GETTING MORE WOMEN INTO SCIENCE: KNOWLEDGE ISSUES

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Innovations surrounding women and gender have rocked the worlds of science and technology in the past three decades. Who, for example, could have predicted that the chief scientist at NASA would be a woman (France Córdova, now Chancellor at the University of California, Riverside)? Or who would have thought that geneticists would dethrone the "master-gene" model—that conceptualized mammalian sex as determined by a single master gene on the Y chromosome—and put in its place an account that emphasizes interactions between the testes and ovaries?[1] Or who would have imagined that an artificial knee would be designed with nineteen unique aspects to meet the unique skeletal and load-bearing needs of females?[2]

In my lifetime, the situation for intellectual women in the United States has improved dramatically. We can measure some of these changes iconographically. Anyone growing up in American consumer culture understands the power of images. Images project messages about hopes and dreams, mien and demeanor, about who should be a scientist and what science is all about. We see some interesting changes in who is imagined to be a scientist in our society. Historically, when prompted to "draw a scientist," 92 percent of the students drew males (Fig. 1).[3] By the late 1990s, that had reduced to 70 percent with some 16 percent of the scientists drawn being clearly female and another 14 percent ambiguous with respect to sex (Fig. 2).[4] A remarkable 96 percent of the scientists continued to be depicted as Caucasian despite the prominence of Asians in science.[5]

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[1] Sarah S. Richardson, *When Gender Criticism Becomes Standard Scientific Practice: The Case of Sex Determination Genetics*, *in* GENDERED INNOVATIONS IN SCIENCE AND ENGINEERING (Londa Schiebinger ed., forthcoming 2008).

[2] Barnaby J. Feder, *Women Get Knees to Call Their Own*, N.Y. TIMES, May 11, 2006, at C3.

[3] Jane Kahle, *Images of Science: The Physicist and the Cowboy*, *in* GENDER ISSUES IN SCIENCE EDUCATION 1, 2 Fig.1 (Barry Fraser & Geoff Giddings eds., 1987).

[4] Jrène Rahm & Paul Chambonneau, *Probing Stereotypes through Students' Drawings of Scientists*, 65 AM. J. PHYSICS 774, 776 Fig.1 (1997). This sample of students was 80% female. *Id.*

