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20 Science, Technology, and Social Movements

David Hess, Steve Breyman, Nancy Campbell, and Brian Martin

As the STS field has paid increasing attention to the problem of how to make our research relevant to the pressing ethical and policy issues of the day, researchers have examined how democratic participation in science and technology can be enhanced (e.g., Fischer, 2000; Sclove, 1995; Wynne, 1996). Social movements are one of the main pathways toward increased democratic participation, and consequently their study has come to occupy increasing attention among STS researchers. Social movements enhance public participation in scientific and technical decision-making, encourage inclusion of popular perspectives even in specialized fields, and contribute to changes in the policy-making process that favor greater participation from nongovernmental organizations and citizens generally.

As researchers informed by STS embark on studies of social movements, they draw on a well-developed body of empirical studies and theory on social movements. Although some currents of general social movement studies, in particular feminist research, exhibit a sophisticated understanding of the social shaping/social construction hypothesis that is continuous with the STS field, in general the central focus of the existing literature on social movements has not been issues of expertise, knowledge, and technology design. As a result, STS perspectives extend the social movements literature by bringing a sophisticated understanding of how the knowledge-making process works in science and how the politics of expertise and technology design play out in various political arenas.

An additional contribution that STS can make to social movement studies, and vice-versa, returns to the history of a current in the STS field that developed out of reform movements within science that sought to link scholarship to partisan and activist goals (Martin, 1993; Woodhouse et al., 2002). The "reconstructivist" current can provide a helpful corrective to both the social movement and STS literatures, which activists tend not to read or use, by posing the question of how research that follows a social justice–oriented agenda is different from research based on a scholar-directed agenda. Just as social movements shape and are shaped by their environment, so social movement researchers shape and are shaped by theirs. The key question in movements for social justice is who does the shaping?

BACKGROUND ON SOCIAL MOVEMENT THEORY

Social movements can be distinguished from several other types of collective, intentional efforts to promote or resist social change. Although all definitions need to acknowledge the fuzziness of categories, the key features are broad scope (unlike networks of activists or single campaigns), extra-institutional strategies such as protest (unlike advocacy groups), a goal of fundamental social change (unlike interest groups), and a challenge to elites or established organizations (unlike elite-based reforms and campaigns). Some social movements embody a challenge from socially or economically disenfranchised groups, but other social movements include diverse coalitions of people who share specific causes (such as breast cancer patients or open-source programmers). Likewise, social movements may seek benefits beyond the immediate interests of their membership; examples include peace movements, human rights movements, and in many cases environmental movements.

Contemporary social movement theory departs from one of three major traditions—resource mobilization theory, frame analysis, and political process/political opportunity theory—but we also address a continental, historical sociological tradition. Resource mobilization theory is the oldest of the three frameworks, and it was influential in the 1970s and 1980s in the anglophone countries (McCarthy & Zald, 1977). Resource mobilization theory focuses on strategy, agency, and organizations, and it examines problems such as building mass membership, competition among social movement organizations, and growth trajectories. From this perspective, science and technology are viewed as one of many potential resources that a movement can access. Frame analysis focuses on questions of meaning, the ways in which movement leaders must define issues to attract adherents, and the processes of frame diffusion (Benford & Snow, 2000). From the frame analysis perspective, science and technology enter into the ways in which issues are defined and made credible to potential supporters. Political process/opportunity theory draws attention to the structural conditions that make it possible for social movements to mobilize, and frequently the studies adopt a comparative perspective (Kitschelt, 1986; McAdam, 1982; Tilly, 1978). From the perspective of political opportunity structures, science and technology can shape the conditions of possibility, including risks and hazards, that create spaces for mobilization and enhance or diminish the success of a movement. In the 1990s some leading social movement researchers developed a fourth, synthetic framework that brought together resource mobilization, framing, and political opportunity structures (McAdam et al., 2001). The "contentious politics" framework shifted the focus of attention toward various processes and mechanisms that occur within and across movements and other forms of political contention.

Theorists working in a continental tradition of social movement theory, which was especially prominent in the 1980s and early 1990s, drew attention to the change of goals, targets, and repertoires of post-1960s movements (Habermas, 1987; Melucci, 1980; Touraine, 1992). Research on "new social movements" involved a debate over the extent to which the environmental, women's, gay-lesbian-bi, and related move-

ments were in some way fundamentally different from older, class-based movements. For example, some claimed that new social movements emphasized lifestyle and identity change over state-oriented political protest. Although many researchers, particularly in the anglophone tradition, were skeptical of the value of such contrasts (e.g., Pichardo, 1997), new social movement theory appealed to those seeking a language for emergent forms of collective action different from those of the modern labor movement, and some theorists developed integrated approaches (e.g., Klandermans & Tarrow 1988; Taylor & Whittier, 1992). New social movement theory also developed another distinction—between state-oriented targets and non-state targets—that has been influential. Of particular relevance to STS researchers are movements that have non-state targets such as science, medicine, and industries (Moore, 1999).

