

Moored Metamorphoses: A Retrospective Essay on Feminist Science Studies

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## Moored Metamorphoses: A Retrospective Essay on Feminist Science Studies

Resistance is fertile.  
—Ruth Ozeki (2003, 416)

I want to go back to that lost forest where metaphors mix, rub shoulders  
with each other and everything turns into everything else.  
—Suniti Namjoshi (1996, 168)

**I** offer “Moored Metamorphoses” as a metaphor both for the development of feminist science studies and for my own intellectual transformations. Feminist science studies opened up for me new and incredible vistas of possibilities. It instilled in me a passion and imagination for what was possible, and it provided me with the tools to navigate my way through the culture of science and to embark on a research program at the intersections of women’s studies and the biological sciences, experimental biology and feminist scholarship. My reflections on feminist science studies are therefore grounded both in the institutional questions of developing an experimental scientific practice while in a women’s studies department and in questions concerning the tools feminist science studies must develop to make such work possible. Almost every discipline in the humanities and social sciences has found a legitimate place in women’s studies, so where is the space for those of us trained in the natural sciences?

Historians date the origins of modern feminist science studies to Carolyn Merchant’s *The Death of Nature* (1980; see also Schiebinger 2003).

I am eternally in the debt of Jean O’Barr, who was editor of *Signs* and director of Women’s Studies when I was a graduate student at Duke University, and Mary Wyer, who was managing editor of *Signs* while it was housed there. They were instrumental in steering me through the literature in feminist theory and feminist science studies and worked patiently with me through this body of work. I am also deeply grateful to Karen Alexander, Kiran Asher, Karen Cardozo, Rebecca Herzig, Karen Lederer, Miranda Outman-Kramer, Mary Wyer, and two anonymous reviewers for their insightful feedback.

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Defining feminist science studies is difficult. It is a heterogeneous and amorphous body of work that has emerged and grown organically rather than having been established as a field that has any consensus or cohesion. Defining its practitioners is difficult—they range from scholars in women's studies, science studies, cultural studies, and visual studies to scholars located in traditional disciplines. After early practitioners developed the theoretical foundations of a critique of the sciences, the field took off in numerous directions, producing a breathtaking array of scholarship, interdisciplinary and disciplinary (see Mayberry, Subramaniam, and Weasel 2001).

The lack of consensus is in many ways liberating—giving rise to a vibrant, diverse field with few boundaries or borders. However, there are drawbacks: for example, the events surrounding the infamous statements made by the president of Harvard University, Lawrence Summers, who postulated that innate differences between men and women may explain the underrepresentation of women in the sciences. Individual groups, administrators, and feminist academics responded, but the lack of organization of feminist science studies scholars, who were best poised to respond, was acutely visible in the public conversations that ensued.<sup>1</sup> It is a pity that the feminists who were best poised intellectually and politically were not organized to respond to what could have been an effective national teaching moment.

I should make two important disclaimers about my focus on science here. First, the borders of science and those of technology, medicine, and engineering are fluid and porous, and there are many places of overlap. Second, despite the entangled literatures of science, technology, medicine, and engineering, science claims a particular epistemic purity as unbiased, apolitical, and value free—and this is significant. While feminists correctly point out that much research in the laboratories of science is not only technological but also applied, the cloak of “pure science” and objectivity continues to surround the sciences. Feminist scholarship on medicine, technology, and engineering remains on the peripheries of what persuades scientists and is largely seen as irrelevant to science curricula. Unlike other disciplines, the sciences have proved resistant to feminist intervention.

That said, feminist studies of medicine and technology are profoundly influential and are vital to feminist science scholarship. For example, feminist studies of medicine have influenced the women's health movement, which in turn has had a significant impact on health research and policy. The National Institutes of Health now has an Office of Research on

<sup>1</sup> See <http://wiseli.engr.wisc.edu/news/Summers.htm>.

Women's Health and has pushed for inclusion of women in clinical trials.<sup>2</sup> In addition to the work done in that office, feminists carefully monitor the status of women's health, women's experiences with their doctors and the health industry, and research protocols and studies and their impact on women's health. This work has given rise to many informative publications on women's health, including self-help books, the most influential being the Boston Women's Health Book Collective's *Our Bodies, Ourselves* (1973). Feminist studies of technology likewise have proliferated, examining the impact of gender on technology, the impact of technology on women's lives, the gendered nature of technology, and cyberlife (Turkle 1995; Hopkins 1998) as well as exploring the role of the modern state in national security and surveillance (Eubanks 2006).<sup>3</sup> There is now an active and critical feminist presence online. Thus feminist science studies with its very porous interdisciplinary boundaries remains a field with no official consensus. My descriptions and analyses are therefore deeply grounded in the questions that engage me and in works that have influenced me as well as in the community of scholars I have encountered. I begin with an exploration of the foundations or moorings of feminist science studies, explore some of the shifts and metamorphoses, and finally imagine new possibilities for the future of feminist science studies.

### **Moorings**

As useful and pertinent today as when they were written, early texts in feminist science studies created an intellectual architecture for the field. My experiences in the field and with its practitioners is another provocation for the title "Moored Metamorphoses": the field changes and shifts in myriad uncontrolled and uncontrollable ways, yet scholars see themselves moored to certain critical ideas, frameworks, and critiques—exploring what it means to be a woman in the sciences, advancing fundamental critiques of science, and analyzing the culture of science and its institutional practices.<sup>4</sup>

<sup>2</sup> See the main Web site for the Office of Research on Women's Health and its recommendations for the inclusion of women in clinical trials at <http://orwh.od.nih.gov/inclusion.html>.

