Gender And Physical Science: A Hard Look At A Hard Science

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A Hard Look at a Hard Science

Amy Bug

> The reader should be reassured again that I do not intend to throw out the baby of science along with the bath water of false views about science. My concern is to identify more carefully where the baby ends and the bath water begins.
>
> Sandra Harding, philosopher of science

> Re: identifying where the baby ends and the bath water begins, it is easy: Define an order parameter that is one within baby space and 1 in the water space. The baby ends at zero regardless of the sharpness of the front. . . . So, although according to the bible water (-1) was good to Moses ($+1$), leading him to the king's court and heart, I would still run a Landau-Ginzburg equation just to verify. . . .
>
> Rafi Blumenfeld, physicist

This essay explores some aspects of the interplay between gender issues and physical science. At the start, we acknowledge the paradoxical status of physics (Keller 1985, chapter 4) as both gender free (an impersonal enumeration of mathematical truths to which our universe adheres) and highly gendered—of the male variety. If physics were not free from the influences of gender, race, and class, how could men and women all over the world reproduce the same experiments with the same results (to ten or eleven decimal places in some cases)? If it were not highly gendered, then would it not be equitably integrated, and would images of physics and of physicists not conflate with images of male activities and male people in most of our minds?[1]

Organizing one's thoughts on issues of women in physical science is a tough task. Immediately, the question arises: Which issue is paramount? There are many questions that compete for attention, among them:

Did/do men outnumber women (the participation, persistence issue)?
Is/was there an exclusion of women from institutions of learning and power?
Is there a gendered quality to the science itself?
Need we assess/reform physical science education?
What are the images of science and scientists that are ingrained within our society?

Though these questions are quite distinct, they resist being answered in isolation, and their answers are intertwined in interesting ways. Further, they have a continuity across time and place. They could have been asked about science and society 200 years ago, 500 years ago, as well as now, and the answers in different eras would inform one another. "We feel a lack of intellectual respect from classmates. We often feel patronized in homework sessions" is a paraphrase of a comment made by a physics major at our small college. "I did not dare lay bare my impulse and intention to any of the wise by asking for advice, lest I be forbidden to write because of my clownishness" is a quote from the tenth-century scientific scholar and cleric Hrosvitha (Wertheim 1995, 43). One gets a strong sense that these two quotes, separated by a thousand years, might have emerged from similar sources—from women struggling in a male-identified scholarly sphere.

The current wave of feminist scholarship has produced enormously interesting work on the aforementioned questions. The plan of this essay is to touch on a few of them. Perhaps this essay will serve best as an introduction for people who are experienced in science but new to the field of women's studies (like me). Women's studies has much to say about who does science, how it is done, and how the character of the science and the scientist are coupled.

Participation

A woman physics major looks around her physics classroom and, at most coeducational institutions, finds herself in the clear minority. In the early

1990s she could expect to find that women comprised about 25 percent of her introductory physics class, about 15 percent of physics majors, and about 3 percent of physics professors (about 1 percent more at a liberal arts college, about 1 percent less at a university). If she attended a large university, the most probable number of women who would eventually graduate with a Ph.D. in physics would be between 1 and 5, the next most probable, zero; these numbers reflect the fact that women in physics are clustered at some institutions and completely absent from many others (American Institute of Physics 1990). In the American Physical Society (the largest professional organization of physicists) in 1990, women comprised 14 percent of members under age 30 and only 3 percent of members over age 40 (American Physical Society 1993). This is a hopeful sign that women are in the process of better populating the field. But a less hopeful sign is the disproportionate way that women leave the discipline at all levels—the so-called leaky pipeline. Also, apparent progress in women's participation, like the proportion of women earning physics Ph.D.'s, which rose from 5 percent in 1975 to 10 percent in 1990, is negated if one looks only at U.S. women (Fehrs and Czuijko 1992). Their participation, as a percentage of all physics Ph.D. recipients in the United States, was virtually unchanged during that time. The increasingly international character of graduate student populations had produced the rise in women's participation. What explanation for these lopsided numbers can one give the young woman in college today? What reassurance can one offer that a life in physical science is well within her reach?

As historians and philosophers of science know well, the history of women in physical science (and participation in public scholarship in general) has not been monolithic. Women's participation has ebbed and flowed. One period of flow began during the Renaissance, when humanism allowed some of the ancient, gender-based prejudices to be questioned on several grounds (Jordan 1990; Scheibinger 1989). There were defenses of women from such thinkers as the Jesuit priest François Poullain de la Barré, from whom comes the quote "The mind has no sex" (quoted in Scheibinger 1989), and the use of Cartesian ideas as inspiration and to demonstrate sex differences were limited only to sex organs. Even Leibniz, though largely silent on the issue, asserted that women had leisure at home and so should study (Scheibinger 1989, 39), and defenses based on women's innate superiority of nature were offered as well. This was also a period when, according to Scheibinger, there were "lexicons listing female worthies in the arts and sciences." But in the eighteenth century, as the prestige of science began to grow, there were attempts to deny that women had ever contributed to development of the sciences, or of the arts. Scheibinger (1993) discusses the movement among eighteenth-century individuals to prove the intellectual inferiority of women to men, and non-Europeans to Europeans. This was a time, argues Martin Bernal, when there was an attempt to de-emphasize African and Asian roots to science and to focus solely on the Greco-Roman contributions (Bernal 1993). For example, one can read in some histories of science, as well as some current elementary physics textbooks, that Galileo was the first to invent and/or turn the telescope heavenward with the full intent to study celestial objects, despite the fact that Galileo himself acknowledged that ancient North Africans had optical devices that were essentially telescopes, and that they used them for celestial observation (Van Sertima 1983, 13). Moreover, the Western scientific revolution had firm roots in Arabic-Muslim and Asian science and mathematics (Hess 1995, chapter 3).