[5] *Id.*

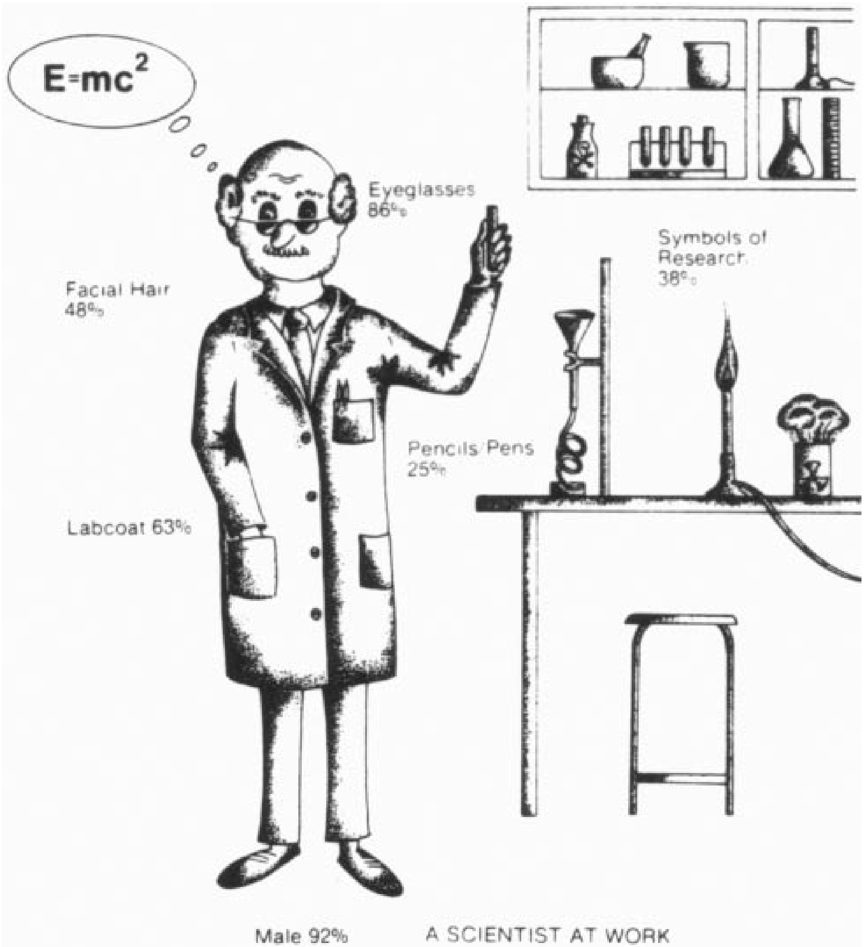

FIGURE 1: JANE KAHLE, *IMAGES OF SCIENCE: THE PHYSICIST AND THE COWBOY*, *IN* GENDER ISSUES IN SCIENCE EDUCATION 1, 2 Fig.1 (Barry Fraser & Geoff Giddings eds., 1987).

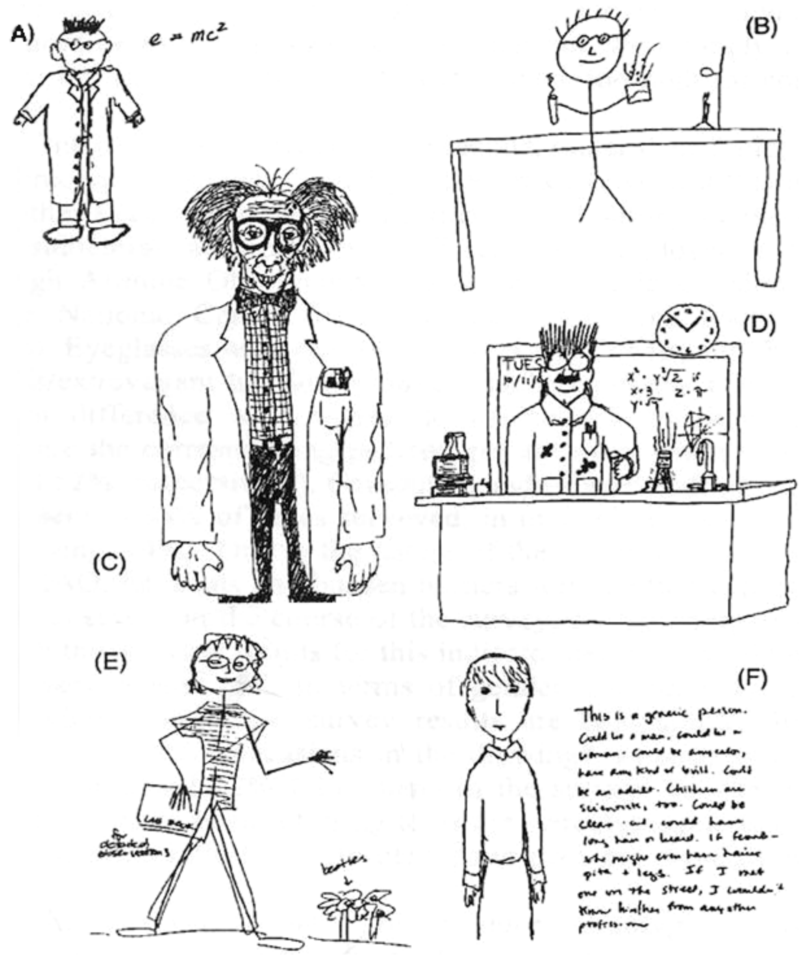

FIGURE 2: JRÈNE RAHM & PAUL CHAMBONNEAU, *PROBING STEREOTYPES THROUGH STUDENTS' DRAWINGS OF SCIENTISTS*, 65 AM. J. PHYSICS 774, 776 Fig.1 (1997).