<sup>3</sup> For the impact of technology on women's lives, see Cowan 1997; Oudshoorn 2003; Wajcman 2004; Vostral 2008. For the gendered nature of technology, see Turkle 1995; Terry and Calvert 1997; Hayles 1999; Lerman, Oldenzel, and Mohun 2003; Fox, Johnson, and Rosser 2006; Suchman 2006.

<sup>4</sup> See Tuana 1989; Keller and Longino 1996; Lederman and Bartsch 2001; Wyer et al. 2008.

***Explorations of what it means to be a woman in the sciences***

Inspired by the feminist movement, much early scholarship in feminist science studies examined the experiences and status of women *in* the sciences. The literature consists of distinct genres: autobiographical essays, historical literature, and work on the status of women in the sciences.

Some early autobiographical essays described the experiences of being a woman in the sciences.<sup>5</sup> These were immensely important to me—mainly because they translated everyday concerns and interactions into a theoretical framework of lived realities in the hallways, classrooms, and laboratories of science and validated my experiences as not idiosyncratic and individual but part of a larger pattern within the culture of the sciences.

Among the historical literature on women in science, Margaret Rossiter's two-volume *Women Scientists in America* (Rossiter 1982, 1995) is particularly important, locating the question of women in science, and the priorities and structures of science, historically in its social, economic, and political contexts. Such historical scholarship has continued to be a productive arena for feminist science studies, one that articulates the changing identities, roles, and conditions of women scientists through history (see also Kohlstedt 1999).

Literature on the status of the women in the sciences continues to thrive. The National Science Foundation continues to put out valuable data on the presence and absence of women in various fields at undergraduate and graduate levels and in the professoriate. There is also an important secondary literature that analyzes these data (Ginorio, Marshall, and Breckenridge 2000; Bystydzienski 2004; Rosser 2004a, 2004b). However, as I will discuss later, the women-in-science literature tends to be undertheorized within feminist work, and there are few connections made between the theoretical frameworks in feminist science studies and the literature on women in the sciences. In many ways, the narrative of the field that began with women *in* the sciences—Ruth Bleier, Anne Fausto-Sterling, Evelyn Hammonds, Donna Haraway, Ruth Hubbard, Evelyn Fox Keller, Sue Rosser, Bonnie Spanier—moved on to address what Hubbard frames as the question of women *and* the sciences or the literature on women/gender *and* the sciences.

The best efforts in feminist science studies that continue to engage with the question of women in the sciences are curriculum transformation efforts. Course development and curricular reforms have resulted in exciting interdisciplinary courses and a talented group of feminist faculty in

<sup>5</sup> See Keller 1977; Weisstein 1977; Moyers 1990; Sands 1993; Ambrose et al. 1999; Wayne 2000; Allen 2001; Spanier 2001a; Whitaker 2001.

the sciences (and women's studies) interested in and conversant with feminist science studies.<sup>6</sup>

***The feminist critiques of science***

While the women *in* science literature on the experiences of women and the culture of science formed an important part of the early work, it was the early feminist critiques of science, or the women/gender *and* science literature, that went on to ground contemporary feminist science studies. The early works of Lynda Birke, Bleier, the Brighton Women and Science Group (1980), Fausto-Sterling, Hammonds, Haraway, Sandra Harding, Hubbard, Keller, Helen Longino, Marion Lowe, Emily Martin, Hilary Rose, Rosser, Londa Schiebinger, Spanier, Nancy Tuana (listed here in alphabetical order, not necessarily in order of importance) elaborated why women, gender, and feminism mattered in the production of scientific knowledge.<sup>7</sup> One can categorize this classical core of feminist science studies into six important themes.

*Biological determinism, scientific objectivity, and value neutrality.* Feminist scholars called into question the presumed objectivity and value neutrality of science and its production of knowledge about men and women. A strong focus of this work was on the biological sciences and involved critiques of biological determinism. Drawing on foundational work in women's studies on the binary sex-gender system, these scholars painstakingly documented how scientists "produced" biological sex differences in the bodies of men and women—from skeletons to brains, intellect, and behaviors. They located the scientific work within their historical periods, documenting how social and cultural ideas permeated scientific language and frameworks. Many carefully analyzed actual scientific studies, showing them to be methodologically poor—badly designed, with inadequate controls, poor analysis, or faulty conclusions. These critiques connected science and scientific knowledge production to issues of power—how science inevitably biologizes and naturalizes the power of the elite through studies of sex and racial differences. Fausto-Sterling (1987) sums it up well in

<sup>6</sup> See Barad 1995; Middlecamp 1995; Mayberry and Rees 1997; Rosser 1995; Mayberry et al. 1999; Mayberry and Welling 2000; Weasel, Honrado, and Bautista 2000; Whitten and Burciaga 2000; Herzig 2001; Kinsman 2001; Fausto-Sterling 2003; Wyer et al. 2008, xiii–xvi.