New social movement theory provides a historical perspective on social movements by suggesting that they have changed in part as a reaction to the colonization of the life-world or because the central societal conflict has shifted away from class struggle to issues of democracy (Habermas, 1987; Tourraine, 1992). However, other approaches in historical sociology, such as the risk society thesis of Beck (1999) or constructivist variants/critiques of it (Wynne, 1996), may be more suitable for understanding why science and technology issues have become increasingly salient in the social movements from the mid-twentieth century to the present. As the perception of increased risks and hazards associated with industrial technology has increased, to some degree new social movements have also become "risk movements" (Halfmann, 1999). Another explanation of the changing repertoires and targets of social movements is that neoliberal policies are undercutting the social understanding by which citizens support the state in return for services and protections such as security and health. Certainly, under neoliberal governance the state has relinquished much of the regulatory potential that would help control and reduce the risks associated with emergent technologies. Social movements, along with some courageous scientists, have stepped into the void. When employing such historical explanations, scholars also need to attend to the contingency and variability of social movement mobilizations. For example, the episodic trajectory of peace movements suggests the difficulty of developing overarching explanations for the increased salience of science and technology to social movements.

MAPPINGS OF SCIENCE, TECHNOLOGY, AND SOCIAL MOVEMENTS

The triangle of science, technology, and social movements can be mapped according to the locus of change. One locus of change involves reform movements or countermovements within scientific fields (Nowotny & Rose, 1979). Science is rarely characterized by a Kuhnian paradigm (Fuller, 2000); instead, researchers tend to be organized in networks that compete with each other for control of resources such as funding, major academic departments, and professional associations and journals. Much of the history of science documents those struggles and the displacement of one network by another, and the sociology of science has also studied such processes through research

on specialty group formation (Mullins, 1972) and the dynamics of actor-networks in science (Latour, 1988). Emergent research suggests that networks and research fields are sometimes connected to broader social movements, such as environmentally oriented reform movements within the natural sciences or feminist reform movements within primatology (Frickel, 2004a; Frickel & Moore, 2005; Haraway, 1989). Research now underway is exploring the dynamics of "scientific and intellectual reform movements" and how social movement theory can be relevant to understanding them (Frickel & Gross, 2005).

Another locus of change involves the adoption and reconfiguration of technology by social movements. Ruling elites have long used information management strategies to maintain their positions, including their monopolization of the means of communication and their suppression of challengers. In turn, social movements also develop media and communication strategies to circumvent control, and in some cases specific social movements or grassroots campaigns develop around media and information reform. Social movement organizations such as Greenpeace have specialized in media-oriented events (Dale, 1996; Mattelart, 1980; Raboy, 1984; Scalmer, 2002), and access to new information technologies, especially the Internet, has also facilitated social movement organization. Social movements' use of the Internet is one of the few areas where the much vaunted but rarely realized "democratic promise" of the Internet is at least partially borne out. Web sites and listservs never sleep; they are available twenty-four hours a day to anyone who has the equipment and infrastructure to access or post to them (Breyman, 2003). For example, the Internet has allowed the global women's movement to become a truly transnational movement, not through an inherent politics of the technology but because the Internet can be used in both instrumental and expressive ways (Moghadam, 2005; Stienstra, 2000). Although information technologies are the most widely used new technology that social movements have adopted and modified, environmental organizations have also adopted new biotechnologies to document problems such as environmental contamination. In some cases the new biotechnologies have divided movements because they create opportunities for activists in the form of new tools for documenting risks and exposures, but they also individualize and medicalize scientific research, thereby making it more difficult for activists to make claims of environmental causation (Shostak, 2004).

A third locus of change involves scientists who enter the political arena, often in collaboration with social movements, to oppose policies supported by elites and advocate alternatives. Political action by scientists has occurred throughout the twentieth century, but in the late 1960s and early 1970s various social-responsibility-in-science and radical science groups emerged, such as the British Society for Social Responsibility in Science and Science for the People in the U.S. (Beckwith, 1986; Biggins, 1978; Moore, 1996, 2006; Moore & Hala, 2002). The radical science movement's critiques covered both political and epistemological dimensions of science, drew inspiration from some revolutionary societies, and proposed an alternative: people's science (Arditti et al., 1980; Moore, 2006; Science for the People, 1974). The movement

affected STS scholarship, although the STS debt to the movement is seldom acknowledged (Martin, 1993). The tradition of social responsibility in science continues today, embodied in at least four major organizational forms (Frickel, 2004b): (1) boundary organizations (Guston, 2001), which are located in universities or government agencies and mediate scientific, political, and industrial worlds; (2) public interest science organizations (Moore, 1996, 2006), which are located outside the government and overtly aligned with social movements; (3) professional scientific associations, which defend scientists' autonomy, including that of dissident scientists, and sometimes take political positions (Moore, 1996); and (4) grassroots support organizations, which are social movement organizations, rather than organizations of scientists, that draw on scientific expertise to develop critiques of and promote alternatives to existing government and industry policies.