There was a very dark period for remembering/crediting women and non-Europeans in Europe and the United States from about 1920 through 1970. This facilitated the public perception today that, as Sharon McGrayne, author of *Nobel Prize Women in Science,* puts it, "there's been only one woman scientist, Marie Curie. And people don't know much about her, so they think she's boring. If they know about other women scientists, they assume they don't do world class work" (Hess 1994, 9). Happily, today there is a comparatively rich supply of biographical material available on the "forgotten" women of science, as well as on living women scientists.[2]

Opportunity or Exclusion?

It seems important to put the scarcity of women's faces and names in science textbooks in historical perspective, and to consider the historical participation of women in scientific and educational institutions. (While the history I mention is a Western one, there is an important message in the fact that African and Eastern educational history is so divergent; for example, that colonial forces denied the African system of universities, which flourished during medieval times, an opportunity to continue [Pappademos

1983].) There was a curtailment of women's educational opportunities in medieval Europe that coincided with their expulsion from positions of authority in the church. By the ninth century, there were new church schools, only open to boys; girls had no access to organized education (Wertheim 1995, chapter 2). David Noble traces this parallel exclusion of women from the church and from the practice of science as it culminated in the scientific revolution (Noble 1992). The scientific revolution was a time of conventional piety when science and church had not yet parted ways, but both presented a united front against the participation of women. Wertheim takes the "physicist as priest" metaphor to heart; the maleness of the two archetypes allowed them to reinforce one another historically and, Wertheim argues, today as well (Wertheim 1995, introduction and chapter 10). Women were excluded from the medieval universities and from the modern ones that cropped up during the Renaissance. Isolated exceptions were Italy and Germany. But no woman who attended ever set a precedent for the admission of women. For example, the illustrious Laura Bassi, a physicist, attended and then became a professor at the University of Bologna in the eighteenth century. Her chair at the university was established in such a way that it would dissolve when she left it, to avoid setting a precedent of having a woman in that place (Scheibinger 1989, 16, 17). Consider how differently we might view the historical impact of women physicists were there a Bassi Chair in physics at Bologna, the occupation of which conferred honor on the occupant. (And occupation of which by an illustrious physicist would reflect honor back on the chair, as does the Lucasian Chair in physics at Cambridge, once occupied by Newton and currently by Stephen Hawking.) The university educational situation in Europe did not even begin to amend itself until the turn of the last century. For example, Lise Meitner, an Austrian physicist, was lucky that Vienna opened its doors in 1901, and she was able to take classes there, and then with Max Planck at the University of Berlin. Still, there was a chemical institute nearby where she did her experiments and where they had classes. She was not allowed upstairs and had to hide under the auditorium seats to listen to lectures (Wertheim 1995, 193–97). Agnes Pockels, keeping house for her father in Germany in the latter part of the nineteenth century, had not even this meager opportunity. Her scientific knowledge was based largely on books to which her brother, a university-educated physicist, provided access. Her dozen or so papers on the physical properties of liquid surfaces were based on research performed entirely in her kitchen (Tanford 1989, chapter 11).

M. Sadker and D. Sadker provide an excellent summary of the history of women's education in the United States (Sadker and Sadker 1994, chapter 2). No public schools were open to women until the early nineteenth century. Oberlin was the first U.S. college to admit women, men, and racial minorities of both sexes. But the "ladies' course" was second rate. (Additionally, the women had to do the men's laundry and serve them meals.) Coeducation in universities began in the mid-nineteenth century when the number of men attending dropped after the Civil War. But a subsequent backlash against coeducation caused some formerly coed universities to instead establish women-only, affiliated colleges. In the late nineteenth century, "real" women's colleges (as opposed to institutions that were, essentially, finishing schools) began to open their doors; Vassar was the first. In the middle of the twentieth century, most major universities and colleges finally went coed. Even then, as conversations with women who matriculated at that time reveal, women were regularly channeled into traditionally feminine vocations (Sadker and Sadker 1994, 33–35).

A similar cycle of advancement and retrenchment was experienced by women scientific professionals, according to Margaret Rossiter (Rossiter 1995a; 1995b), whose monumental works delineate the educational and working conditions for women scientists in America. During the middle of the twentieth century, women scientists were scarce in colleges, industry, and government, and the fit was often less than perfect. For example, because of anti-nepotism rules, physicists Maria Mayer and Libby Marshall were appointed as "volunteer professors" at the University of Chicago, a situation that was "awkward . . . but humane," according to Rossiter (Rossiter 1995a, 138). A quest for institutional prestige eroded the progress women had made in securing faculty positions, even at women's colleges (Sadker and Sadker 1994, chapter 2; Rossiter 1995a, chapter 10). On the other hand, for some physicists with the highest levels of research aspiration and talent, work at small colleges was not the best fit. Emmy Noether, a mathematical physicist (who had never secured a paid position during her many years at Göttingen University), spent the end of her career at Bryn Mawr College (Wertheim 1995, 190–93). But we should no more imagine this brilliant researcher being completely fulfilled in an under-graduate teaching environment than we could imagine Einstein being so. Lise Meitner, despite her growing desire to emigrate from Berlin in the early 1930s, refused to consider a position at Swarthmore College, because of its insufficient laboratory space, and/or lack of assistants for her work, and/or inability to allow her to work with large amounts of radioactive materials (Sime 1996, 149).