We can also see gendered innovations in the content of science, in this case, in understandings of human evolution. Most of us grew up with an image of human evolution as the "evolution of man." Evolutionary theory presented males as actively and aggressively driving forward human evolution.[6] According to Charles Darwin, only what he termed the "equal transmission of characters" allowed women to continue to evolve along with males, who were the ones who embodied the traits of courage and intelligence that kept humans evolving.[7]

[6] *See generally* MAN THE HUNTER (Richard B. Lee & Irven DeVore eds., 1968).

[7] Linda Marie Fedigan, *The Changing Role of Women in Models of Human Evolution*, 15 ANN. REV. ANTHROPOLOGY 25, 29–33 (1986); *see also* SARAH BLAFFER HRDY, THE

In 1993, a much-heralded new image was produced to correct this picture. In that year the American Museum of Natural History in New York opened its new "Human Biology and Evolution" exhibit featuring this reconstruction of early humans from the 3.5 million-year-old footprints preserved in volcanic ash near Laetoli (Fig. 3).[8] This diorama clearly gives woman a place in human evolution, and although the assumptions captured in this image have changed dramatically since the 1960s, the process is still incomplete. The humans embodying the footprints are portrayed as a robust male towering over his smaller female consort, his arm positioned to protect and reassure her. We simply do not know, however, the sex or relationship of the two individuals who made these impressions—footprints cannot be sexed. These early humans might have been a large male and his much smaller mate, but they might also have been a parent comforting his or her adolescent offspring, or just two friends fleeing the volcano.

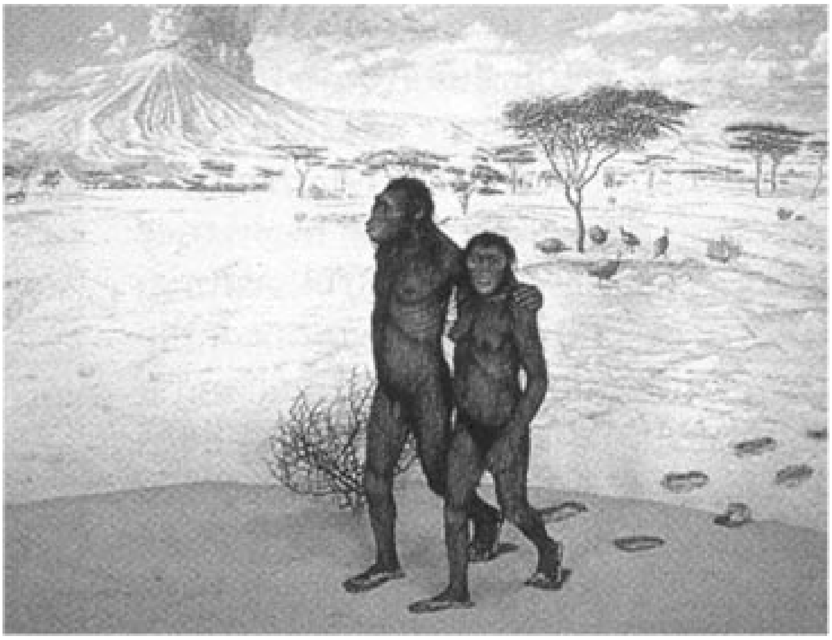

FIGURE 3: HUMAN BIOLOGY AND EVOLUTION, IMAGE # 2A19270 © AMERICAN MUSEUM OF NATURAL HISTORY.

WOMAN THAT NEVER EVOLVED (1999) (describing how social Darwinism has been used to explain and justify social inequalities between men and women). For early critiques of Darwin, see generally HEDWIG DOHM, WOMEN'S NATURE AND PRIVILEGE (Constance Campbell trans., Hyperion 1976) (1896); ELIZA BURT GAMBLE, EVOLUTION OF WOMAN: AN INQUIRY INTO THE DOGMA OF HER INFERIORITY TO MEN (Hyperion 1976) (1894); ANTOINETTE BROWN BLACKWELL, THE SEXES THROUGHOUT NATURE (Hyperion 1976) (1875).

[8] Image # 2A19270 © American Museum of Natural History.