Scientists who work with social movements find that their relations can become tense and involve complex negotiated settlements. Some scientists seek to maintain the role of the disinterested researcher who shuns visibility and attempts to produce peer-reviewed knowledge on a controversial issue. However, even scientists who adopt such neutral strategies can rapidly find themselves at the center of unwanted and highly public controversies for which they are ill prepared (Allen, 2003, 2004). The existence of a social movement has also tended to increase the surveillance and levels of suppression of scientists whose work can aid the movement (Martin, 1999). At the same time, social movement activists sometimes view their alliances with scientists with ambivalence partly because of the independence of the scientists and the unpredictability of the research generated by scientists (Yearley, 1992). In some cases scientists may help social movements by developing research programs and technologies that have some correlation with the ends of social movements, but they may do so on the basis of a *quid pro quo* or an offer to develop a research program or technology that may not be exactly what the social movement wanted (Clarke, 1998, 2000). In short, scientists' concern with autonomy is frequently a source of tension between them and social movements.

The remainder of this essay focuses on how social movements have influenced the development of modern science and technology through epistemic and technological change (Eyerman & Jamison, 1991; Jamison, 2001a,b). Nineteenth- and twentieth-century social movements tended to flourish during periods of economic decline, yet they often contained seeds of innovation that were developed in subsequent expansionary periods (Jamison, 2006). For example, well before the most recent wave of influential social movement activity, in the early nineteenth century a branch of the labor movement, the Luddites, developed a politics of technology that challenged the imposition of capitalist control over the labor process during Britain's industrialization (Thompson, 1963; see also MacKenzie & Wajcman, 1999: part II). In contrast with the popular use of the term Luddite today to describe machine-breaking activities, the original Luddites had a comprehensive and sophisticated program (Binfield, 2004; Fox, 2002; Sale, 1995), and the Luddite tradition has influenced some contemporary STS researchers (Noble, 1993; cf. Hedman, 1989).

Table 20.1
Oppositional and Alternative Social Movements

Social Movement	Oppose Existing Technologies	Develop Alternative Science and Technology
Health	Antismoking, antivaccine	Health-care access, embodied health movements
Environmental	Antinuclear, anti-GM food, environmental justice	Organic food, recycling and remanufacturing, green chemistry
Peace/weapons	Disarmament	Nonviolent defense
Information/media	Media reform	Alternative media, open source

Social movements today continue to be challengers, producers, and sometimes advocates of science and technology. Social movements challenge research priorities, professional practices, research methods, technology development, market developments, risk assessments, and public policy by renegotiating what counts as science for the purposes of governance. They do so through various roles, including those of entrepreneurial brokers, movement intellectuals, and custodians of local knowledge (Jamison, 2001a,b). Social movement organizations develop alliances with scientists or scientific organizations, hire scientists and occasionally contract for research, and draw on their own lay and local knowledge of issues that involve science and technology (Epstein, 1996; Moore, 2005). The movements may emerge to oppose specific research agendas or technology trajectories, and they may also develop in support of alternatives (table 20.1). We focus on health, environmental, peace, and information/media movements, partly because our collective knowledge is specialized in those four areas and partly because they have mounted the clearest epistemic challenges to the direction of science and society.

HEALTH SOCIAL MOVEMENTS

Prior to the last decades of the twentieth century, when huge disease-based patient advocacy movements emerged around AIDS and breast cancer, the primary popular mobilizations in the health arena were based on increasing access to health care (e.g., health insurance and government programs) and public health works (e.g., sanitation systems). In the late twentieth century, social movements responsive to the movements for civil rights and women's rights developed wings specifically directed towards increasing access to health care, changing the quality of health care, and reforming the caring professions. For example, U.S. women mobilized to gain greater access to reproductive technologies and control over reproduction (Clarke, 1998; Wajcman, 1991). Health reform was a cornerstone of early civil rights organizing in the United States during segregation, and a "medical" civil rights movement emerged in the 1950s to push for racial integration of the medical professions as well as community health

initiatives (Smith, 1995). The women's health movement, which developed in close conjunction with the movement for sexual self-determination and the reproductive rights movement, established a clinical infrastructure that increased women's access to woman-friendly health care (Morgen, 2002).

