Science and Technology in a Multicultural and Postcolonial World:

Gender Issues

1. Introduction. The method of western modern sciences was supposed to generate value-neutral, objective, disinterested facts about nature's order. Yet feminist analyses have shown how these methods and facts have been permeated by gendered values and interests. To be sure, this is so to different degrees and in different ways for different sciences.[1] Nevertheless, standard ways of conceptualizing and practicing scientific method appear to leave research incapable of achieving cultural neutrality in principle, not just in practice. Moreover, gender analyses have shown how in at least some research contexts cultural neutrality is undesirable; culture is also productive of knowledge, not just an obstacle to it. Who does science can influence what we will know about the world.

This work has been immensely controversial from the very beginning. One reason is that Western modern sciences and technologies (WMST) and their logics are central to ideals of modernity, democracy, progress, and "civilization." These ideals help to constitute individuals' and social institutions' identities and conceptions of what are legitimate and important missions. Challenges to these ideals on behalf of women can appear impertinent, arrogant, and wrong-headed, and even deeply disturbing. Yet these gender perspectives on science have

become increasingly influential, shaping even national and international policy agendas in such areas as health, the environment, science education, and Third World development policies. In this way they have become a significant force in current renegotiations of ideals of modernity, democracy, progress and "civilization."

Scientific and technological change is always a site for political struggle. Which groups will receive the benefits and which will bear the costs of such changes? Moreover, when gender relations are renegotiated, other significant kinds of social relations always also are at issue, such as class, race, sexuality, and empire. Thus gender perspectives on scientific and technological change always have implications for such other social struggles.

The sections below will identify central themes from the European and North American accounts and from accounts that start off from women's lives in the so-called developing world (from the "North" and the "South"[2]). The concluding section proposes clues to several directions that future work in these fields may well pursue.

One caution before turning to these projects. There is no single, monolithic feminism or, thus, preferred way to do gender analyses. The terms "feminism" and "gender" both have diverse meanings and uses, and the choices of when to use which term and what to mean by it are always controversial. As a start, we can note that "gender" can be used in two ways. It can refer to the objects of empirical study that are "out there" prior to

inquirers' observation of them, that is to men and women and to gendered structural and symbolic social relations, or to the analytic framework that researchers bring to their inquiries--to the study of how gendered individuals, social structures, and systems of meaning are socially produced. Both foci have been important to feminist science and technology studies. As indicated, in both cases gender should be understood as always in a mutually constituting relationship with class, race, ethnicity, sexuality and other structural and symbolic social systems.

2. Northern feminist science and technology studies (STS). In Europe and the United States these analyses have been produced under the influence of more than three decades of the women's movement and, during the same period, of post-positivist social studies of science and technology. The latter have sought to display the integrity of moments in modern science's past with their social eras instead of only with their intellectual histories, as historian Thomas Kuhn put the point. (Kuhn 1970) Thus feminist analyses show how modern sciences have been integrated with the gender relations of their historic eras. The focus here will be on identifying a few main themes within five topics that have proved especially fruitful, if disheartening: sexist and androcentric discrimination through the processes and results of scientific research, sciences' social structures, science education, technology design, and in epistemologies and philosophies of science.

Scientific sexism. Our Bodies, Ourselves: The Boston Women's Health Guide was published in 1970. This pioneering start to the women's health movement revealed the ignorance that had directed physicians'interactions with patients as well as policies of the medical-industrial complex. Contrary to conventional warnings about the bad effects of politics on the growth of knowledge, it took a coalition of feminist scientists and political activists to launch this new focus of research. Evidently some kinds of politics can advance the growth of knowledge.[3] At the same time, feminist biologists began to criticize sociobiology's claims about the naturalness of women's subordination to male domination. One group organized "genes and gender" programs at annual meetings of the American Association for the Advancement of Science, and produced some of the first readers on gender and science. (Tobach and Rosoff 1978, 1979, 1981, 1984) Feminist biologists and the women's health movement have remained powerful forces in feminist science studies. (Fausto-Sterling 1994/1985, Clarke 2000)