The purpose of this essay is to analyze U.S. theory and practice of creating equality for women in science. As a framework, I set out three distinct levels for analysis: 1) the participation of *women* in science; 2) gender in the *cultures* of science; 3) gender in the *results* of science.[9] I will touch on each of these levels but focus on the third, and explore, in particular, how gender analysis, when turned to the sciences, can profoundly affect human knowledge. We will investigate how sharpening understandings of how gender functions in science and society can open new questions and fields for future research and spark creativity in particular fields of science.

While I think it helpful to distinguish these three analytical levels to the problem of getting more women into science, these three levels are closely tied together. I firmly believe, however, that women will *not* become equal participants in science until we have fully investigated and resolved issues at the third level, the level of knowledge.

When considering how bringing women into science might require and/or result in changes in the theories and practices of science, we must remember that modern, academic disciplines are arbitrary ways of cutting up knowledge. They are historical, not natural. Disciplines have developed over the past two hundred years when women and underrepresented minorities were stringently excluded from the academy.[10] We need to be open to the possibility that human knowledge—what we know, what we value, what we consider important—may change dramatically when women become full partners in knowledge production. Science is about critical thinking, exploration, and travel into unknown worlds.

And we need to seize the moment right now as universities across the country move toward interdisciplinarity in an unprecedented fashion. Knowledge and the keepers of knowledge—academic institutions—are being remade. Now is the time to make gender an important category of analysis in new disciplinary configurations.

The Participation of *Women* in Science

The first and most straightforward level of analysis focuses on increasing the participation of women in science. This level addresses the history and sociology of women's engagement in scientific institutions. Who are the great women scientists? What are their achievements? What are the experiences of women in university, industrial, and governmental laboratories?[11]

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[9] *See generally* Londa Schiebinger, Has Feminism Changed Science? (1999).

[10] *See generally* Londa Schiebinger, The Mind Has No Sex? Women in the Origins of Modern Science (1989).

[11] *See generally* Margaret W. Rossiter, Women Scientists in America: Before Affirmative Action, 1940–1972 (1995) (looking at the positions of women in scientific laboratories in the mid-twentieth century); The Outer Circle: Women in the Scientific Community (Harriet Zuckerman et. al. eds., 1991) (discussing modern research into women in science); Margaret W. Rossiter, Women Scientists in America: Struggles

Since the Sputnik years, the United States and Western European countries have attempted to increase the participation of their populations in science—women as well as men. In the U.S. this led to foundational legislation, including the Equal Pay Act of 1963,[12] Equal Employment Opportunity Act,[13] and Title IX of 1972,[14] designed to foster equality for women. Beginning in the 1980s, the National Science Foundation ("NSF") has attempted to improve the numbers of women in science and engineering by jump-starting their careers with extra research monies and career supports.[15] The National Academies (the National Academy of Science, National Academy of Engineering, and the Institute of Medicine) have undertaken similar programs. Founded in 1991, the Academies' Committee on Women in Science and Engineering ("CWSE") has worked with Congress and universities in setting policy aimed at assisting women's careers.[16] These types of programs have generally aimed at increasing the numbers of women in science by "fixing the women"—that is, making them more competitive—by increasing funding to women's research, teaching them how to negotiate for salary, or, more generally, how to succeed in a man's world.

An interesting new development at this level is the attempt to apply Title IX to science. In spring 2005, the Government Accountability Office issued a report prepared for Senators Ron Wyden and Barbara Boxer on how Title IX of the U.S. Education Amendments of 1972 can be harnessed to increase the number of women and minorities in science.[17] Work on this issue is still in progress.[18]

Gender in the *Cultures* of Science

A culture is more than institutions, legal regulations, or a series of degrees or certifications. It consists of the unspoken assumptions and values of its members. Despite claims to objectivity and value-neutrality, the sciences have identifiable cultures whose customs and folkways have developed over time. Many of these customs developed historically in the absence of wo-

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and Strategies to 1940 (1982) (discussing the early history of women in scientific laboratories).

[12] Equal Pay Act of 1963 § 1, 29 U.S.C. § 201 (2000).

[13] Equal Employment Opportunity Act of 1972 § 1, 42 U.S.C. § 2000e (2000).