<sup>7</sup> See Keller 1983, 1985, 1992b, 1995; Lowe and Hubbard 1983; Bleier 1984, 1986; Fausto-Sterling 1985, 2000; Harding 1986, 1991, 1993, 1998, 2006, 2008; Martin 1987; Haraway 1989, 1991, 1997, 2000, 2003, 2007; Schiebinger 1989, 1993, 1999, 2003; Hubbard 1990, 1995; Rosser 1992, 1995, 1997, 2004a; Tuana 1993; Rose 1994; Birke and Hubbard 1995; Spanier 1995; Hubbard and Wald 1997; Hammonds 1999.

the title of one of her essays, “Society Writes Biology/Biology Constructs Gender”: biology and society, nature and culture, are co-constituted in that culture constructs ideas of gender and biology naturalizes societal ideas and mores. Culture is literally written on the body. Fausto-Sterling’s recent (2008) work wonderfully demonstrates this.

These early scholars were fundamentally making a critique of power and of how dominant cultural ideologies and normative structures find their way into scientific theories and laws. They stress that scientists of the past were not necessarily bad scientists but rather were embedded in their political and cultural times. This critique of the embeddedness of gender relations in science and scientific knowledge is perhaps one of the most important contributions of feminist science studies. The study of the construction of women’s bodies and minds has played a central role in women’s studies and in feminist theories in all disciplines. By elucidating the centrality of culture, politics, and power to science, feminist scholars made room for a sophisticated analysis of gender, culture, and politics. As Evelyn Fox Keller and Helen Longino put it, “Gender opened up an entirely new window on the nature of scientific inquiry” (1996, 2). In addition, the broad theoretical work concerning the relationship between nature and culture, science and society, brought into women’s studies the tools and methods for analyzing scientific studies (some of which of course were the tools of mainstream sciences). However, one of the most frustrating phenomena for those in the field is the hydra-like nature of biological determinism, necessitating constant vigilance as new studies emerge and the tentacles of biological determinism constantly reappear. This means that feminist scholars have to reiterate these foundational ideas and critiques every time a new study finds a sexual or racial difference. Scarcely a day goes by without some new study touting biological differences of sex, race, class, or sexuality. The science of difference (sex, gender, race, class, sexuality, etc.) is a testament to the entrenched practice of reifying bodily differences—be it in the skeleton, the skin, the brain, the blood, or the genes. Furthermore, reading the core of feminist science studies leaves one with little doubt that the deep historical roots of biological differences are intricately connected to material and social inequalities of marginalized groups.

It must be noted, however, that with the exception of a few pieces, the early works were largely grounded in the biological sciences and especially focused on the construction of women’s bodies. Recently scholars

in the physical sciences, chemistry, computer science, and engineering have worked hard to extend feminist critiques into the other sciences.<sup>8</sup>

*Reproduction and the labor of women.* A central concern for feminists has been the reduction of women's bodies and biology to their reproductive capacities. Feminists challenged these reductions as biologically deterministic and pointed to their profound impact on women's political and economic marginalization. They challenged scientific theories that reify women's reproductive bodies and often called attention to the ensuing control of women's bodies through their increasing medicalization. These challenges have led to contentious debates within feminism. Some feminists revel in the power of women's reproductive capacities, the wonder and beauty of pregnancy, and the joy of giving birth. Some feminists have strongly opposed reproductive technologies as violating the integrity of women's bodies (Raymond 1994). In contrast, others see women's reproduction as the site of women's oppression. These latter feminists have imagined reproductive technologies (such as artificial wombs) as the key to women's liberation from reproduction and patriarchy (Firestone 1972).

While lively debates continue, for the most part recent feminist work acknowledges the contradictions of feminism and the oppressive and liberatory possibilities of reproductive technologies (Clarke 1998; Franklin and McKinnon 2001; Thompson 2005). For example, they force us to examine the development, invention, and proliferation of reproductive technologies as a product of a patriarchal culture that values women as mothers and commodifies women's bodies (Franklin and McKinnon 2001; Thompson 2005; Taylor 2008). Indeed, the history of reproductive technologies strains credulity. The extent of the use and abuse of women's bodies is striking, and it often occurs with the consent and eager participation of women. The complicity of women in these technologies highlights gender, race, and class privilege as new forms of eugenic practices emerge (Franklin and Roberts 2006). Issues of power and class come to the fore when surrogacy or egg donation, practices increasingly becoming transnational, function as paid labor. On the other hand, reproductive technologies have exploded the heteronormativity of parenthood, delightfully subverting traditional norms of family. The feminist literature on

<sup>8</sup> See Keller 1985; Perry and Gerber 1990; Rosser 1995; Turkle 1995; Shulman 1996; Whitten 1996; Wylie 1997; Rolin 1999; Bug 2003; Conkey 2003; Lerman et al. 2003; Fox et al. 2006; Barad 2007; Damarin 2008.



reproductive technologies remains rich and engages some of the most urgent feminist questions facing us, including the political, scientific, medical, economic, labor, ethical, policy, and legal worlds.