Meanwhile criticisms of sexist and androcentric methods and results of research in history and the social sciences had also begun to appear. (Harding 1987) These provided resources for public policy struggles. For example, the U.S. legal system slowly was forced to recognize the necessity of taking a feminist position on rape, domestic abuse, sexual harassment, women's "equal worth" at work, and the "rational woman" standard in liability cases. Social science research figured in struggles over lesbian mothers, "deadbeat dads", and wages or

recompense for women's housework. Equally significant were the ways this work revealed the empirical and theoretical inadequacies of social theories in every discipline. Since the natural sciences have social histories, this work has also influenced gender-focused histories, sociologies, and philosophies of science and technology. It has even shaped studies of sciences one might presume to be most immune to cultural influences, such as physics and astronomy at the origins of modern science (Merchant 1980, Schiebinger 1989, 1993), Boyle's chemistry (Potter 2000), early Twentieth Century physics and biology (Keller 1984), contemporary high-energy physics (Traweek 1988), and molecular biology (Spanier 1995?).

Discriminatory social structures. Beginning in the 19th Century, critics had decried discrimination against girls and women in the social structure of science, mathematics, medicine, and engineering. (Rossiter 1982, 1995, Schiebinger 1989, 1993) These struggles were far from over in the 1970's. The formation of women's caucuses in natural and social science disciplines and of women's organizations in universities and in industry carried on these campaigns.

Today, when the formal barriers against women's access to science and engineering education, degrees, publication, lab appointments, and membership in scientific societies finally are illegal in Europe, the U.S., and many other parts of the world, it remains challenging to identify and then eliminate powerful continuing sources of discrimination.[4] The MIT Women and Science Report (Massachusetts Institute of Technology 1999) created

shock waves in many elite science and engineering departments as it revealed the ways in which society's gender norms, including expectations of women's obligations to family, continue to discriminate in different ways against both senior and junior MIT women faculty. In the developing world, the lack of economic resources and social welfare services for families insures that girls' domestic obligations will cause them to drop out of school long before they could gain any science education or, for many, even achieve basic literacy. On the other hand, many countries outside the North have far higher proportions of women on science faculties and national science policy agencies than does the U.S. or Western European nations. This isn't aways the result of feminist activism. Instead, to understand the causes of such variation requires close attention to divere factors, including national science and technology policy, and different opportunities available to nations' science projects in the global political economy. (Harding and McGregor 1996, Koblitz 1996)[5]

Science education. Early equity approaches to remedying girls' and women's underrepresentation in the sciences and engineering assumed that girls and women were deficient in the abilities and talents necessary to compete for careers in these fields. They had "math anxiety," didn't like dissecting frogs, and were lacking in analytic skills. More recent work shifted the focus to deficiencies in pedagogy, curriculum, and the goals of both science and science education. (Brickhouse 1994, Kelly 1981, 1987, Rosser 1986, 1993) Perhaps most illuminating has

been the emergence of a critical focus on the masculinized culture of science and science education, and on how "doing science" is a way of constituting certain kinds of social identity. While the identities formed through doing science have conventionally been masculine ones, girls have also used their love of doing science to constitute distinctive feminine identities, and in different ways for girls of different racial and ethnic identities. (Brickhouse 2001) This work on education offers resources to historians and sociologists of science more generally. Meanwhile, there is reason to rejoice that equity efforts have paid off, at least in many science classrooms,[6] though little such success is yet visible in most fields of professional science education. Moreover, equity is just one of the goals of feminist work in science education.[7] For example, in a more comprehensive sense of the term, feminists have drawn attention to the "scientific illiteracy" of elites about the gender projects of scientific research and its various institutions, from science and technology museums to National Geographic and "Discovery" TV programs.

Gender and Technology. From the beginning of the women's movement in the 1970's, there were projects intended to gain access for women to technological skills and practices from which they had been excluded. For example, courses on car maintenance and on repairing household technologies were offered through the new women's centers. Women were encouraged to enter male territories in the construction trades and the emerging

information technologies, as well as agriculture and engineering schools. Accounts of women inventors appeared.

