather, the idea is "to find institutions that generate roughly the right results, even though we have no ideal deliberators to make the instantaneous decisions we hope to replicate" (2001, 123).

Science in a Democratic Society revisits the model of well-ordered science and extends it even further, so that it now includes not just the three stages of inquiry outlined above, but also the contexts of certification, application, and access. This extension is based on the notion of "public knowledge," which "exists whenever and wherever there are channels of communication through which information is transmitted from some organism in a social group to others" (86). Systems of public knowledge incorporate a division of epistemic labor enabling people and organisms to obtain knowledge from other members of their group as well as a public depository of knowledge. Kitcher discusses the evolution of such systems through history and makes the important point that the existing system of public knowledge in contemporary democracies emerged quite unplanned, without any explicit theoretical grounding regarding how it might serve the collective good:

> Where the systems of public knowledge present in the bands of Paleolithic have an evident structure and coherence, where the ancient Greece and Christianized Western Europe have a more or less explicit rationale, the elements of our own system, with institutionalized Science as a prominent part of it, have emerged contingently and haphazardly. Not much time, if any, has been devoted to wondering about how public knowledge might be shaped as to be good for democracy. We lack any convincing theoretical conception of how Science contributes to valuable goals (100).

Kitcher's model of well-ordered science is meant precisely to fill this lacuna, and his new book significantly improves upon the earlier model by drawing on the idea of a public knowledge system whose structure can be characterized in terms of four general processes: investigation, submission, certification, and transmission. Kitcher identifies the following questions that we can raise with respect to the four processes that make up systems of public knowledge: *Investigation*: Which research programs are worth pursuing? What sorts of social and moral considerations constrain them? *Submission*: Who are entitled to submit reports to the public depository of knowledge? What are their qualifications and how are they trained? What are the standards and criteria they must meet in their inquiries? *Certification*: What are the requirements for accepting and rejecting submitted reports as part of the public knowledge? *Transmission* (*application and access*): What use should be made of the public knowledge? Who has access to what part of the public depository? (90).

Contrary to the argument made in his first book, Kitcher now contends that for science to be well ordered in a society, it is not enough for that society to have institutions assigning priorities to lines of investigation that match those of the ideal deliberation. He now requires that science be well ordered also with respect to its system of certification and transmission. "The context of certification will be said to be well ordered just in case an ideal deliberation would endorse levels of proximity to the truth and of the probability of generating truth so that both the general methodological standards enunciated and the particular judgments extending those explicit standards fall within the range of reasonableness determined by those levels" (149). Such a context should be ideally transparent as well, that is, people (scientists and non-scientists alike) should be able to "recognize the methods, procedures and judgments used in certification" and find them acceptable (151). A transparent system of certification will boost confidence in the scientific community, and, by contrast, any lack of transparency will erode public trust in science and undermine its authority. Finally, all citizens must have access to the public depository, and "applications of public knowledge is well ordered just in case they would be approved by an ideal discussion under conditions of mutual engagement *at the time and in the circumstances* when the knowledge for the application becomes available" (170).

In essence, the ideal of well-ordered science is a form of "enlightened democracy," and Kitcher is sadly aware that in practice contemporary democracies often fall short of this ideal even though they approximate it in haphazard ways, but considers it important that we have a well-formulated ideal toward which we can strive. The articulation of such an ideal is all we can ask of philosophers.