*Gendered images and language.* Another central critique pays careful attention to gendered images, language, discourses, and metaphors in science. Drawing on literary theory, cultural studies, visual studies, and media studies, feminist scholars have chronicled how powerfully metaphors and images shape science. In addition to analyzing the gendered nature of images and language, this body of work argues that metaphors and images are not harmless products of science but instead are constitutive of science. So, for example, Keller argues that the idea of a code drawn from computer science profoundly constitutes the field of genetics and its model of genes, gene function, and gene regulation (Keller 1995). Similarly, Haraway (1991) and Martin (1987) analyze how the language of invasions, borders, and wars shapes theories of the immune system, the field of immunology, and the construction and treatment of diseases. These insights have been profound, leading to a burgeoning field of cultural and visual studies of science.<sup>9</sup>

*Challenging the boundaries between nature and culture.* Beginning with Merchant (1980), feminists have explored science's construction of nature and the environment. From patriarchal conceptions of the domination and commodification of nature, to heterosexist Victorian narratives of Darwinian plant sexuality, to colonial and postcolonial interventions and exploitations, to neoliberal policies and their impact on the environment, to ecofeminist reformulations of nature, to respect for life and knowledge, to movements for environmental justice, feminists have critiqued and reimagined nature in multiple ways.<sup>10</sup> The extensive and exciting literature in this area fundamentally questions the binaries of nature and culture to reimagine the world as a system of "naturecultures," simultaneously natural and cultural (Haraway 2000, 105). Finally, scholars in feminist science studies have taken the question of community and activism seriously in reintegrating science with community, environment, and activism. This robust body of work connects with feminist literature on social movements

<sup>9</sup> See Daniels 1997; Haraway 1997; Subramaniam 2001; Subramaniam and Witmore 2001; Moore 2002.

<sup>10</sup> See Hubbard 1983; Keller 1983; Shiva 1989, 2008; Birke and Hubbard 1995; Sturgeon 1997a, 1997b; Warren 1997; Cuomo 1998, 2002; Di Chiro 1998a, 1998b, 2006; Kuletz 1998; Spanier 2001b; Philip 2004, 2008; Schiebinger and Swan 2005; Murphy 2006.

and ideas of citizen science. Scholars have explored issues of environmental degradation and the exploitation of nature, the environmental impact of pollutants and toxins on women's bodies, and efforts to integrate science and women's health concerns.<sup>11</sup>

*The role of capitalism.* Beginning with analyses of colonial expansion and the implication of scientific development through colonialist practices, feminists continue to trace the embeddedness of science in markets, capital, and the economy. If anything, modern science is increasingly becoming a scientific-industrial complex (Fry-Revere 2007). Demolishing the myth of science as a pure and uncontested laboratory practice, this body of work traces the hegemony of science to the circuits of global capital. The increasing connection between science and industry is a recurring theme, the study of which has grown ever more urgent, in modern biotechnology, in genetic engineering, in consumer technologies, and in the growing surveillance of a security state. The making and selling of drugs, the rigor of studies, the conflict of interest involving researchers and entrepreneurs, the funding of science, a weakening Food and Drug Administration, and a politicized national science policy bureaucracy are all critical issues. The flows of this increasingly global science are indeed transnational, and tracing the circulations of biocapital, international patents, World Trade Organization policies, commodification of resources such as water, and bioprospecting are issues at the heart of feminist science studies.<sup>12</sup> They also link to important social movements across the globe that challenge the growing hegemony of science, democracy, and governance (Jasnoff 2005; Harding 2008; Philip 2008).

*Knowledge and its production.* Feminist philosophy of science, in particular feminist epistemology, has been a particularly productive area of growth. Some of the early works of Lorraine Daston, Haraway, Harding, Longino, Lynn Hankinson Nelson, and Tuana raise questions about objectivity as practiced in the sciences and its ability to produce value-free knowledge.<sup>13</sup> Indeed the whole question of whether it is possible to ever produce unbiased or value-free knowledge has been a critical question in women's studies and in particular in feminist science studies. Many critiques of biological determinism are deeply grounded in feminist philos-

<sup>11</sup> See Kuletz 1998; Di Chiro 2000, 2006; Spanier 2001b; Boswell-Penc 2006; Sze 2006.

<sup>12</sup> See Hayden 2003; Schiebinger 2004; Sunder Rajan 2006; Harding 2008; Shiva 2008.

<sup>13</sup> See Harding 1986, 1991, 2008; Haraway 1989, 1991, 1997, 2007; Longino 1990, 2002; Nelson 1990; Daston 1999.

ophy. Feminist philosophers have dissected scientific studies, carefully taking apart their methodologies, experiments, and claims to knowledge. Indeed, if there were a discipline in which work in feminist science studies should be singled out for particular attention, it would be philosophy. Furthermore, feminist philosophy of science has been crucial in the move from the feminist critiques of science to imagining new knowledge in the sciences grounded in feminist thought, methods, and epistemologies. Epistemologies of “situated knowledges” (Haraway 1991, 183), “science as social knowledge” (Longino 1990), “strong objectivity” (Harding 1991, 138), and “agential realism” (Barad 2007, 132) are some of the powerful alternate formulations that feminist studies scholars suggest. Feminist philosophy opened up possibilities of new worlds and new knowledges in exciting and new ways, and feminist philosophical questions continue to ground some of the best work in feminist science studies. One could argue that some of this work has been mainstreamed and used widely in science and technology studies, while not always explicitly focused on gender.<sup>14</sup>

#### **Explorations into the culture of science**

The literature of women *in* and women/gender *and* sciences is bridged by a small body of work that incorporates feminist critiques of science into an examination of the culture of science, thus operationalizing feminist science studies (Kohlstedt and Longino 1997). There are many macro- and microstudies of laboratory life, research practices, professional development, publication and citation patterns, and so on within mainstream science studies. While these are certainly important and give us some insight into the culture of science, the majority of them pay no attention to gender, race, ethnicity, nation, or any other social variable. Among the literature that deals with issues of women and gender, three sets of work are particularly important and were deeply influential for me.