But it took the arrival of social constructivist analyses in technology studies to open the way for deeper understandings of how technologies themselves were gendered. First, the object of study shifted from the nature of the "hardware" itself to the nature and processes of technological change, processes that are usually sites of interlocked class, race, empire, culture, and, yes, gender struggles, and thus participate in the emergence of new social formations. Second, such change was understood to have three components: changes in "hardware" (the conventional meaning of technology), in the skills required to design, use, and repair the hardware, and in the organization of labor with such skills. Who did and who didn't get to design, use, and repair cars, washing machines, and computers? Thus, third, explanations of technological change require attention to how class, race, culture, and gender projects of the larger social formations instigate technological change. (Cockburn 1985, Noble, 1995, Wajcman 1991) Moreover, scientific methods are themselves technologies of knowledge production. In this way social aspects of technological change permeate sciences' cognitive, technical cores.[8]

Epistemological androcentrism. Epistemologies of scientific knowledge have been presumed to be as culturally-neutral as the physics and chemistry achievements that they try to explain. Yet it was normal scientific assumptions and practices through which sexist and androcentric accounts were

legitimated as objective ones--as "good biology," sociology or psychology. The very standards of science appear to be sexist and androcentric. Certainly it is annoying to encounter overt and covert sexism in the behaviors of individual scientists. But these individual and intended behaviors are not the cause of the sexist and androcentric beliefs and practices identified above. Instead, it is institutional assumptions, practices, and cultures, larger social assumptions, and "civilizational" or philosophic standards that create and maintain the legitimacy of sexist and androcentric scientific accounts.[9] Feminists have had to revise and strengthen standards for the objectivity, rationality, and good methods of the sciences. Here I point to two such projects focused on objectivity and good methods.

How can a science maximize objectivity when the adequacy of its assumptions and practices is measured in terms of the latter's distance from "the feminine," from characteristics associated with women or femininity? Familiar exemplary logics of scientific research consistently prescribe the masculine side (first below) of a series of gendered dualisms: objectivity vs. subjectivity, rationality vs. irrationality and emotionality, mind vs. matter or body, "hard" natural sciences vs. "soft" social sciences.[10] Feminist scholars have produced critical accounts of such standards, and proposals for both overtly feminine and more effectively gender-neutral standards.[11]

Another focus has been to improve the exemplary methods, in the sense of epistemologies, of research. Feminist standpoint epistemologies are perhaps the most influential of these,

emerging independently from sociologists of knowledge, political philosophers, and philosophers of science, and providing a comprehensive political/epistemological framework for thinking about what and how knowledge gets produced and legitimated.[12] As a "rational reconstruction" it proposes that feminist research has succeeded in producing such empirically sound and theoretically more comprehensive analyses in natural and social sciences by starting off thinking about its projects "from women's lives" instead of from the dominant conceptual frameworks of the disciplines that are themselves grounded in the lives of those men who design and manage social institutions and their practices. It has insisted that all knowledge is "situated knowledge," in Donna Haraway's phrase (Haraway 1991) The disciplines are part of the apparatus of "ruling" in modern, Western kinds of societies, as sociologist Dorothy Smith (1987) puts the point. They work up the complex and confusing phenomena of daily life into categories and causal maps such that administrators can manage legal, economic, welfare, educational, medical, and other agencies and institutions. Women as well as men from exploited groups have been excluded from designing and managing both those institutions and the disciplinary projects that service them.

Thus the lives of women and of other exploited groups can continue to provide a valuable starting point or subject position from which research can be designed to reveal "the conceptual practices of power" in Smith's (1990a) phrase. Note that though standpoint approaches start off thought from the

lives of women or and other exploited groups, their point is to "study up." What is distinctive about them is not that they study women, but that they provide "institutional ethnographies" of, for example, the legal mind (MacKinnon 1982), or disciplinary frameworks in sociology (Collins 1991/1999, Smith 1987, 1990a, 1990b), political philosophy (Hartsock 1983), or medical/health research (Martin 1987).