There are many possible categorizations of health social movements (see chapter 21 in this volume); we focus here on a category that Brown & Zavestoski (2004: 685–86) have called embodied health movements, which address "disease, disability, or illness experience by challenging science on etiology, diagnosis, treatment, and prevention." Primary examples of embodied health social movements are those based on disease, such as the breast cancer movement, and those based on therapies, such as the complementary and alternative medicine (CAM) movement or the antivaccination movement. Embodied health social movements problematize the biological body, challenge existing scientific and medical knowledge, and involve collaborations between activists and scientists and health professionals (Brown et al., 2004a).

An intense focus on the biosocial body emerged in the context of the second wave women's movement, which linked self-identity, health, sexuality, and reproductive status (Boston Women's Health Book Collective, 1971). That focus, which was unique to health-related and sexual rights social movements, provided a model as well as an organizing base for HIV/AIDS, breast cancer, and other mobilizations around specific diseases. The AIDS, breast cancer, CAM, and feminist health movements developed extensive epistemic challenges to health research in arenas such as clinical trials methods, alternative therapies, and the modernization of research funding to include patient advocates (Epstein, 1996; Hess, 2004a; Treichler, 1996; Klawiter, 2002). Research on embodied health social movements has some parallels with environmental and other technology-oriented movements, so some of the findings can be generalized to other social movements where science and technology issues are salient.

Embodied health social movements often face and challenge a "dominant epidemiological paradigm" based on a biomedical model widely believed to represent consensus knowledge about a disease, its etiology, and its treatment (Zavetoski et al., 2001; see also Clarke & Olesen, 1999; Kroll-Smith & Floyd, 1997). Some movements have challenged diagnostic criteria as well as disease categories such as homosexuality (Fausto-Sterling, 2000; Terry, 1999) or schizophrenia (Crossley, 1998, 2006), and others have challenged the safety of standard preventative or therapeutic measures such as vaccines (Blume, 2006). The challenges are particularly acute in cases of presumptive diseases—such as postpartum depression (Taylor, 1996), Gulf War–related diseases (Zavestoski et al., 2001), and multiple chemical sensitivity (Dumit, 2006)—where there is no expert consensus regarding the existence of the disease, in contrast with diseases for which the existence is undisputed, such as breast cancer. In the case of breast cancer activism, the goal has centered on the less epistemically challenging issues of increasing research spending on treatment, diversifying treatment choices, developing greater access to treatment choices (Casamayou, 2001; Lerner, 2001) and, to a lesser extent, promoting prevention through nutrition and reduced exposure to carcinogenic chemicals (Epstein et al., 1998). Such activism has yielded significant

changes in the "regimes of practice" that breast cancer patients experience in the clinical setting (Klawiter, 2004). The medicalization of breast cancer prevention has embroiled the movement in scientific and regulatory controversies over the value of the use of drugs such as tamoxifen in "at risk" healthy women. Analysis of social movement action on this issue has necessitated a broadened theoretical framework that includes the pharmaceutical industry, regulatory policy, design controversies over clinical trials, clinical standards differences, and the doctor-patient relationship (Fosket, 2004; Klawiter, 2002; Wooddell, 2004).

The various movements for complementary and alternative medicine usually involve scientific controversies over the etiology and treatment of recognized diseases, but they provoke intense political confrontations with the medical profession, regulators, and medical research community (Johnston, 2004). The movement for CAM cancer therapies in the United States exhibits two general features shared with other pro- or alternative "technology- and product-oriented movements," such as movements for sustainable agriculture, renewable energy, and open source software: (1) opposition to a specific technology or product combined with support for an alternative, and (2) a mix of grassroots social movement and advocacy organizations with professional and/or industrial reform movements that involve scientists and/or entrepreneurs (Hess, 2005, 2007). Professional reform movements generally do not use extra-institutional strategies, but they are often sympathetic with social movements that do, even if they operate at some distance from them (Frickel, 2004a; Hoffman, 1989; Woodhouse & Breyman, 2005). The organizational mixture of the CAM movement is one factor behind the medical mainstream's range of organizational responses, which include avoidance, compromise, acquiescence, manipulation, and defiance (Goldner, 2004).

Over time, many health social movements, like other social movements, undergo diversification and transformation. Sometimes countermovements develop, or movements emerge on both sides of a long-standing controversy, as in the case of pro- and anti-fluoridation networks (Martin, 1991; McNeil, 1957). Often movements divide into accommodationist and radical wings; the former organizations tend toward professionalized advocacy rather than grassroots activism. The pharmaceutical industry has provided significant funding for U.S. breast cancer organizations, leading to the possibility of organizational capture, while at the same time the growth of private breast cancer research foundations has created opportunities for, and potential conflicts among, lay funders and scientist researchers (Gibbon, 2003).