This marks an orientation that is very different from that of Bucchi, Callon, and his collaborators. As social scientists, they describe and analyze actual techno-scientific issues, problems and practices that exist in today's democracies and make their recommendations accordingly. By contrast, Kitcher, as a philosopher, is more interested in developing an ideal model of science against which the existing regime can be measured. For that reason, he pays less attention to the practical question of how his ideal model can be approximated by actual institutions and practices. This is not to say, however, that he is oblivious to the matter of application. Indeed, *Science in a Democratic Society* is much more attuned to this question than *Science, Truth, and Democracy*, which was skeptical about building realistic models of well-ordered science due to the absence of empirical information required for the task (2001, 135). Kitcher now acknowledges that there are several institutions and practices, such as citizens' panels and juries, which "could give substance to his ideal model" and "serve as intermediaries between the research community and the broader public" (13; cf. also 129, 223–226). Moreover, although he does not explicitly define how to make science "well ordered" with respect to the submission component of systems of public knowledge, he does suggest that "[d]emocratic societies might well explore ways of making greater use of people who are not professional scientists," such as amateur astronomers and naturalists, and even experienced computer gamers who are contributing to the solution of the problem of protein folding (137). In this way, Kitcher encourages hybrid forums and public participation in science more generally and therefore establishes a significant point of contact between the recommendations of social scientists and practitioners of science, technology, and society. Kitcher also agrees with Bucchi and Callon that current forms of representative democracy are unable to meet the existing techno-scientific challenges and need to be made more democratic—in other words, more dialogic or deliberative.

Nevertheless, Kitcher argues that not all forms of public participation are equally valuable. He believes that deliberative polling, as pioneered by James Fishkin, is more suited to his model of well-ordered science than citizen juries. This is not only because the former provides broader representation (the latter are just too small, typically consisting of 15–20 people), but also because it does a better job of tutoring than the latter (224).

Institutions of representation

In 2004, against the recommendation of its own experts, the FDA refused to license over-the-counter sales of Plan B, an emergency contraceptive highly effective in preventing pregnancy when taken within 72 hours of unprotected sex. Since the drug is effective only within a very limited time frame, the producers of the drug had applied to the FDA for approval to make Plan B available without prescription. In the furor that ensued, Hillary Clinton, then a Democratic senator, protested that the FDA's decision was, as quoted by Mark B. Brown (1), "an unfortunate triumph of politics over science." Brown's *Science in Democracy: Expertise, Institutions, and Representation* explores representation in science and politics and offers a strong challenge to the conceptual underpinnings of such protests against the politicization of science. In both politics and science, Brown suggests, we need to move beyond a view that sees representation as correspondence. Political and scientific representation do not merely mirror an existing reality, they are "practices of mediation that engage and transform what they represent" (7). According to Brown, "moving beyond representation as correspondence … leads to a theory of democracy as a system of collective representation that continually mobilizes and transforms both nature and citizens" (8).

Following Mark Warren's account of politics, Brown maintains that for science to be politicized, there must be conflicting views over the best course of collective action and at least one party must seek to resolve the conflict through the exercise of power (188–190). This approach has the benefit of showing that science is often not political and identifying the contexts in which it makes sense to seek the democratization of scientific institutions, which Brown interprets as responding to politics through the equalization of power (190–191). There is an increasing politicization of science, however, because traditional ways of relying on expert knowledge are unable to deal with current problems. In many of the significant issues, "expert knowledge … is often incomplete and uncertain" and many of the problems are such that "they do not lend themselves to precise measurement, prediction, and control according to a single set of disciplinary standards"; it is under these circumstances that "competing interest groups can each find high-quality science advice that supports their political views," resulting in the politicization of science and loss of trust in scientists (11). Rather than lamenting the politicization of science, we should consider *how* science could be more productively politicized. Brown's response to the politicization of science, which he develops by drawing on the insights of Machiavelli, Dewey, and Latour, is to call for a diverse set of institutions providing the conditions for diverse modes of representation necessary for a democracy (192).

Brown's wide-ranging survey of the different senses of representation in both politics and science offers a corrective to the exclusive focus on deliberative institutions found in many of the works under review. According to Brown, representation has different elements, the most dominant of which are authorization, accountability, participation, deliberation, and resemblance (which he discusses at length in chapter nine). Different institutions of representation can combine these elements in different ways. For instance, while deliberative bodies such as citizens' juries can resemble the group they represent, and can be venues for deliberation, they are rarely authorized to carry out actions in the name of the groups they represent. Elected representatives, by contrast, are authorized to take action by and are accountable to the public they represent for the consequences of that action. While for Bucchi and Callon, deliberative forums are the main means of democratizing science, according to Brown, "[t]he degree to which citizens enjoy democratic representation … should be judged with respect to the ecology of institutions to which they have access," and "citizens in a representative democracy should have access to several modes of representation" including advisory bodies, citizens' juries, and elected representatives (237).