In three decades, feminist critical perspectives on WMST have become significant players in more general projects of rethinking modernity, democracy, and social progress. Yet they remain Eurocentric and "part of the problem" for the majority of the world's citizens to the extent that they fail to engage with critical perspectives provided by multicultural and postcolonial science and technology studies, to which we now turn.

3. Southern feminist STS. Women in the South want from science much that women in the North value, from improved access to appropriate science and technology education and work to better access to effective health care and workplace technologies, and to safe and flourishing natural environments. (Gender Working Group 1995, Kettel 1995, Braidotti 1994, Harding and McGregor 1996, Shiva 1989, L. Smith 1999.) Moreover, WMST are tightly linked to ideals in the South, too, of modernity, democracy and social progress. For many citizens of the South, as in the North, to get to think in the terms of modern, international sciences and engineering is to enter high status global conversations, to become citizens of the world. WMS methods and the facts they produce are often experienced as a

welcome alternative to traditional discriminatory and just plain ineffectual beliefs and practices in the developing world.

Yet much Southern science and technology thinking, including feminist work, occurs in the context of three science and technology movements that emerged after World War II. These expand the horizons of everyone's understandings of sciences around the globe, and of the ideological and material conditions for the successes of WMST themselves. These are the comparative ethnoscience movement, the "science and empires" movement, and the post-colonial criticisms of Northern development policies, practices and philosophies.[13]

The comparative ethnoscience movement has had two goals. One is to show the local, cultural features of European sciences and technologies by analyzing them with the methods anthropologists had developed to study the production of knowledge in non-Western societies. Undermining the "exceptionalist" assumption that only ignorance and false beliefs, not WMST's production of truths, were suitable objects for social explanation, these accounts insisted on methodological symmetry in the study of WMST and other local knowledge systems, as they put the point. In effect, they pursued on a postcolonial global map historian Thomas Kuhn's project of showing the integrity of moments in WMST with their historic eras.[14]

This project had the effect of beginning to level the playing field for evaluating achievements of Southern S&T, which could no longer be devalued on the grounds that they alone

contained cultural elements. (Selin 1997) This project has sparked the creation of indigenous knowledge national ministries, conferences, and journals.[15] It has brought global attention to intellectual property rights for indigenous knowledge, and to the need to expand "real science" to include much more than Northern science studies have been willing to countenance.

This project also has drawn attention to ways that women have a distinctive standpoint on nature wherever women and men are assigned different interactions with their bodies and the world around them. Women, like men become repositories of systematic, effective, knowledge about nature developed through such interactions. This knowledge constantly must be revised as women's natural and social environments change--deserts expand, farmland erodes, toxics permeate water and food supplies, new diseases spread, new ideas arrive on television or from culturally new neighbors or international agencies.

A second context for Southern feminist work is the "science and empires" movement among historians. A central focus here is the question of causal relations between the two great marks of modernity--the "Voyages of Discovery" and the emergence of modern sciences in Europe. These scholars demonstrated how each had required the success of the other for its own success. European expansion (the "Voyages") required the development of what we could call oceanography, climatology, and astronomy of the Southern Hemisphere in order for ships to reach the Americas and return to Europe. The Europeans aso needed better

cartography, and knowledge of the unfamiliar flora, fauna, and geology of the lands on which they wanted to settle and establish economically profitable enterprises. They needed knowledge of the threats to life and health and remedies to diseases that they encountered in the new lands. In turn, modern sciences needed the funding, support, and transportation that expansionist projects could provide. The systematic knowledge they developed responded to the needs of advancing European empire. The systematic ignorance they produced alongside it was marked by disinterest in the needs of the indigenes they encountered, and in all but economic "development." Which leads us to the third movement, and the implications for women of both.