Another effect of the diversification and transformation of health social movements is that in some cases, such as the AIDS movement, social movement leaders undergo an "expertification" process (Epstein, 1996). The crossing of lay-expert divisions has continued to attract attention in the study of health social movements. In the U.S. breast cancer movement, the diversification of organizations across class and ethnic divisions was accompanied by organizational conflict between long-standing staff, who acquired various forms of expertise, and newcomers, who possessed new and dif-

ferent knowledges (Hoffman, 2004). In interactions with scientists, health social movement organizations play a role of discriminating between science and nonscience that is similar to the state-funded boundary organizations described by Guston (2001), but the organizations push the boundaries of science in new directions and challenge identities and interests on both sides of the lay-expert divide (Brown et al., 2004a; Ganchoff, 2004). Those interactions emphasize the mutual learning that occurs among patients, researchers, and clinicians in "reflexive organization" (Rabeharisoa & Callon, 2004). Some activists make the transition from the "narrow-band" competence of lay expertise, which is largely "interactional" expertise in Collins's terms (2002), by assembling networks of researchers to produce biomedical knowledge or by obtaining more education so that they become professional researchers (Hess, 2004a). Institutionally and historically, in the United States a process of "medical modernization"—which recognizes the legitimacy of participation from patient representatives in funding decisions—has tended to replace the previous strategy of suppression of dissident scientist/activist coalitions that coincided with a paternalistic, transmission model of biomedical knowledge (Hess, 2004a).

In addition to diversifying lay-expert divisions through hybridization, health social movements have also undergone fragmentation in social composition that has typically accompanied growth and alliances across social categories. The original AIDS movement in the United States was largely middle-class, male, and white, but over time it struggled with new issues as the social address opened up to African Americans and women (Epstein, 1996). Likewise, antismoking campaigns have struggled with the politics of extension to ethnic communities in California and with the politics of national cultural differences as the campaigns extended outward from the English-speaking countries (Reid, 2005). In some cases, antitobacco and other antidrug movements have also become linked to other social justice issues such as structural inequality and gender equity (Campbell, 2000; Nathanson, 1999; Oaks, 2001). The heterogeneity of participants in the U.S. disability rights and reproductive rights movements led to the formation of "divided interests" in the reproductive technologies arena (Rapp, 1999). Although health social movements can fracture around gender, racial-ethnic categories, sexualities, categories of age and ability, and class-based identities, recognition of differences and health disparities can also stimulate greater attention to "culturally competent" health care provision; gender, age, and ability equity; and the inclusion of formerly stigmatized identities such as sex workers and persons with alcoholism, drug addiction, and AIDS (Campbell, 2000; Stoller, 1998). Social movements have exerted pressure for mechanisms to ensure greater accountability among "markets" composed of users, consumers, and patients and the government agencies, health care providers, scientific researchers, and technological designers that supply these markets (Clarke, 1998; Oudshoorn & Pinch, 2003). Finally, movements to promote or limit the use of specific reproductive technologies arise to address the diversity of power-laden cultural contexts in which health-care decisions are made (Briggs, 2003; Sen & Snow, 1994).

ENVIRONMENTAL MOVEMENTS

Many scholars now recognize that *the* environmental movement is, like other social movement categories, a diverse sociological entity. Historical studies generally delineate a major transition during the 1960s from a focus on preservation and conservation to industrial pollution, and in the United States and some other countries during the 1980s there was a second shift to a focus on environmental justice (Dowie, 1995; Gottlieb, 1993; Kline, 1997). Organizations tend to focus on one of the three types of environmental action, but many have mixed goals that reflect the influence of all three waves. In many countries, striking divisions have emerged between the government-oriented, insider, advocacy organizations and the proliferation of struggles at the grassroots level around environmental justice. There is also tremendous diversity across world regions and even within wealthy Western regions. For example, in Europe there has been a relatively stronger policy articulation of environmental concerns than in the United States, where green or left-wing parties have been much more marginalized in electoral politics.

Of the various opposition movements within the broader environmental movement that target mainstream science and technology, the worldwide movements against nuclear power and genetically modified (GM) food provide two examples of how movements challenge scientific knowledge and emergent technologies, particularly around issues of risk and safety. Activists have proceeded, independently of STS critiques of technological determinism, on the assumption that nuclear power is not inevitable (Smith & Marx, 1994; Winner, 1977). Activists and STS scholars alike developed a critique of the politics of design around nuclear power: it is expensive, potentially dangerous, dependent on experts, and thus antagonistic to democratic society (Patterson, 1977; Perin, 2004; Winner, 1986; Woodhouse & Morone 1988). Likewise, campaigns against GM foods have challenged industrial, scientific, and government assurances of safety (Bauer & Gaskell, 2002; Purdue, 2000). Although activists have sometimes been drawn into a debate with experts over the risks of GM food in Europe, India, and other world regions, they also utilize frames beyond the science of risk and safety. For example, they frequently frame the debate and protest events around concerns with globalization and U.S. food hegemony (Harper, 2004; Heller, 2001; Shiva, 2000). In addition to the comparative effectiveness of frames of food politics, differences in industrial structure help account for the different degrees of success of movements against GM food (Schurman, 2004).