Some critical remarks

The failures of dominant science policy framework and the calls and attempts to democratize science and science policy should be set against the background of the transformation of the regime of social organization of science. The old regime was formulated vividly in Vannevar Bush's famous 1945 report, *Science—The Endless Frontier*, within which a simple division of labor between the state and the scientists was envisioned: while the former would set the research prerogatives and provide the funds, the latter would produce scientific discoveries which would then be developed into useful products by the industry for the benefit of the nation. In this mode of scientific knowledge production, universities would have high autonomy and be the major actors in producing "basic" science, the paradigmatic example of which was physics. Beginning from the mid-70s, this regime started to break down under the pressure of a number of forces, corresponding to what is called "post-industrial capitalism" or "knowledge economy," in which expert knowledge, which is above all scientific knowledge, has become a factor of production more important than labor, land, and money and of primary importance in establishing and maintaining economic competitiveness (Irzik 2007). The resulting new regime of the social organization of science is described variously as "post-academic science" (Ziman 2000), "mode-2 science" (Gibbons et al. 1994; Nowotny et al. 2001), "triple helix" (Etzkowitz 2008), and "globalized privatization regime" (Mirowski and Sent 2008). These labels reflect what might be considered rival conceptualizations of the new regime with notable differences among them, but there is no doubt that the new regime is based on the capitalization of knowledge through an ever-expanding system of intellectual property rights, the privatization of publicly funded research, and new forms of collaboration between the university, the state, and industry, giving rise to entrepreneurial universities. Knowledge production under this regime became transdisciplinary, transnational, faster, much more application- and profit-oriented, accountable, and socially distributed in the sense that actors and sites of knowledge production multiplied.

While most practitioners of STS are content to merely describe this transformation and while some even welcome it, a number of other scholars express concern that commercialization of certain segments of academic science (most notably, genetics, biomedicine, computer and information sciences, nanoscience and nanotechnology) is having a serious negative impact on scientific research and the value structure underlying it. To name a few, research interests are increasingly shaped by commercial and corporate interests rather than by scientific value or social utility; unprecedented conflicts of interests between scientists, university administrators, and businessmen pervade many areas; secrecy is spreading; the new system of intellectual property, which allows the copyrighting of computer programs and patenting of life forms such as genes, DNA, cell lines, and even whole animals, is shrinking the intellectual commons; and so on (cf., for example Krimsky 2004; Radder 2010).

It is obvious that none of these consequences are in accord with the ideal of well-ordered science, a point with which Kitcher is certainly aware of (Kitcher, 211–215; 241–242), and the democratization of science and science policy could play a significant role in limiting the commercialization of science. However, we would like to caution that the democratization of science policy by itself cannot contain the undesirable consequences of commercialization of science. As political scientists teach us, to put it bluntly, corporate interests and power can and does corrupt the proper functioning of democracy (Wolin 2008; Lessig 2011). Their point is not only the simple one of money buying politicians and policy makers; it is rather that corporate interests and power managerialize democracy and thus infuse it with the values of managerial culture, which are established within the logic of an unregulated and relentless-free market economy. This is a subtle and yet far more damaging form of corruption. A managed democracy is a travesty of democracy. If it is true, as a number of scholars argue, that a similar phenomenon is also occurring in academic science, then democratization will not, by itself, be a solution to the problems created by commercialization. On the contrary, the commercialization of science will prevent the proper functioning of democracy in science. This is just another way of saying that, for a properly functioning democracy, certain conditions must be fulfilled first, and the regulation of market forces and limiting of corporate power are perhaps the most important of them.

Techno-scientific problems faced by today's democracies are *hard* ones, involving technical, moral, political, social, epistemic, and economic dimensions. Often people are divided over which ends policies ought to work toward, and in many cases, even if the ends are agreed upon, no one, not even the experts, knows how to best achieve them. The risks and uncertainties involved are just too great. Due to the complex technical nature of the problems at hand, democratically elected governments and citizens alike must rely on the expertise of relevant communities at least to some degree, which implies that they will have to delegate some of their authority to a non-elected technocratic elite. This inevitably creates a tension, which is the impetus for hybrid forums, as we saw.