By the 1990's it became clear that four decades of Northern development policies had produced only systematc mal- and dedevelopment for precisely those peoples whose standard of living development was supposed to raise--the 70% or so of the world's most economically and politically vulnerable peoples living in the South. It was the "investing classes" in the North and their economically advantaged allies in the South who had benefitted from these policies. From its origins, development was conceptualized as the transfer of Northern S&T and their rationality to the South. So the failures of development began to reflect directly on limitations of Northern S&T that had previously been virtually invisible to the North. (Sachs 1992) Coalitions of Southern and Northern feminists worked through governmental and non-governmental organizations

to draw attention to the fact that since women and their children are disproportionately represented in the politically and economically most vulnerable groups, development has increased the vulnerability of the vast majority of the world's women. (Braidotti 1994.) European expansion had alway been experienced as brutal conquest by the societies Europeans encountered in the Americas, Asia, Australia and the Pacific Islands, and Africa. However, feminist understandings of the effects of late Twentieth Century "development" policies illuminated heretofore unforeseen effects on women of "The Voyages of Discovery." Today even the International Monetary Fund and the World Bank have come to recognize these effects. Must more WMST in a world of political and economic ineqality continue to increase the gap between the "haves" and the "havenots"?

Southern feminist approaches to S&T have helped to create a new map for Northerners and their feminist concerns. However, the work of getting pro-democratic national and international responses to such concerns still lies ahead of us all. What are other possible future directions for feminist work?

4. More Future Directions. One ongoing, difficult project has been to expand fruitful relations between these diverse feminist projects and the work of women scientists. Many of the researchers, scholars, and activists who have created feminist science and technology projects have brought their science expertise and concerns to this feminist work. Nevertheless, for most scientists, women and men, the use of unfamiliar and

suspect philosophy, social science, and humanities languages and conceptual frameworks, as well as of the intellectual and political assumptions of Southern feminists' projects, have seemed daunting and alienating. Yet NSF and other national, regional, and now even international funders have been sponsoring projects that assist scientists in understanding and using the resources of the feminist STS literatures in teaching and in designing research projects. Two recent collections provide especially useful resources for such projects. (Mayberry, Subramaniam, and Weasel 2001; Wyer et al 2000) Especially interesting here is Lisa Weasel's analysis of how scientists could use the European "Science Shop" model, a kind of "pro bono" commitment, to organize scientific research responding to women's needs in local communities. (Weasel 2001)

Another promising project is to follow the direction of Brickhouse's work to expand issues in science education beyond those of access. How do people learn science? What can be considered science in the K-16 arena? How could learning to do science help to create citizens invested in both democratic sciences and democratic societies? (Brickhouse 2001)

Finally, the emergence of information technologies at the base of the global economy has only begun to come into focus in feminist science and technology analyses. The most obvious concern here is how to counter their use to further disempower women at work. (Mitter, forthcoming; Balka and Smith, 2000.) Another topic is the exploration of how problematic masculinity projects are developed through virtual reality activities.

(Hayles 1999?) A third, barely conceptualized project is to understand the role that the emergence of the information society is playing in the "end of patriarchalism," the constitution of women's movements, and of new forms of family, reproduction, and sexuality. (Castells 1997)

To conclude, feminist science and technology concerns have been gathering steam around the globe over more than three decades. As usual, when feminist frameworks are used to try to add women's and gender issues to the purportedly value-neutral conceptual frameworks and agendas of existing disciplines, institutions, and policy-making, the gendered dimensions and limitations of the latter become visible. Feminist science and technology projects, with all their diversity, uncertainties, and conflicts, will continue to provide valuable resources for pro-democratic social transformations.[16]

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[1] In the U.S. "science" unmodified refers to the natural sciences. Europeans use the term to cover both natural and social sciences, and even the insights of literature and the arts--it means knowledge. I shall focus here primarily on the natural sciences, with only occasional sidetrips into the social sciences.