Environmental movements not only challenge the epistemic assurances of governments and scientists but also encourage the development of alternatives. In the 1970s, proponents of appropriate technology—sometimes also called alternative technology or intermediate technology—argued that technologies embodied elite political values, and they developed and promoted technologies appropriate for communities (Kleiman, forthcoming). In poorer countries, appropriate technology ideally required low capital; used local resources; was labor intensive and small scale; could be con-

trolled by villagers; and could be controlled, produced, and modified by villagers in ways that brought people together and were environmentally sound (Darrow & Saxenian, 1986). There have been many debates about the politics of appropriate technology (Boyle et al., 1976; Illich, 1973; Kleiman, forthcoming; Lovins, 1977; Riedijk, 1986; Willoughby, 1990); the key point is that the movement drew attention to the politics of technology design (Winner, 1986). The legacy of the appropriate technology movement today is, in developing countries, one of low-tech, locally controlled development projects, and, in wealthy countries, advocacy around renewable energy and sustainable agriculture.

Renewable energy and sustainable agriculture gradually grew from social movements into industries with associated scientific research programs. For example, wind energy in Denmark was once a social movement, but over time it was mainstreamed (Jamison et al., 1990). As the control of design shifted from lay users to professionals oriented toward industrial production on wind farms, the scale of the technology increased (Jørgensen and Karnøe, 1995). The transformations of technology design involve a process of "complementarization" or redesign that adapted alternative, movement-based technologies to fit into existing portfolios of industrial production technologies and industry products (Hess, 2005). Likewise, the organic food movement developed an alternative form of scientific knowledge that challenged dominant research programs and combined lay-expert knowledges (Hassanein, 1999). Over time, organic food production underwent industrialization, and a portion of the movement became mainstreamed, but the grassroots side of the movement regrouped around the antiglobalization politics of local, sustainable agriculture (Guthman, 2004; Hess, 2004b). The organic food movement also played a significant role in the mobilization against GM food, another indication of the fluidity of movements that oppose some forms of technology and support alternatives for other forms (Reed, 2002). Similar changes occurred with the recycling movement, which in some places began as a grassroots movement and was subsequently incorporated into the waste industry (Pellow, 2002; Scheinberg, 2003; Weinberg et al., 2000).

More generally, the environmental movement underwent a change from activism to brokerage, and protest politics shifted toward the development of green business networks (Jamison, 2001b). By the 1990s, a new polarization had also emerged between the ecological modernization frame of green business and the environmental justice orientation of grassroots activists (Hård & Jamison, 2005; Mol, 2000; Pellow 2002; Pellow & Park 2002). As environmentalism underwent professionalization and industrialization, "object conflicts" developed over definitions of what the technology/product should be. The conflicts took place in three arenas: research agendas, consumer decisions and loyalties, and standards set by regulatory agencies or industrial groups (Hess, 2004b). Clashes over regulatory standards can also involve a movement's environmental values versus the health and safety values of state agencies (Henderson, 2006). The processes of institutionalizing environmental social movement goals has also led to a "systematic discounting" of efforts by activists and advocates to build corporate responsibility goals into legislation and corporate policies, as

occurred in the case of the failure to respond completely to the calls for reform in the wake of the Bhopal disaster (Fortun, 2001).

In addition to problems that occur with industrialization, activists also encounter problems in their efforts to work with scientists and other social movements. As activists and environmental professionals work together, many have become convinced of the need for heterogeneity in environmental problem-solving models (Di Chiro, 2003, 2004). By recognizing the different bases of lay and scientific knowledges, activists and scientists may develop deliberative processes that allow for synergy between lay and expert knowledges (Breyman, 1993; Brown & Mikkelsen, 1990; Carson & Martin, 2002; Fischer, 2000). In building cross-movement bridges, issues of expertise and design have been salient in the relations between environmental justice and sustainability groups (Agyeman et al., 2003), civil rights and urban transportation design reformers (Bullard et al., 2004), and labor and environmental coalitions (Burgmann & Burgmann, 1998; Gould et al., 2004; Grossman & Daneker, 1979; Mundey, 1981; Roddewig, 1978; Obach, 2002; Rose, 2000). Likewise, the environmental breast cancer movement (a wing of the larger breast cancer movement that focuses on environmental factors such as endocrine-disrupting chemicals) has allied with the environmental justice movement (Ley, forthcoming). The two movements may each be in a "steering" or "guiding" role with respect to the broader breast cancer and environmental movements of which they are a part (Brown et al., 2004b). Likewise, food-based politics provide a point of connection between health and environmental movements (Cohen, 2005; Hess, 2002).