[14] Title IX of the Education Amendments of 1972 § 1, 20 U.S.C. § 1681 (2000).

[15] Sue V. Rosser, *Building Two-Way Streets to Implement Policies that Work for Gender and Science*, *in* Gendered Innovations in Science and Engineering, *supra* note 1.

[16] France A. Córdova, *Projects of the National Academies on Women in Science and Engineering*, *in* Gendered Innovations in Science and Engineering, *supra* note 1.

[17] U.S. Gov't Accountability Office, Gender Issues: Women's Participation in the Sciences Has Increased, But Agencies Need to Do More to Ensure Compliance with Title IX, GAO Report No. GAO-04-639 (2004), *available at* http://www.gao.gov/new.items/d04639.pdf.

[18] *See, e.g.*, Michelle R. Clayman Institute for Gender Research, Stanford University, Making Use of Title IX: Women in Science, Engineering, Technology, and Mathematics (2006), http://www.stanford.edu/group/gender/ResearchPrograms/TitleIX.html.

men and, as I have argued elsewhere, also in opposition to their participation.[19] This second level asks how the cultures of science, where success requires at least some mastery of the rituals of day-to-day conformity, codes governing language, styles of interactions, modes of dress, hierarchies of values and practices, have been formed by their predominantly male practitioners. Programs at this level work to "fix the institutions." The National Science Foundation's current ADVANCE grants, for example, attempt to transform university cultures.[20] These efforts range from removing subtle gender biases from hiring practices to restructuring the academic work/life balance by offering parental leave or stopping the tenure clock.[21]

Much remains to be done at this level. To this end, Stanford's Clayman Institute for Gender Research launched a major study of dual-career academic couples in 2006.[22] The growing phenomenon of dual-career couples represents an asymmetry in professional culture that affects women's careers more than men's since women more often than men are partnered with professionals. Among heterosexual couples in the U.S. (and we do not yet have equivalent studies of same-sex couples), women tend to practice "hypergamy," that is to say, they tend to marry men of higher (or at least not lower) status than their own. This is due partly to the fact that women's social status was determined historically through marriage, while men's was more often determined by inheritance or success in a profession. Consequently, professional women today are more disproportionately partnered with professionals than are men. To complicate matters further, academics tend to couple within the same discipline. While only 6 percent of physicists are women, for example, an astonishing 43 percent of them are married to other physicists.[23] An additional 25 percent are married to some other type of scientist.[24] A remarkable 70 percent of women mathematicians and 46 percent of women chemists are partnered with men in their own fields.[25]

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[19] *See generally* SCHIEBINGER, *supra* note 10.

[20] NAT'L SCI. FOUND., ADVANCE: INCREASING THE PARTICIPATION AND ADVANCEMENT OF WOMEN IN ACADEMIC SCIENCE AND ENGINEERING CAREERS (2005), http://www.nsf.gov/pubs/2005/nsf05584/nsf05584.htm. The synopsis of the program available on the website states "Institutional Transformation Awards support academic institutional transformation to promote the increased participation and advancement of women scientists and engineers in academe. These awards support innovative and comprehensive programs for institution-wide change." *Id.*

[21] *See generally* SCHIEBINGER, *supra* note 9; COMM. ON MAXIMIZING THE POTENTIAL OF WOMEN IN ACADEMIC SCI. & ENG'G, NAT'L ACADS., BEYOND BIAS AND BARRIERS: FULFILLING THE POTENTIAL OF WOMEN IN ACADEMIC SCIENCE AND ENGINEERING (2006); VIRGINIA VALIAN, WHY SO SLOW? THE ADVANCEMENT OF WOMEN (1998).

[22] *See* MICHELLE R. CLAYMAN INSTITUTE FOR GENDER RESEARCH, STANFORD UNIVERSITY, DUAL CAREER ACADEMIC COUPLES (forthcoming 2007), *description available at* http://www.stanford.edu/group/gender.

[23] PAMELA HAWKINS BLONDIN, AMERICAN PHYSICAL SOCIETY, 1990 SURVEY OF THE MEMBERSHIP OF THE AMERICAN PHYSICAL SOCIETY 19, 23–24 (1990) (on file with author).