Anthropological work on the culture of science dissects how the culture actually functions. For example, in *Beamtimes and Lifetimes*, Sharon Traweek (1992), an anthropologist, studies scientists and their laboratory cultures and practices. To me her description of scientific culture as “the culture of no culture” (162) remains one of the most memorable phrases in the field. Her book goes on to elaborate how the culture of no culture actually works and functions. Traweek’s cross-cultural work on high-energy physics across Japan and the United States is an insistent reminder against essentialized ideas of sex or gender (Traweek 1993). Works fo-

<sup>14</sup> Thanks to an anonymous reviewer for this insight.

ocusing on women scientists from other countries and cultural contexts are also particularly instructive, dispelling the idea that the ideal scientist is a universal category. Indeed, an exploration of sciences in other countries and cultures reinforces the centrality of national, disciplinary, and social contexts of science.<sup>15</sup>

Feminist work on the history of science allows us to understand the mythology of science and scientists as a historical and genealogical production rather than a list of characteristics that produced the best science. How did science come to develop such a culture? How did it come to have these particular codes of behaviors, philosophies, and actions? David Noble's *A World Without Women* (1992) remains important. Noble traces the history of Western science to its Christian clerical culture, noting how many of the characteristics of the clerical tradition continue to inhabit our ideals of scientists today. More recently, Rebecca Herzig's *Suffering for Science* (2005) is a wonderful elucidation of how science in the nineteenth and twentieth centuries developed an ethic of self-sacrifice and suffering and how historical ideas continue to shape scientists.

Postcolonial scholars of science, in turn, carefully examine the category of Western science, highlighting both how colonial expansion helped shape it and how indigenous ideas, concepts, practices, and philosophies were sometimes appropriated (and rarely credited) by it; these indigenous knowledges remain as unique philosophies and practices in many cultures and countries.<sup>16</sup> Western science thus emerges as a distinct category (more in its claims than in its history) and yet is clearly implicated in colonialism and the cultures and knowledges of the colonized.<sup>17</sup> In this literature, Western science loses some of its claims to universality and is instead transformed into a modern institution through particular histories, geographies, and politics. Although this body of work at times essentializes and romanticizes the third world, it does force us to confront alternate knowledge systems, practices, and sciences as worthy of serious inquiry and consideration (Shiva 1989; Harding 1998, 2006, 2008).

I highlight anthropological, historical, and postcolonial and indigenous work as examples that vividly translate how explorations of knowledge production in science are deeply connected to the everyday assumptions, behaviors, norms, and mythologies of science. It is works like these, in

<sup>15</sup> See Haraway 1989; Nandy 1995; Subrahmanyam 1998; Sur 2001; Verran 2001; Beoku-Betts 2004.

<sup>16</sup> Prakash 1999; Alexander 2002; Raina and Habib 2004; Anderson 2006.

<sup>17</sup> See Shiva 1989; Harding 1998, 2006, 2008; Schiebinger 2004; Schiebinger and Swan 2005.

addition to the biographies of individual women scientists, that I believe will help us make the connections across the growing chasm between the women/gender *in* and women/gender *and* literatures. This is a severely underdeveloped and undertheorized but critical body of work for feminist science studies.<sup>18</sup>

I must note that one striking feature of the scholars I cite is that they are largely scholars who practice in the United States. This is not entirely my idiosyncratic reading but rather a curious feature of feminist science studies. While there are certainly exceptions (see, e.g., Waldby, Wakeford, and Green 2006) both the women *in* and gender *and* literatures tend to be U.S. focused. The women *in* science literature is overtly preoccupied with the United States, with a focus on the future workforce and scientific capacities. In fact, jingoistic arguments are as common as administrators' and politicians' angst about an increasing "foreign" presence and the declining status of U.S. science and technology. The U.S. focus of the gender *and* science literature is especially curious given that science and technology studies tends to be much more international. There may be two reasons for this U.S. focus. First, though there are certainly exceptions, women's studies as a field tends to be similarly nation bound—with national associations, societies, and journals. Second, much of the critique of feminist science studies is contextual, locating science and technology within particular histories and politics, and here the national context of the United States may circumscribe theoretical arguments. For example, feminist critiques of biological determinism, environmental issues, or surveillance are theorized in direct response to specific U.S. histories and politics of the women's movement, slavery, environmental regulations, multinational corporations, and the state of politics after the attacks of September 11, 2001.<sup>19</sup>

### **Metamorphoses**

#### ***Meditations on the development of feminist science studies***

Reflecting on the field of feminist science studies, one can see several glaring patterns emerge. First, many early scholars who offered the feminist critiques of science were scientists themselves, and the field began as one grounded in the lives and experiences of women scientists. For about a decade, these links were sustained as feminist science studies scholars con-

<sup>18</sup> See Sayre 1975; Keller 1983, 1997; *Social Studies of Science* 2002; Maddox 2003; Rife 2006.

<sup>19</sup> I am deeply grateful to Rebecca Herzig for this observation and insight.

tinued to be involved in projects on women in the sciences (Keller 1987). But these connections have worn thin as many feminist studies scholars have grown frustrated at the lack of movement in the discussions and frameworks on women in the sciences (Hammonds and Subramaniam 2003, 928). In fact, I would suggest, many would not consider the literature on women in science part of feminist science studies anymore. This is a shift within the field and, to me, a profound loss.