Mainstream philosophers of science have largely remained indifferent to these issues that scholars of STS have been dealing with for quite some time. This is not to say that there was no interaction between the two groups; there was, but it was confined to bitter philosophical disputes about the social constructivist picture of science endorsed by most of the STS practitioners and its alternatives defended by mainstream philosophers of science. One can have a good sense of the source of these disputes by looking at some of the philosophical discussions in Bijker et al. and Callon et al. Both groups of scholars approach their topics from a social constructivist perspective and are critical of the so-called standard view of science. Unfortunately, however, their knowledge of the "standard" philosophy of science is disappointing. Consider, for example, the following passage:

> Scientific knowledge is true knowledge. True knowledge consists of facts. Facts are neutral, objective, and clearly distinguishable from values, and are

> discovered in empirical research. In other words, we know something by measuring it. Such is the "standard image of science" (Bijker et al., 24).

Bijker et al. claim that this view, which they attribute to philosophers of science, prevailed until the 1970s. They do not mention any names other than Popper, but one supposes that logical empiricists are implicated as well. It stretches one's imagination to call the above three sentences the "standard" image of science for which people like Karl Popper, Rudolf Carnap, Otto Neurath can be held responsible, and, oddly enough, Bijker et al. are somewhat aware of this, as they call their description "slightly caricaturist" (28). Slightly? Elsewhere, they conflate "empirical" with "empiricism," thinking as if every empirical study is necessarily empiricist. After pointing out that, unlike the normative approaches of philosophy of science, STS is concerned with an empirical investigation of how the dividing line between science and non-science is drawn in actual practices, they write: "This does not mean that STS is naively empirical, as empiricism itself is a position that is no longer tenable after STS" (185, n. 23). Their poor understanding of "standard" philosophy of science infects even their own understanding of their methodology. They tell us that the theoretical perspective informing their study of Gezondheidsraad is social constructivism and "grounded theory," by which they mean "an inductive methodology for gathering, comparing, synthesizing, analyzing, and conceptualizing qualitative data for the purpose of theory development. Important elements in a grounded theory approach are an integrated collection and analysis of data, a comparative research design, an early development of categories, and a thrust toward theory development" (41). This sounds like a pretty standard empiricist methodology to us, and one wonders whether they are not contradicting themselves, given their earlier rejection of empiricism.

Similarly, Callon et al.'s work suffers from sweeping, superficial, and sometimes plainly false philosophical claims. For example, they write that the hierarchy between *episteme* and *doxa* established by Plato more than two millennia ago continues to manifest today in the hierarchy between scientific knowledge and mere opinion. They claim that this amounts to severing science from common sense and reflects itself in the philosopher's obsession to demarcate science from non-science (Callon, 100). But as any student of history of philosophy knows, there is a world of difference between Plato's notion of episteme and contemporary conceptions of scientific knowledge. Whereas the former is certain and therefore infallible, the latter is not. There is no hierarchical difference between scientific and commonsense knowledge in terms of (un)certainty, as both are fallible. Callon et al. are also mistaken about Popper's views regarding the relationship between scientific and commonsense knowledge, since for Popper one is merely a development of the other (cf., for example, Popper 1965, 18).

These examples help explain (albeit partially) the schism that exists between STS and mainstream philosophy of science. Nevertheless, whatever the philosophical deficiencies of the former from the perspective of the latter may be, STS scholarship deserves credit for persistently drawing our attention to the social context of science and opening up new areas of research.

Most of the work in philosophy of science confined to the context of justification, largely neglected questions of science policy, the use of science in society, and the influence of social factors on science. (A notable exception is of course the work of feminist philosophers of science such as Helen Longino 2002 and Kourany 2010.). This is unfortunate for a discipline that calls itself "philosophy of science," but there is reason to be hopeful, as more and more philosophers of science are taking up the program of a socially and politically engaged philosophy of science (see, for example, Douglas 2009; Radder 2010; Carrier et al. 2008). We conjecture and certainly hope that it will preoccupy philosophers of science for years to come.

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