[2] The 1992 United Nations' Conference on Environment and Development in Rio de Janeiro produced in the media the language of "North" and "South" to replace the earlier "developed" vs. "underdeveloped" and "First World" vs. "Third World" terminologies. The latter originated in U.S. and European 1950's foreign relations policies, and the far older orientalist language of the "West" vs. the rest. Of course "North/South" is literally inaccurate (Japan is economically in the "North"; much of Eastern Europe, as well as "Northern" inner cities, are in the "South"). Moreover, any such dualism is inherently problematic, naturalizing a homogeneity within each category and an essential opposition between them in ways that are empirically unjustified, theoretically questionable, and politically

problematic. However, I use this contrast strategically here to sketch out global patterns documented in the literature cited.

[3] Environmental and AIDS research had a similar start-up pattern.

[4] An internet search for "women in science and technology" will probably turn up half-a-dozen or more sites where such issues are discussed. These sites come and go: eight were running in January 1995; none of these were still operating in May 2001.

[5] The Third World Organization for Women in Science (TWOWS) provides an important international network "supporting the advancement of girls and women in science and technology." It sponsors national chapters, conveys news of jobs, fellowships, workshops, conferences, on-line dialogues, etc. Electronic versions of its newsletter may be found at http://www.ictp.trieste.it/~twas/twows.html.

[6] Nancy Brickhouse reports that "Girls are as likely to be enrolled in some advanced high school science courses as boys (AAUW 1998) and are as numerous in some scientific college majors as boys (e.g., biology). Furthermore, sex differences in achievement are small or nonexistent (Third International Mathematics and Science Study 1997)". (2001, p. 282.)

[7] Brickhouse 1998 provides a good review of an array of such issues.

[8] In different ways this was an insight of both Foucault and Kuhn. It is developed in Hacking 1983 and Rouse 1987.

[9] Note that it is masculinity, not just femininity, that is the issue in these accounts. See Noble 1992, 1995 for two influential historical studies of the masculinity of modern sciences and technology.

[10] Moreover, as we shall see the Southern STS point out, these standards were similarly measured in terms of their distance from whatever was thought of as "the primitive"--, for example, magic, superstition, and ethnosciences, not to mention products of the "savage mind," in the memorable words of French anthropologist Levy-Bruhl (1910).

[11] On these objectivity projects see Harding 1991, 1998; Keller 1984, E. Lloyd 1996. On constitutive vs. contextual scientific values see Longino 1990. On rationality, see G. Lloyd 1984, Rooney 1994.

[12] Collins 1991/1999; Haraway 1991; Harding 1986, 1991, 1998; Hartsock 1983; Rose 1984; Smith 1987, 1990a, 1990b. For interesting recent accounts see Garcia Selgas, Forthcoming, and Rouse's 1996 evaluation of feminist philosophy of science more generally.

[13] For an overview of these movements and their implications for philosophies of WMST see Harding 1998. See also Braidotti 1994, Haraway 1989, Harding 1993, Harding and McGregor 1996, Shiva 1989, L. Smith 1999, UNCSTD 1996, for a diverse set of feminist accounts that start off from the lives of women in the South. For influential writings from the three Southern STS movements that have shaped much of this feminist work, see Brockway 1979, Crosby 1987, Goonatilake 1984, 1992, Headrick 1981, Hess 1995, Joseph 1991, Kaptchuk 1983, Kumar 1991, Lach 1977, McClellan 1992, Nandy 1990, Needham 1954ff, 1969, Petitjean 1992, Sabra 1976, Sachs 1992, Selin 1997, Watson-Verrn and Turnbull 1995, Weatherford 1988.

[14] Three influential such accounts were Latour and Woolgar's (1979) study of the production of truth in a biochemical laboratory, Donna Haraway's (1989) study of the merging of functionalism in biology and sociology in primatology studies at the Yerkes Labs in Atlanta in the context of prison, military, and industrial concerns for controlling the behaviors of captive populations, and Sharon Traweek's (1988) comparative study of the practices of Japanese and U.S./European high-energy physics.

[15] See especially the Indigenous Knowledge and Development Monitor. Online: http://www.nufficcs.nl/ciran/ikdm/.

[16] My thanks to Katherine Ann Muir for her assistance in the preparation of this essay.