Second, while some in the physical sciences, mathematics, and engineering have begun to engage with the feminist literature in interesting and creative ways, feminist science studies continues to be grounded in the biological sciences. There is a growing literature on technology, but it deals much more with the consequences of technological innovations than with the actual science—theories, instruments, computer languages, and code—that makes the technology available.

Third, with some exceptions, gender continues to be theorized as an unproblematic and universal category. Intersectional analyses that include race, ethnicity, class, sexuality, nationality, colonialism, and so on are few (Harding 1993; Collins 1999; Hammonds and Subramaniam 2003).

Fourth, the move from feminist critiques of science to feminist studies of science, which seemed to take hold in the mid-1990s, was significant. The move reflected the growing interest in a reconstructive project for women's studies and the sciences. It opened up the possibility of a body of work that moved beyond a critique of the sciences. If feminists found the production of some scientific knowledge problematic, could we develop new theories, methodologies, or epistemologies that produced knowledge about the natural world that feminists could embrace? Feminist scholars in other disciplines developed new theories and methodologies that make gender a central problematic in their fields. Can we do the same for the sciences? Might we produce new knowledge about nature grounded in feminist research? This was an exciting proposition, but unfortunately feminists have not embraced the transformative power of their own critique. As the field of feminist science studies has grown and thrived, it has remained moored to the mode of critique of science, and the patterns I outlined just above continue to shape the field today. There are distinct reasons for each of these patterns that have to do with how the field formulates questions of feminism and science. In what follows I explore each of these four features.

*From pipelines to power.* The metaphor of the pipeline has endured as *the* metaphor in discussions of the recruitment and retention of girls and

women in science.<sup>20</sup> The metaphor invokes a long pipe leading from kindergarten to the scientific laboratory with leaks as a figure for the attrition of women and students of color. It is common to hear of leaks along the entire pipeline. The metaphor travels into retention issues, with strategies to plug the leaks, therefore pouring more women and students of color into the laboratories of science. If feminist science studies teach us anything, it is that metaphors and language are powerful and evocative; they embody dreams and visions. But feminist analysis can also develop an alternate analysis of this metaphor. We could argue that the pipeline metaphor is a rather good one to describe the experiences of many women in the sciences, although, I hasten to add, not their thrill of discovery and exploration. We could also describe the pipes as long, dark, dingy, impenetrable tubes and masses of metal crisscrossing the terrain of industrial capital. We could describe the pipe as one that contains, constrains, limits, and cuts off the oxygen of the travelers within. Imagining the regimented travels in pipes that give the travelers no agency in their journey, we might start rooting for the leaks and for those who escape the drudgery of pipe travel.

And this, I believe, has been the crux of the difference between the literatures on women *in* and women/gender *and* sciences. In one the leaks are seen as a problem, and in the other the problem is the pipe itself. If science is indeed in the business of laying down pipes, why would we want to enter them, and why do we want to encourage young girls and women who find the pipes inhospitable to enter them? Instead, why do we not rejoice at the leaks? In addition to supporting women in science, why do we not find alternate modes of science within women's studies? After all, these alternate modes where we engage disciplinary practices in an interdisciplinary manner constitute the way women's studies engages with all other disciplines. Despite the best intentions of feminists to move us away from the women-as-deficient model and shift the focus from women's deficiencies to the deficiencies of science and its cultures (Rosser 1997), many continue to help women survive in the culture of science through networking, mentoring, finding role models, confidence building, and work-family policies. Within women's studies, we persist in a politics of martyrdom that rallies girls and women to "stay in." Within the sciences, despite the best efforts of feminists to shift the focus, the pipeline metaphor and the focus on women have endured in most gender equity projects.

<sup>20</sup> The history of the metaphor of the pipeline and its ensuing power to frame national policy is a fascinating topic that has been ill researched. Tracing the history of the pipeline metaphor would make a wonderful doctoral dissertation.

*Which feminisms? Which sciences?* Gender equity projects represent the vast majority of the initiatives of women in the sciences. Having been part of several such projects, I am struck by the limited ways in which we use the idea of feminism and the idea of science; they are both problematic. The use of the singular “feminism” for a diverse and contentious field reduces what we offer to the sciences. There is a rich debate in feminism on which analytic tools best explain our gendered world; all feminists do not agree. Derived from liberal feminist politics, equity projects work to level the playing field, focusing on equal rights, representation, and access to opportunities (Kirk and Okazawa-Rey 2007). They have worked to remove barriers and discriminatory practices in the sciences in hiring, recruitment of students, salaries, family leave policies, standards for promotion, and so on. As Angela B. Ginorio, Terry Marshall, and Lisa Breckenridge (2000) show in an oral history project that explores attitudes about feminism among scientists, feminist liberal ideas are as pervasive in science as in society. Equity initiatives have been very important and have played a role in some successes in recruitment and retention. As with liberal feminism in the workplace outside the sciences, equity feminism has allowed women to participate in the science workplace on equal terms with men. Some of the inroads into knowledge production in the sciences follow an empiricist and liberal feminist model by removing empiricist bias to produce knowledge that is gender neutral. However, feminist scholarship reminds us that systemic inequities are deeper than bias of and discrimination by individuals—indeed, they are embedded in the living, breathing cultures of the workplace and science. It is not surprising that after initial gains, the numbers of women in science have stagnated.