The Woman behind the Curtain

The theme of invisibility is one that pervades the study of women in science. In an apocryphal story, the woman scholar gives her scientific lectures from behind a curtain, so that listeners (male) will not be distracted by her beauty. (Sometimes the story is told with Laura Bassi as the subject, sometimes it is another historical woman worthy.) This veiled woman is a potent metaphor for the fact that women's contributions, and the names of the women who made them, are often obscured. The Sadkers describe an exercise wherein people are given 5 minutes to write down 20 famous women—no sports figures or entertainers allowed (Sadker and Sadker 1994, chapter 1). How hard my class found the exercise when one of my students suggested we try it![3] When we restricted the exercise to names of scientists, it became virtually impossible. Why? Clearly our early education bears some responsibility; the impressions that our early social studies teachers and books have made last a lifetime. (Students tell me that high-school texts now put marginalized people in blue boxes. In my day, they didn't even have the boxes.) But this begs the question of why, in the first place, women worthies should be marginal characters, and whether their lesser historical and demographic weight is compounded by the fact that their achievements are underestimated or underreported.

The model of women inventors is an interesting one to consider. The Sadkers report that they saw middle-school teachers write lists of inventors on the board, all male (Sadker and Sadker 1994, chapter 1). There was no mention of how hard it was for women to get patents in their own name until very recently; of new scholarship that shows that the routinely cited discovery, the cotton gin, formerly credited to a man, was invented by a woman. There was no suggestion that some enormously important devices have been invented by women in the twentieth century (like the computer compiler, invented by Grace Hopper, or the tunable dye laser, invented by Mary Spaeth). Sadly, despite the fact that women inventors are now on about 8 percent of patent applications,[4] despite the fact that at the time the Sadkers did their research there were numerous books in print, at various grade levels, describing the achievements of women inventors,[5] the enduring stereotype is that women invent nothing, as described in this excerpt of a letter that H. J. Mozans reproduces:

> I was out driving once with an old farmer in Vermont, writes Mrs. Ada C. Bowles, and he told me, "You women may talk about your rights, but why don't you invent something?" I answered, "Your horse's feed bag and the shade over his head were both of them invented by women." The old fellow was so taken aback that he was barely able to gasp, "Do tell!" (Mozans 1913, 346)

According to Steven Shapin, a great deal of the hands-on scientific work during the English scientific revolution was done by technicians who were "triply invisible" to historians, to other scientists, and as relevant actors with control over the laboratory where results are produced (Shapin 1994, chapter 8). A minority of scientists, Robert Boyle among them, mentioned their technicians by name in print. Shapin compares these technicians to the Victorian domestic servants, who were "not there." Class intersected with educational opportunity, which determined whether one was an assistant with "mere skill" or a collaborator with "genuine knowledge." While women did not occupy these jobs in England, one can see this sort of role being played in the series of women astronomers from the sixteenth century onward (Wertheim 1995, chapter 3), people like Maria Winkelmann, the eighteenth-century astronomer for the Berlin Academy. Most of these women worked in Germany, all worked in family observatories "under" husbands, fathers, brothers (like the sixteenth-century Danish astronomer Sophe Brahe), or even sons whom they had trained. All can be viewed as examples of people working from a tradition identified by Scheibinger as a craft, or artisan, tradition (Scheibinger 1989, chapter 3). The work was hands-on and not viewed as very cerebral—charting astronomical objects, preparing calendars. There is an interesting carryover to the history of U.S. astronomers from the late nineteenth century onward. Certain subspecialties were considered acceptable for women, those that involved "large scale processing of data" (Mack 1990). These gave women a path to professional employment as astronomers. Many women's colleges supported programs (e.g., Maria Mitchell's program at Vassar in the nineteenth century) that produced graduates who supplied major observatories. Pamela Mack notes that from 1890 to 1920 women authored 4 percent of astronomy papers in the three major journals. Of these, about 48 percent came from women at women's colleges. However, many of the women who made technical contributions to papers in that era do not appear as authors; the papers are written in supervisors' names (Mack 1990, 75). Again, here are contributions of "invisible" women.

Joan Hoffman, one of my students at Swarthmore College, drew a parallel (antiparallel?) between the way a gentleman scientist heading a lab in the seventeenth or eighteenth century might merely enable research, yet receive full credit, and the way women like Robert Boyle's sisters enabled his research, yet received no credit. (Boyle's older sister actually had his chemistry laboratory commissioned and built for him in her manse, and both of his two sisters provided constant intellectual, social, and emotional support [Shapin 1994, chapter 8].) Ruth Bleier makes the observation that in modern times as well, eminent scientists have "a veritable army of unpaid or underpaid women behind them" (Bleier 1986, 4). Clearly, though, the observation that women often receive inadequate credit for their roles as enablers generalizes far beyond science to women's roles in the workplace and in the world economy.[6] The discussion comes full circle if we observe, with Namenwirth, that today "[s]cientific research . . . becomes an arena of competition for prominence and authority, not unlike the arenas of business and politics," and that in this arena there is a "[f]usion of the scientist's image with a masculine authority stereotype" (Namenwirth 1986, 23). An excellent summary of work by Merton, Traweek, and others on the competitive culture of science appears in appears in the Wellesley "Pathways" Report (Rayman and Brett 1993).