PEACE, INFORMATION, AND OTHER MOVEMENTS

Although the epistemic politics of health and environmental movements have dominated the intellectual landscape for STS-related scholarship, other movements have engaged in epistemic challenges to science and technology. For example, with the increasing role of technology in warfare, peace movements have grappled with issues of expertise, technology design, and antiwar tactics. There has been some study of the social shaping of military technologies, for example, the machine gun (Ellis, 1975), airplanes (Schatzberg, 1994), missile guidance systems (MacKenzie & Spinardi, 1995), and computing (Edwards, 1996). Particular types of weapons, especially those that are deemed inhumane, have long generated special disgust and consequent attempts to abolish or regulate them. Examples include antipersonnel weapons such as dumdum bullets and land mines, biological and chemical weapons, nuclear weapons, and "nonlethal" weapons (Gusterson, 1996; Prokosch, 1995; Rappert, 2003).

Of opposition efforts, antinuclear weapons movements have been most prominent. Some scientists raised concerns about nuclear weapons from the very beginning, with the *Bulletin of the Atomic Scientists* serving as an ongoing platform for debate and critique. Popular opposition expanded in the late 1950s with concerns about radioactive fallout. Official reassurances were challenged by a few dissident scientists, of whom Linus Pauling (1958) was most prominent during that period. The movement faded

in the early 1960s, especially following the 1963 Partial Test Ban Treaty. Beginning about 1979, a second phase of the global antinuclear weapons movement blossomed, with an associated expansion of social analysis. In the 1980s, a number of scientists and writers painted doomsday scenarios, including "nuclear winter," and concluded that the survival of the human species could not be guaranteed (Ehrlich et al., 1985; Schell, 1982). This is a prominent example of science deployed in service of a social movement; the scientists presumed that they had a special mandate to intervene in policy debates because they had access to scientific knowledge (Eden, 2004; Martin, 1988). The debate about nuclear winter vanished from scientific and public sight after the end of the Cold War, despite the persistence of nuclear arsenals, showing the way that international affairs, as well as social movements, can affect research agendas and the saliency of policy issues (Breyman, 1997).

The nonviolence movement is in part a component of the peace movement, but it has also influenced other social movements such as the environmental, antiracist, and feminist movements. Nonviolent action—such as noncooperation, strikes, boycotts, fasts, and setting up alternative institutions—challenges oppressive systems and offers an alternative to violence. In relation to peace issues, the nonviolence movement has focused on social and psychological dimensions of resistance to oppression and aggression. Nonviolence provides an alternative agenda for research and development, for example in the design of communication systems and technological systems (such as energy, industry, and agriculture) for survival in the case of attack (Martin, 1997, 2001). A nonviolence agenda points both to different technologies—for example, network communication forms such as telephone, fax, and e-mail rather than centralized media such as television and radio, usually the first targets in military coups—and to different, more participatory research methods. Social movements have not adopted this approach explicitly, but in many cases they are proceeding along parallel lines. For example, the appropriate technology movement sets criteria for technology that mesh perfectly with technological specifications for nonviolent resistance.

Information and media reform movements also target issues of technology design. At the most basic level, literacy campaigns have been a constant of some social movement agendas, and basic literacy education continues to be a site for contesting class domination among the poor (Freire, 1972). Where compulsory schooling is the norm, adult education is a more common source for information-oriented resistance (Lovett et al., 1983). However, literacy campaigns can be a double-edged sword. For example, the emerging STS-inspired research on the digital divide documents how computer illiteracy has been overestimated, and in fact many persons with limited income utilize information-technology skills in their work. For them, the role of computer-based surveillance is a more salient issue (Eubanks, 2006; Monahan, 2005, 2006).

Another strand of information and social movements focuses on media reform. Opposition movements stretch back to the commercialization of U.S. radio in the 1920s and to the development of public broadcasting in subsequent decades, the history for which varies significantly across countries (McChesney, 1993). In the 1990s, a new wave of media reform took off when an international coalition of church,

education, and media-related NGOs joined together to protest the increasing concentration and commercialization of the mass media (Free Press, 2003; Goodale, 1996). Alternative media also has a long history, but the 1960s social movements spurred the creation of alternative radio and print media, often oriented to local markets and self-identified as part of a "community media movement" (Downing, 1984; Pierce, 2003). The organizations have been subject to problems of burn-out or bureaucratization, as well as a drift toward commercialization (Castells, 2001; McChesney, 2001). Social movement activists have often made hopeful statements about the Internet, and some have suggested that its design, which is interactive and decentralized in contrast with broadcast and print media, is inherently liberatory. However, the Internet is also subject to political control (Privacy International and the GreenNet Educational Trust, 2003), and the relationship between the Internet and democracy remains a topic of empirical study (Fortier, 2001; Kalathil & Boas, 2003). Current debates on the democratic potential of the Internet were preceded by a prior generation of debates on "computerization movements." Some touted the advantages of widespread computer use in the workplace, home, and schools, a view that challenges the prevalent idea that the introduction of computing was entirely driven by technical or market considerations. In contrast, other groups, including representatives of traditional social movements, developed a dystopian view of the computer, such as environmentalists who saw them as sources of alienation (Hakken & Andrews, 1993; Kling & Iacono, 1988; Mander, 1984).