In comparison to a liberal feminist model of feminism, a perusal of feminist science studies shows a diversity of feminism(s) (Rosser 1997). As I elaborated earlier in this essay, feminists have employed a number of analytic tools, in addition to the tools of gender equity, in their analysis of science. Reducing feminism to the goal of equity misrepresents feminist studies of science. But one cannot hope to address questions of gender equity in liberal feminisms using the language and tools of analyses that focus on issues such as gender normativity, capitalism, neoliberalism, intersectionality, and postcoloniality in the lived cultures of science. We need to develop a literature on women and culture *in* the sciences that is grounded in the rich repertoire of feminist analyses.

And the time is ripe for such work. All of us in academia are witnessing growing pressure for external funding and the blurring of lines between academia and industry. Increasing theocratical interventions into teaching science provide a challenge to the hegemony of science. Funding from



national foundations for basic science and health research continues to dwindle. Immigration policies confront graduate education in the sciences head-on. A perusal of mainstream science journals makes it apparent that some of the political and social issues facing science are quite evident to practicing scientists. Scientists and science policy experts are theorizing these trends, although feminist analyses are sorely lacking. There is an urgent need for feminists to translate the richness of feminist analytic frameworks and articulate more fully how historical, economic, political, ethical, and transnational issues shape not only the production of scientific knowledge but also the lived realities and cultures of science and, indeed, the institution of science itself. Moving from pipelines to a focus on politics and power, feminists can better articulate the liberatory politics that underlie feminist science studies and use them as a basis for collaboration for a new future for feminist science studies.

Like feminisms, sciences must be understood in the plural. Sciences show tremendous heterogeneity in their focus of study, methods used, experimental designs, and the degree to which cultural and societal concerns are already included in their repertoire of thought. To a biological scientist, the array of diversity, from theoretical biophysics and biomathematics to urban ecology, is staggering. The reductive use of “science” within feminist science studies has implied a much too general theory of all science. One of the challenges in feminist science studies is that it emerged very firmly grounded in the biological sciences and in particular in the construction of women’s bodies. The elaboration of gender and the binary sex-gender system came to frame much biological discourse. And yet these formulations seem to frame discussions in the nonbiological sciences as well. While looking at gendered or reductionist metaphors, languages, images, and discourses in geology, physics, or mathematics can be productive, it is also severely limiting. Feminist science studies has developed into a vast and diverse field implicating multiple analyses and practices of science. We need to broaden our idea of study beyond binary gender formulations. An example of such broadening can be found in the work of Karen Barad (2007). Drawing on the work of physicist Niels Bohr as well as feminist theorists such as Judith Butler, Barad develops an account of material-discursive practices in scientific knowledge. She demonstrates how diverse fields like physics, science studies, and feminist studies can together yield new ways of knowledge making. But in order to reap the benefits to be found at the intersections, as Barad demonstrates, we need a more sophisticated framework of feminism(s) and science(s).

***Intersectional interstices: Beyond universal woman and gender***

The continued use of the categories woman and gender as universal and unproblematic is perhaps not surprising. This is a problem that permeates feminist studies across the disciplines. Despite over three decades of feminists of color raising the issue of race, it is consistently undertheorized in feminist literature, including feminist science studies (Collins 1999). Conversely, there is a wealth of knowledge about race and ethnicity that largely ignores gender. One sees similar patterns with the literature on class, ethnicity, sexuality, and nationality. White, middle-class, heterosexual women continue to embody the category woman, just as men embody the categories of racial minorities. The title of a wonderful anthology put it best a quarter of a century ago: *All the Women Are White, All the Blacks Are Men, But Some of Us Are Brave* (Hull, Scott, and Smith 1982). Here feminist science studies has a particularly important role to play. Categories of sex, gender, class, sexuality, race, and ethnicity emerge historically at particular periods, and science has played an important role in their development and evolution. Scientists were central in the naturalization of discourses about the inferiority and superiority of various groups. Furthermore, as Nancy Leys Stepan (1993) and others have argued, the histories of race and gender are connected: analogies between race and gender have been invoked at various points to frame the inferiority of groups. Scholars point to the necessity of understanding race and gender not as absolute but as constructed, intersecting, and relational categories.<sup>21</sup> As Hammonds argues, “To look at how the sciences of human difference emerged, evolved, changed, and achieved a certain kind of cognitive and social authority through the lens of race, gender, and sexuality can tell us a great deal about how science works variously in complex modern societies” (Hammonds and Subramaniam 2003, 932).

Social movements for women’s rights, suffrage, abolition, civil rights, and gay and lesbian rights have each used other social movements in their own struggles. Intersectional analyses seem particularly urgent now. We live in times where we see a resurgence of race as a category in genetic and especially pharmacogenetic analyses.<sup>22</sup> We have seen the advent of race-based medicines, vitamins, diagnoses, and behaviors (Kahn 2008). As Dorothy Roberts argues, we live in profound contradiction: just as

<sup>21</sup> See Haraway 1989, 1997; Schiebinger 1993; Fausto-Sterling 1995, 2003, 2008; Roberts 1997; Gere 1999; Briggs 2002; Reardon 2005.

<sup>22</sup> See Fausto-Sterling 2008; Fujimura, Duster, and Rajagopalan 2008; Fullwiley 2008; Koenig, Lee, and Richardson 2008; Roberts 2009.

there is a push in social policy to erase race as a category of analysis, we begin to see a great effort to include race as a genetic category in order to see it more clearly through the microscopes of genetics; race is lost in the macro world and vivid in the micro (Roberts 2008). Science's constructions of the reproductive bodies of black and white women—one pathologized and the other reified—continue to shape the reproductive politics of today (Roberts 1997).