It is important to acknowledge that science was not what we would consider a job in the modern sense—and indeed the word "science" was not even coined—until the nineteenth century, when the word was used by William Whewell (Whewell 1834). Understandably, the gentleman "scientists" of sixteenth- through eighteenth-century Europe had a common background of class, money, and leisure in which to conduct their work, and scientists who rose from humble beginnings were rare.[7] From the early years of the scientific revolution, some women participated. But their participation was at the fringes of scientific society, and only noble women like Queen Christina of Sweden or Margaret Cavendish, Duchess of Newcastle, could do so. Acceptable roles consisted of sponsoring learned men in one's court or home and engaging learned men as tutors. Acceptable, too, was a father's arrangement of tutoring in science or mathematics for his daughters. But a woman's trajectory always stopped short of an institutional affiliation. The British Royal Society was established in the late 1600s, and the French Academy around the same time. They both admitted their first woman about 300 years later. Margaret Cavendish was permitted into the Royal Society only for a visit, and only once (Scheibinger 1989, 25, 26). Although there were individual members who very much supported her admittance, the French Academy failed to vote to admit Marie Curie, even after she had won her (first) Nobel prize (McGrayne 1993, 29–30; Scheibinger 1989, 10). This limited trajectory for qualified women reminds one of Rossiter's term "the American Inconsistency," which refers to the fact that until only recently, American society educated, but did not employ, scientific women.

Scientific books were sometimes published by women worthies, but the identity these books always seemed to forge for their authors was that of commentator, expositor, facilitator, not the originator of any of the ideas they espoused. Emilie du Chatelet produced the first (and still the only) French version of Newton's *Principia*. Jane Marcet's extremely popular series of books, *Conversations on Chemistry,* was credited with influencing the young Michael Faraday to take up chemistry, particularly electrochemistry and the study of "voltaic current" (Miller 1990; Bordeau 1982, 110).

Harriet Zuckerman's book *Scientific Elite* is an interesting study of the sociology around that ultimate route to visibility in science, the winning of a Nobel prize. Bearing in mind that the elites in "nearly all departments of social life come in disproportionate numbers from the middle and upper occupational strata" (Zuckerman 1996, 63), she finds it to be manifestly true for the U.S. scientist laureates, as measured by occupational rank of one's father, which in turn correlates with other measures of socioeconomic status. "While inequalities in the socioeconomic origins of American scientists at large have been significantly reduced during the past half century, this has not been the case for the ultraelite in science. Even in a system as meritocratic as American science, in which identified talent tends to be rewarded on the basis of performance rather than origin, . . . the ultraelite continue to come largely from the middle and upper middle strata"

(Zuckerman 1996, 67). Clearly, women are likely to occupy Zuckerman's "41st chair" (a reference to the French Academy, which has only 40 chairs). Jocelyn Bell, the discoverer (while a student) of pulsars, did not win along with her adviser. Lise Meitner never won, though she was nominated in nine different years, almost always jointly with her coworker Otto Hahn.[8] Yet, Zuckerman reports, when Hahn won with Fritz Strassman, he reports it was "given to me for work I had done alone or with my colleague Fritz Strassman," and washed his hands of Meitner's reported "unhappiness" at being left out (Zuckerman 1996, xxiii; Sime 1996, chapter 14 and page 342).

In summary, we encourage our students to think of science as a field in which excellent ideas are unambiguously so. We like to think of it as a meritocracy, not subject to the fickleness of history, because one's scientific work speaks for itself. But if one is excluded from the only scientific society in one's country, its journal won't accept one's paper, people of one's sex are not even permitted in the university faculty club, one has no way, either speaking or writing, to communicate one's thoughts to peers—all of these being the status quo for women until the latter part of this century—one's work can't speak for itself; it is silenced.[9] In the words of Margaret Cavendish: "Being a woman (I) cannot . . . Publicly . . . Preach, Teach, Declare or Explain (my works) by Words of Mouth, as most of the Famous Philosophers have done, who there by made their Philosophical Opinions more Famous, than I fear mine will ever be" (qtd. in Scheibinger 1989, 37).

Feminist Physics?

The issue of whether there is a gendered quality to physics itself is extremely complicated. One might begin with the hypothesis that all human activities are deeply impressed with culturally determined gender norms (Harding 1991).[10] The error we physicists might be making, if we claim that our subject is free of gender content, is to overlook how much our humanity shapes our professional activities at all levels (Easlea 1986).[11] (Often, as with racism, the majority group has the luxury of overlooking such things, whereas the minority group does not.) As Elizabeth Fee notes, "the scientist, the creator of knowledge, cannot step outside his or her social persona" (Fee 1986, 53). One might continue by observing with Schuerich that "Good work depends on exclusion of bias; value free science. Feminists' claim is opposite. But feminist revisions can correct previously undetected bias. The conventional scientific method makes no claim that discovery is context free, only that justification is" (Schuerich 1992, 3).The scientist and feminist Ruth Bleier goes further yet, suggesting that "the scientific method is generally viewed as the protector against rampant subjectivity and the guarantor of the objectivity and validity of scientific knowledge. Yet each step in the scientific method is profoundly affected by the values, opinions, biases, beliefs and interests of the scientist" (Bleier 1986, 3). Clearly, ideas like these open the door to a fascinating debate, which is currently unfolding in the literature thanks to the attention of philosophers of science, Sandra Harding, Evelyn Fox Keller, Helen Longino, and Karen Barad among them (Harding 1991; Keller and Longino 1996; Barad 1996).