In the 1980s and 1990s, some leaders of the 1960s counterculture helped rethink the computer from a symbol of the "system" to a symbol of liberation, and those ideas spread through a network of people around the *Whole Earth Catalog* (Turner, 2005) as well as in experiments around community informatics (Cohill & Kavenaugh, 2000; Gurstein, 2000). The community informatics projects faced problems of organizational viability that were similar to the volunteer media experiments of community radio and alternative newspapers. To survive, some of the community informatics projects institutionalized as nonprofit organizations and sought the support of local governments or foundations (Castells, 2001; Schuler, 2000). A second wave of voluntary, Internet-based alternative organizations emerged during the Seattle demonstrations against the World Trade Organization in 1999, when the Independent Media Centers (IMC), or Indymedia, movement was launched (Morris, 2004; Pierce, 2003). The computer programmers who designed Indymedia software were motivated by a desire to construct a system that allowed open access for publishing while restricting the potential for central control, and its ethic of open access had some similarities to two other Internet-based reform movements: open source and open content.

Unlike the Indymedia movement and community informatics, the "free/libre open source software" (FLOSS) movement is more oriented toward the politics of software design, and its alternative code can be used by governments, corporations, and activists alike. The reform movement mobilizes volunteer programmers partly by offering a system of credit and recognition that has similarities to the scientific reward system (Kelty, 2001). One of the key transitions (and divisions) in the FLOSS move-

ment's history was its reframing from the term "free software," associated with activist Richard Stallman, to "open source" and a more business-oriented perspective (Bretthauer, 2002). The best-known product is the operating system Linux, which has become competitive with commercial programs (Moody, 2002; Weber, 2004). As commercialization has progressed, object conflicts have developed around maintaining the original GNU license structure versus more commercially oriented license structures developed by proprietary software firms such as Microsoft (Hess, 2005). In the open-content movement (the provision of free information in the public domain, including scientific journal articles), conflicts have developed between copyright holders, especially media and publishing companies, on the one side and scientists, librarians, hackers, and consumers on the other (Poynder, 2004). Hackers also challenge emergent digital global property rights regimes through the development of code that allows users to swap files or break encryption codes. They view their work as civil disobedience, given that corporations and governments have prosecuted their activism as criminal violations of intellectual property laws (Postigo, 2005).

CONCLUSIONS

Social movement organizations that emerge from grassroots grievances frequently challenge consensus scientific knowledge, official assessments of safety and risk, and the technology trajectories developed by elites in industry and the state. They seek alliances with scientists and already established interest groups as well as with entrepreneurs and the business sector. Yet, relations among social movements, scientific research networks, and business organizations are frequently beset by conflict as much as cooperation. At a technical level, the success of alternative technologies and products comes at the cost of a complementarization process in which the more politically charged design elements and social organizational innovations drop out. At the discursive level, social movements must often pitch critical alternatives in a language that reflects the dominant "governing mentalities" that prevail in a particular policy arena in order to be heard as credible (Campbell, 2000). As a result, some social movements that seek changes in science and technology issues often find their goals incorporated at a technical level but at a cost of severing the technical goals from the broader political and justice goals. In summary, social movements, scientists, and entrepreneurs are uneasy allies and partners, and alliances sometimes shift into conflict and hostility—or they simply drift in different directions—even as they generate new research programs, technologies, and material culture.

Regarding topics for further exploration of the uneasy partnerships involved in social movements, science, and technology, several questions emerge from our review, among them the following: Is it true that issues of science and technology have become more salient in social movements, and, if so, what are the historical explanations? How does the science, technology, and movement interface vary across not only time but also space? To what extent do comparative differences become less important as movements become more globalized? How do science and technology

issues work in conservative and antidemocratic movements (which were not the focus of this essay)?

Before charting an agenda for the study of STS and social movements, we suggest that it would be valuable to step back and return to the broader issue of science, technology, and democracy that was raised at the beginning of this essay. If mapping social movements is to be more than an academic enterprise, if that work is meant to contribute to the success of democratic social movements, then the first question might be how can the study of science, technology, and social movements be configured in a way that is of value to activists? Does the goal require a shift in methods, such as moving toward participant-action research? Those questions return to one of the originary strands of STS, when portions of the interdisciplinary field were closely connected to scientific and technological reform movements.

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