With the resurgence of biology and genetics as arbiters of health and wellness, it is urgent that we approach them through the frameworks of feminist science studies. It is not only that feminist science studies needs to employ intersectional categories of analysis just as other fields in women's studies must but, rather, that feminist science studies is poised to explicate what we mean by intersectionality itself. How and when did biological categories of difference emerge? How did they come to translate or be translated into social categories of difference? Tracing the global genealogies of difference through the similarities and contradictions of slavery, colonialism, and class and gender oppression elaborates the centrality of science and difference. Tracing the global genealogies of science through its expansion in colonial times reveals how hierarchies of gender, race, class, and sexuality are shaped by these histories.

### **"Un"moorings: Why we must learn to count past 2**

It is a strange irony that scientists, who are often labeled antisocial, actually work in highly social settings. Conversely, working in the humanities, which takes the social seriously, necessitates solitary communing with one's computer. Since C. P. Snow's (1959) essay on "the two cultures" the division between the humanities and the sciences has endured, and, despite the heterogeneity of feminist practices and the many similarities among disciplines, we have reinforced and reified this binary. However, scholarship that explores the workings of science points to its deeply social nature and its strong networks and communities (Longino 1990; Rouse 1996). Rather than casting the humanities and the sciences, and feminism and science, as binary oppositional practices, work and theories that stress the similarities, commonalities, and resonances may be a productive avenue for future collaborations. A recent anthology, *Tactical Biopolitics*, attempts precisely that (da Costa and Philip 2008).

If Snow proclaimed a fundamental divide between humanities and the sciences, early scholarship in women's studies cemented this binary in the development of the sex-gender binary. Keller (1992a) argues that people constantly conflate sex and gender. She recounts that when she tells people

that she works on *gender and* the sciences, it is immediately followed by a question about what she has learned about *women in* the sciences. Feminists have worked hard to elaborate a complex theory of gender and social construction. But in looking at the intellectual and institutional contexts of this development, the evolution of the sex-gender binary seems to have further cemented the binaries of the humanities and the sciences in women's studies. As Fausto-Sterling notes in her important essay on building two-way streets between feminism and science, women's studies continues to define itself outside the sciences by "the sanctioning of female ignorance of matters scientific" (1992, 337). For those of us who were trained in the sciences and work in women's studies, the marginalization is real and present every day. I cannot count the number of times I have been told by departments that they cannot afford to hire a scholar in feminist science studies because they are too small and need to cover the core before they can include science. Despite the growth of feminist scholarship, the conception of women's studies as a field of the humanities and social sciences remains. The binary of sex-gender that the field sought to enforce seems to have been successful. Sex, the biological category, seems to have been relegated to the sciences and declared out of bounds (except in critique), while gender becomes the focus of women's studies (Fausto-Sterling 2005). If the sciences were conceptualized as a world without women, then women's studies, it would appear, is conceptualized as a world without science. The refusal to incorporate the sciences into the core of women's studies and as legitimate knowledge worth studying and producing has been at the heart of why feminist science studies has been unable to move beyond critique within women's studies.

But this conceptualization of women's studies as a field of humanities and social sciences is a bit curious given the emergent scholarship on sex, gender, and sexuality. If anything, recent scholarship in sexuality studies, including, gay, lesbian, queer, intersexual, and transgender studies, has exploded the easy boundaries of sex and gender, biology and social construction. The body seems much too complex to reduce to easy questions of biology versus socialization.<sup>23</sup> Recent work has pushed us to rethink nature and culture not as oppositional binaries but rather as co-constituted (Fausto-Sterling 2000) and "co-productions" (Reardon 2005, 6), as "material semiotic apparatuses" (Haraway 1997, 16) or "naturecultures" (Haraway 2000, 105) grounded in our histories of sex, gender, race, ethnicity, class, sexualities, and colonialism. We need to take these theo-

<sup>23</sup> See Terry and Urla 1995; Kessler 1998; Dreger 1999; Terry 1999; Fausto-Sterling 2000; Kraus 2000; Wilson 2004.

retical insights to heart in reconceptualizing women's studies as an interdisciplinary field beyond the humanities and social sciences.

The striking features of the early literature—the focus on biology, the separation of working scientists and scientific culture from knowledge production, the unitary understandings of feminism and science, and the reinforcing binaries of humanities/sciences and biology/society—continue to moor the field. It is time to move beyond each of them. To consider feminism(s) and science(s) in all their complexities and to explore the similarities in both would require real collaboration across these binaries. This cannot be just an intellectual project: the contours of the academy necessitate conversations about institutional locations and instrumental practices. And, to be sure, women's studies will have to deal with the very difficult and real challenges of the ethical practices of science raised by scientists like Martha Crouch, a biologist who quit her laboratory research because of the ways in which her work in biotechnology were implicated in promoting industrialized agriculture (Mokhiber and Weissman 2000). But women's and gender studies cannot look to the sciences as out there waiting to be transformed. We need laboratories of our own. We need to be agents, scientists, experimenters, and programmers of that future knowledge. Drawing on the pioneering works of the early feminist critics of science and the dreams of contemporary feminist theorists, activists, and scientists, we can build these new laboratories to imagine new interdisciplinary and intersectional knowledges and reimagine feminist science studies onto the international world stage, where it rightfully belongs. Can feminism change science? Yes, but only if it is willing to change itself.

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