Henry Bauer, in his book *Scientific Literacy and the Myth of the Scientific Method,* points out how new is the interest of historians of science in the "externalist" view, that the "context of discovery"—not just the "context of justification"—is quite worthy of study, and quite fundamental to the definition of science. The context of discovery was traditionally excluded from consideration because it was a nonrational part of human experience (Bauer 1992, chapter 6). Hence, it was defined to be irrelevant to science, which was in turn defined as the rational side of the enterprise—a circular definition. Thomas Kuhn, of course, started the "externalist" revolution when he argued that the actual practice of science does not adhere to the "scientific method" (Kuhn 1970). An important distinction made by Bauer is between frontier science and textbook science. He argues that it is impossible to have feminist textbook science, in the sense of a feminist Newton's law or periodic table. Textbook science is rectified by time, distilled into pure law, and represents a logical and coherent body of knowledge with a broad base of people who have confidence it its veracity. The creation of frontier science is a human activity, and the body knowledge on the frontier is incoherent and unreliable. Feminist and other critiques have a real foothold there (Bauer 1992, chapter 6).

As one example of a cultural context for frontier science, Stevenson and Byerly point out that British home life had for centuries encouraged the sort of "enjoyable tinkering" (on the part of the men) that led to prominent scientific discoveries (Stevenson and Byerly 1995, 71, 72). Indeed, there was some snobbery about this; they quote physicist P. Blackett as distinguishing this from the French tradition of idling around in cafés when instead people should be home in their sheds. Blackett was a photographer who toiled in *his* shed; he looked through tens of thousands of alpha particle tracks that he photographed to find the first nuclear reaction, a collision with an alpha particle and a nitrogen molecule. (In response to Blackett, though, we might point out that his French contemporaries Marie and Pierre Curie toiled for years in *their* shed to purify radioactive ores.) The shed versus café debate was the heir to an earlier debate between the salon-based, feminine science of France and the institute-based, masculine science of England. We might symbolize the steps that French science, and ultimately world science, took toward adopting the English scientific culture, by contrasting the early-eighteenth-century collaboration of Voltaire with the physicist Emilie du Chatelet (she helped him with his math) with the later-eighteenth-century attitude of Rousseau, and also of Voltaire by midcentury, whom Scheibinger quotes as pronouncing that "all the arts have been invented by man, not woman" (Scheibinger 1989, chapters 4 and 8, and page 102).

To define physical science in a certain way, following the lead of European "gentleman" scientists from the seventeenth century onward, has brought the field of physics profound successes. Electromagnetism, thermodynamics, relativity, and quantum physics have all produced quantitative predictions about the universe that hold with marvelous success—"unreasonable" success, according to Eugene Paul Wigner—that "we neither understand nor deserve." What is the secret to this success? Bruce Gregory asserts that "Physics is primarily procedural. Its procedure is to uncover the value of a theory by determining its consequences and then seeing if these predictions are confirmed by measurements" (Gregory 1988, 187). Though this is indeed a recipe for success, it is not a recipe unique to physics. Yet, among scientists, there exists what Stephen J. Gould has referred to as "physics envy," and a notorious snobbishness of physics toward sciences with less of a claim to universal truth.[12] The subversive (for a physicist) thought arises that we owe our success not to having such great answers, but to confining ourselves narrowly to such great questions. Wertheim makes this point, noting that the *calculatores* of the fourteenth century were the first scholars to get a handle on velocity and acceleration, the fundamentals of a science of motion. But they also tried to quantify human stuff, such as sin and charity (Wertheim 1995, 53–54). Perhaps physics took a big leap forward around the time that Galileo dropped two masses from a tower in Italy, not because the methods changed but because physicists began asking only the questions for which their methods had good answers.[13]

Der Noether? Die Einstein

The following excerpt from a 1937 coffee-table book on chemistry speaks for itself, as its gendered language and subject matter stake out the field as a male domain: "Although nature, the great chemist, has provided man with the prototypes and methods by which he has attempted, with considerable success, to conquer his environment, her motives and objectives have seldom been man's. The beautiful silks with which man bedecks himself and his womankind, . . . were created for far different purposes than those to which man has put them" (Morrison 1937, 13). Responsibility in language is one of the principles of feminist science espoused by Bleier, and others, in the volume *Feminist Approaches to Science* (Bleier 1986, 16). The choice of words in the teaching or practice of science will readily reveal gender inequities and can have the unfortunate consequence of maintaining them. One cannot only excise the flagrant examples of sexist language, as in the quote above. Inside the physics (and any other) classroom, even the gender of pronouns matters. Various studies have shown that in hearing or reading "he," as well as "man" or "mankind," readers and listeners presume they are hearing about a male (Henley 1989, 59–78; Kramer, Thorne, and Henley 1978; Schneider and Hacker 1973). There is a recent trend in elementary physics texts of depicting people in a way that is representative in terms of gender and race, which is well-founded in this regard. However, the unwavering custom in these same texts of giving names of famous scientists and biographical snippets works to undo this progress. (Anthony Standen criticizes this attempt in chemistry texts: "'Culture' and 'human interest' are dragged in by the scruff of the neck in the form of little potted biographies of famous chemists of the past . . . without giving anything extra that would make the biographical facts interesting and worth knowing by tying them in with the rest of history" [Standen 1950, 80].) In elementary texts, we can see women as subject to the laws of physics as they throw Frisbees, ride bicycles, wire circuits, and fire lasers, but we are simultaneously reminded, thanks to these historical interludes, that not a single woman has "authored" a law of physics. And sadly, "each time a girl opens a book and reads a womanless history, she learns she is worth less" (Sadker and Sadker 1994, 13). Indeed, the importance of being first at articulating a physical principle or effect, which may or may not, depending on the vagaries of history, result in having one's name attached to it, is something that proponents of a feminist science would question. It is at odds with accepted principles of feminist science, which emphasize cooperativeness and collaborativeness (Bleier 1986, 16). Merton describes the "fierce competition among scientists throughout history to be recognized as 'the Discoverer'" (Merton 1962).[14] No less a scientist than Einstein commented on how inappropriate was this drive to be first in discovery, how reminiscent it was of the attempt to win a game, or at sports (Stevenson and Byerly 1995, 44).

The tension between a woman's scientific prowess and the societal norms for her gender may be revealed in the language with which her achievement is discussed. "Sich männlich erweisen" (has proven herself manly) was how a university rector commended Dorothea Erxleben, who was one of the first women to earn a German medical degree. "A Woman who has translated and illuminated Newton [is] in short a very great man" was Voltaire's comment on Emilie du Chatelet. "The best man at Harvard" was Edwin Hubble's pronouncement on astrophysicist Cecelia Payne Gaposchkin. "Monstrosity," said August Strindberg of the great mathematical physicist Sonya Kovalevsky. One could go on and on like this, but as Sandra Harding observes, "it is important to see that the focus should not be on whether individuals in the history of science were sexist. Most of them were; in this they were like most men (and many women) of their day. Instead, the point is that the sexual meanings of nature and inquiry . . . express the anxieties of whole societies or, at least, of the groups whose interests science was intended to advance. Cultural meanings, not individual ones, should be the issue here" (Harding 1991, 44). This should indeed be the focus when we look at androcentric language in physical science. What factors in the culture at large, and in the culture of the science, allow us all to accept the unspoken premise of a joke that begins "Why do physicists have mistresses?"[15] What factors are at work to make the term *woman physicist* an oxymoron?

One interesting set of gendered metaphors within Western scientific culture are baby metaphors. They provide a revealing view of scientific activity through some scientists' eyes, particularly those of some nuclear physicists. Though it is only one subdiscipline of physics, thanks to various political factors the field of nuclear physics has intersected strongly with weapons research. It expanded enormously in the middle of the twentieth century and has thus set a certain pattern for the modern culture of physics as a whole. One might also take a broader view and observe that weapons research and physical science have long had a kinship. In the thirteenth century, Roger Bacon trumpeted the eventual development of optical weapons to his pope (Wertheim 1995, 51). Newton depicted hunters firing at game on the frontispiece of his book introducing calculus (reprinted in Scheibinger 1989, fig. 22.), and so on. The ready identification of physics with the military is, for example, one documented reason that many schoolchildren feel science is a subject meant for boys (Kelly 1981).

Brian Easlea discusses Earnest Rutherford, the "father of atomic physics," at length. In Rutherford's lab "the nucleus was born" (according to C. G. Darwin, his student) (Easlea 1983, 62). That so-and-so is the father of such and such field is a common cliché, yet it deserves a little thought. If so-and-so is the father, then who is the mother? Or is it understood, rather, that this is a special type of paternity, and no maternal element is required? If so, one needs to consider the notion of uterus envy, emphasized by Easlea, Frechet, and others.[16] On the other hand, if one considers, with Francis Bacon, that the scientist has established "a chaste and lawful marriage between Mind and Nature" (quoted in Keller 1985, 36), might Nature be thought of as the mother? This would bring us to the Nature-as-a-woman image with all of its complicated dimensions,[17] including her domination by a tyrannical, male science. As the poet e. e. cummings asks in a poem addressed to the earth, "how often . . . has the naughty thumb of science prodded thy beauty?"

But whoever the mother of such and such a field is, if indeed there is a mother at all, she is of as little consequence as the mothers forced to remain behind curtains in Bacon's utopian community, Solomon's House. Keller notes, "In this inversion of the traditional metaphor, this veritable back firing, nature's veil is rent, maternal procreativity is effectively co-opted, but the secret of life has become the secret of death" (Keller 1992, 45).

The scientific humanist Jacob Brownowski starts his meditation *Science and Human Values* by discussing a visit in 1945 to Nagasaki, soon after it was destroyed by the atomic bomb. The popular song "Is You Is or Is You Ain't Ma Baby?" was playing on the car radio, and he asks whether the awful technology of nuclear weaponry, and the science itself, should be acknowledged as mankind's baby? (With Henley et al., perhaps we should understand the author to mean the male half of humankind.) Brownowski sees science as a precious aspect of our society and he feels that this baby should be acknowledged: "Science has nothing to be ashamed of even in the ruins of Nagasaki" (Brownowski 1956, 73). The community of defense professionals also take great pride (or hubris?) in this baby, as is revealed in studies by Carol Cohn. She has written a series of papers about her interactions with these intellectuals, almost exclusively male, who consult for the government, working at universities and think tanks on issues of nuclear armaments. While these professionals are not, in general, physical scientists, the physicist Freeman Dyson, who has consulted extensively with the military, has confirmed that there is a similarity between the "world of warriors" and of physicists. In both worlds there is a premium on staying cool, using language that emphasizes technical accuracy and objectivity (Dyson quoted in Easlea 1986, 146). They are both worlds where a certain type of cartoonish masculinity is valued. (I say cartoonish, for it is a special type of masculinity traditionally associated with scientists, one that, in many ways, stands in opposition to stereotypical masculinity in our society [see the works cited in note 1].) "Rutherford will think it very effeminate of us to use a null method when we might" is how one of Rutherford's students dismissed a detection technique he eschewed as, apparently, not macho enough (Easlea 1983, 61).

The atomic bomb project was, in Cohn's words, "rife with images of male birth" (Cohn 1987, 687). For example, Ernest Lawrence wrote to the University of Chicago physicists, "Congratulations to the new parents. Can hardly wait to see the new arrival" (quoted in Keller 1992, 44). At Lawrence Livermore National Laboratory, the H-bomb was "Teller's baby," though others said Stan Ulam was the father and Edward Teller was rather its mother (Cohn 1996, 177). The comment originated with Hans Bethe: "Edward was the mother, because he carried the baby for quite a while" (quoted in Easlea 1983, 131). Cohn notes that in this context, maternity is being belittled by being equated with nurturance, as opposed to being considered an agency of creation. (This also belittles nurturance.) Those at Livermore who wanted to disparage Teller's contribution would ascribe to him the maternal role (Easlea 1983, 131). The motherhood imagery was also used in the context of a new satellite system: "We'll do the motherhood role telemetry, tracking, and control the maintenance" (Cohn 1987, 687). The invitation to "pat the missile" that Cohn received on a nuclear submarine evokes for her several images—patting something small and cute, like a baby, is one of them.

Not only were atomic bombs not-of-woman-born, the ones that worked correctly were male (Jungk 1956, 197). "It's a boy," announces a telegram from Teller upon the successful test of the H-bomb (quoted in Easlea 1983, 130). Keller explains that a bomb with "thrust" is a boy baby; a girl baby is understood to be a dud (Jungk 1956, cited in Keller 1992, 197). The bombs dropped on Hiroshima and Nagasaki were dubbed "Fat Man" and "Little Boy," respectively. Curiously, when one sees photographs of nuclear generators—for example, the last image of Barnaby's *Man and the Atom* (Barnaby 1971, 207)—there is an unmistakable emphasis on the phallic character of the device.

Cohn, Easlea, Keller, and others make the point that this world of nuclear professionals is a strange and surrogate world. It is one where life and death are permuted, where bombs are babies, where creative people father destructive monsters, as J. Robert Oppenheimer quotes from the Bhagavad-Gita: "I am become Death, the shatterer of worlds" (Keller 1992, 45; Jungk 1956, 197). Given this bizarre culture, and given the assumption that it reflects scientific culture, should it surprise us that physical science will be perceived as very one-sided, very "masculine"? The epigraphs that began this essay play into this stereotype. Blumenfeld's comment was a lighthearted response to the Harding quote. He shows us how natural it is for a physicist, a true heir of Galileo, to gravitate toward the methods that have served physics traditionally very well. And how strangely these methods juxtapose with a reality that includes sin and charity, parents and children—as if Pharaoh's daughter needed a detailed calculation of statistical mechanics before plucking Moses from the river! To practicing scientists, women and men, a crucial question can be whether one can strike a balance between one's own generativities of babies and of science. Easlea relates that Frederic Joliot loved his new cloud chamber, and he would talk of the creating of a cloud trail by an elementary particle: "Is it not the most beautiful phenomenon in the world?" Whereupon, if Irene Joliot-Curie was in the lab (pregnant at the time), she would reply, "Yes, my dear, it would be the most beautiful phenomenon in the world, if there were not that of childbirth" (quoted in Easlea 1983, 66). These attitudes did not stop either parent from having children and creating artificial radioactivity, winning a Nobel prize, being among the first to identify the positron, and so on.

One of the strengths of women's studies is that, applied to a discipline, it can reveal it in a new light. Thinking about the interplay of gender and science brings fresh insights about science itself. "The culture of no culture" is what the anthropologist Sharon Traweek has called the view of physics that is traditionally held by physicists and their students (Traweek 1988, 132), one of perfect objectivity: mechanistic, no genders, inhuman. But how can this be? I have used the word repeatedly and somewhat matter-of-factly in this essay. This term might be defined as the "patterns of expectations, beliefs, values, ideas and material objects that define the taken for granted way of life for a society or group" (Anderson 1983, 382). According to this definition, how could the community of physical scientists not have a culture, and a rich one at that? We often lose potential physics students, the so-called "second tier" of Tobias's study (Tobias 1990), mostly women and people of color who rebel at what they either perceive to be Traweek's nonculture, or a culture to be avoided—like the culture of defense professionals, perhaps. But a modern understanding of the history and practice of physics, one that acknowledges formerly "invisible" participants and celebrates the collaborative aspects of research, portrays a very different side of the culture. Happily, the culture of physics can be heterogeneous without sacrificing any of the empirical soundness of physical theory thanks to (Wigner's blessed) appropriateness of a mathematical analysis of the world. Research in physical science has throughout history been a cooperative, as well as creative, endeavor.[18] Understanding old physics, and articulating new physics, does not require a Y chromosome. It does require chromosomes. It is something requiring intellect, passion, and personhood.

Notes

1. A few representative works on perceived qualities of scientists are D. C. Fort and H. L. Varney, "How Students See Scientists," *Science and Children* (May 1989), 8; M. C. LaFollette, *Making Science Our Own* (Chicago: University of Chicago Press, 1990); and R. D. Hanes, *From Faust to Strangelove: Representations of the Scientist in Western Literature* (Baltimore, Md.: Johns Hopkins University Press, 1994).
2. A few recent compendia on past and present women scientists are: B. F. Shearer, ed., *Notable Women in the Physical Sciences: A Biographical Dictionary* (Westport, Conn.: Greenwood, 1996); B. F. Shearer, ed., *Notable Women in the Life Sciences: A Biographical Dictionary* (Westport, Conn.: Greenwood, 1996);

H. M. Pycior et al., eds., *Creative Couples in the Sciences* (New Brunswick, N.J.: Rutgers University Press, 1996); M. Alic, *Hypatia's Heritage* (Boston: Beacon, 1986); P. G. Amir-Am and D. Outram, eds., *Uneasy Careers and Intimate Lives* (New Brunswick, N.J.: Rutgers University Press, 1987); M. B. Ogilvie, *Women in Science: Antiquity through the Nineteenth Century* (Cambridge, Mass.: MIT Press, 1990). Some books on contemporary women scientists are S. Ambrose et al., eds., *Journeys of Women in the Sciences* (Philadelphia: Temple University Press, 1997); M. Morse, *Women Changing Science: Voices from a Field in Transition* (New York: Insight Books, 1995). Some recent biographies of notable physicists are R. L. Sime, *Lise Meitner: A Life in Physics* (Berkeley: University of California Press, 1996); S. Quinn, *Marie Curie: A Life* (New York: Simon and Schuster, 1995); J. W. Brewer, ed., *Emmy Noether: A Tribute to Her Life and Work* (Ann Arbor: Books on Demand, 1981).

3. Indeed, it might have been better to see no names at all than to see a student produce a list like this: (1) Pochohontas (the Disney movie of that name had recently been released), (2) Lizzie Borden . . .
4. While the U.S. Department of Patents does not record the sex of patent applicants, they attempt to infer these data. A full report "Buttons to Biotech—U.S. Patenting by Women, 1977 to 1988," (U.S. Patent and Trademark Office Technology Assessment and Forecast Program, January 1989) chronicles the period mentioned in the title. Supplementary, updated figures show that the percentage of patents that include at least one woman inventor have grown each year from 1988 onward. The figure of 8 percent corresponds to the year 1993.
5. For example, J. M. Gage, *Woman as Inventor* (issued under the auspices of the New York State Woman Suffrage Association) (Fayetteville, N.Y.: F. A. Darling Printer, 1870), was followed in 1888 by a compendium of women inventors issued by the U.S. Patent Office. Among more recent books are P. C. Ives, *Creativity and Inventions: The Genius of Afro-Americans and Women in the United States and their Patents* (Arlington, Va.: Research Unlimited, 1987); E. A. Vare, *Mothers of Invention: From the Bra to the Bomb: Forgotten Women* (New York: Morrow, 1988); A. L. MacDonald, *Feminine Ingenuity: Women and Invention in America* (New York: Ballantine Books, 1992); A. Stanley, *Mothers and Daughters of Invention: Notes for a Revised History* (Metuchen, N.J.: Scarecrow Press, 1993). There are many more books on this topic available today.
6. See, for example, R. Steinberg and L. Haignere, "Separate but Equivalent: Equal Pay for Work of Comparable Worth" in *Beyond Methodology,* ed. M. M. Fonow and J. A. Cook (Bloomington: Indiana University Press, 1991); E. Boserup, *Woman's Role in Economic Development* (New York: St. Martin's Press, 1970).
7. Scheibinger notes that though the Royal Society was founded so as to be open to men of all backgrounds "both learned and vulgar . . . the vast majority of the members . . . came from the ranks of gentlemen virtuosi, or wellborn connoisseurs of the new science" (Scheibinger 1989, 25).

8. Sime's biography of Meitner provides many details about the Nobel prize, and the attitudes of Hahn and other scientists close to the issue (many of whom understood Meitner's partnership in the discovery and felt her lack of acknowledgment unjust). Meitner's comment was that Hahn "simply suppressed the past. . . . I am a part of that suppressed past" (Sime 1996, x).
9. "Let the data speak for themselves . . . scientists demand. The problem with this argument is, of course, that data never do speak for themselves"—Evelyn Fox Keller (Keller 1985, 130–31).
10. See, for example, Anderson (1983), chapter 2, for a discussion of the interplay between culturally determined gender and everyday life. For arguments that scientific endeavors are not immune, see M. Namenwirth 1986, as well as Harding 1991.
11. See, for example, Stevenson and Byerly (1995) for an introduction to how scientists' activities are shaped by culture and society.
12. For example, chapter 3 of A. Standen, *Science Is a Sacred Cow* is entitled "Science at Its Best—Physics" and begins: "The various sciences can all be arranged in order, going from fairly good through mediocre to downright bad. Allowing the scientists to put their best foot forward, we may as well begin with the best of the sciences, which is physics" (Standen 1950, 59).
13. Interesting, in this regard, is Galileo's determination to distinguish quantities that are "really present in physical objects from those that are merely subjective qualities of human sensation" (Stevenson and Byerly 1995, 27), and to make the former the focus of his studies.
14. See also the case studies involving priority disputes among famous scientists in Stevenson and Byerly (1995) chapter 5.
15. Answer: So that they can tell their wives they are with their mistresses, and their mistresses that they are with their wives, and spend the night at the lab.
16. "Male science, male alchemy is partially rooted in male uterus envy, in the desire to create something miraculous out of male inventiveness."—Phyllis Chesler, *About Men* (quoted in Frechet 1991, 216, 217).
17. See, for example, C. Merchant, *The Death of Nature* (San Francisco: Harper and Row, 1980), chapter 7.
18. One book that emphasizes these and other feminine-identified aspects of scientific culture is L. J. Shepherd, *Lifting the Veil: The Feminine Face of Science* (Boston: Shamhala Press, 1993).

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