[24] *Id.*

[25] Michelle R. Clayman Institute for Gender Research, Stanford University, Dual-Career Academic Couple Study (2006–07) (unpublished results of a survey of thirteen leading U.S. research universities, on file with author).

Although universities have begun to reform hiring practices to accommodate some, usually outstanding, dual-career couples, being a partner in such a couple makes it difficult to follow the logic of a career and seize opportunities as they arise.[26]

The Stanford study seeks to understand hiring and retention practices involving couples at leading U.S. research universities. This study will culminate in policy recommendations aimed at helping universities recruit and retain top faculty, including women, to leading faculty and administrative positions. Restructuring university practices will help transform the way universities do business and grow academic cultures where women, too, can flourish.

Gender in the *Results* of Science

Many people are willing to concede that women have not been given a fair shake, that social attitudes and scientific institutions need to be reformed. They are also increasingly willing to concede that women are excluded in subtle and often invisible ways. They stop short, however, from analyzing how gendered practices and ideologies have structured knowledge. Is the question of gender in science merely one of institutions and opportunities for women, or does it impact upon the content of these disciplines as well?

Since the Enlightenment, science has stirred hearts and minds with its promise of a "neutral" and privileged vantage point, above and beyond the rough and tumble of political life. Men and women alike have responded to the lure of science: "the promise of touching the world at its innermost being, a touching made possible by the power of pure thought."[27] The power of Western science—its methods, techniques, and epistemologies—is celebrated for producing objective and universal knowledge, transcending cultural restraints. With respect to gender, race, and much else, however, science is not value neutral. Scholars have begun to document how gender inequalities, built into the institutions of science, have influenced the knowledge issuing from those institutions.[28]

Here I will discuss several examples of how removing gender bias can open science to new perspectives, new questions, and new missions. Before

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[26] *See generally* Lisa Wolf-Wendel et al., The Two-Body Problem: Dual-Career-Couple Hiring Policies in Higher Education (2003); Laurie McNeil & Marc Sher, Dual-Science-Career-Couples: Survey Results (1998), http://www.physics.wm.edu/~sher/survey.pdf.

[27] Evelyn Fox Keller, Secrets of Life, Secrets of Death: Essays on Language, Gender and Science 78 (2002).

[28] *See, e.g.*, Engendering Archaeology: Women and Prehistory (Joan Gero & Margaret W. Conkey eds., 1991); Londa Schiebinger, Nature's Body: Gender in the Making of Modern Science (2004); Schiebinger, *supra* note 9; Bonnie Spanier, Impartial Science: Gender Ideology in Molecular Biology (1995); Women in Human Evolution (Lori Hager ed., 1997).

we turn to these examples, let me say a word first about difference feminism in this regard. Difference feminism—the notion that *women* do science differently—can be especially *unhelpful* when applied to knowledge. In the 1980s much difference feminism promoted the notion that women had a lot to contribute to science because, it was said, women hold different values and think differently.[29] It is important to understand, however, that gender characteristics often attributed to women—cooperation, caring, cultivating a feeling for the organism, or whatever it may be—date back to the eighteenth century and were produced in efforts to keep women out of science and the public sphere.[30] In romanticizing traditional femininity, difference feminism does little to overturn conventional stereotypes of men and women. Women's historically wrought gender differences cannot serve as an epistemological base for new theories and practices in the sciences. There is no "female style" or "women's ways of knowing" ready to be plugged in at the laboratory bench or clinical bedside. Women as females of the species do not do science differently; science should not necessarily be "for women, by women, about women." Moreover, difference feminism or standpoint theory, as it is sometimes called, can tend to exclude men from understanding how gender operates.[31]

This is not to say that gender bias has not had a huge impact on science: ignoring these biases is to ignore possible sources of error in past and also future science. What we need is to develop tools of gender analysis. This should include: collecting empirical examples of how gender analysis has changed theory or practice in specific subfields of science; developing frameworks for gender analysis; developing new ways of addressing these issues for sciences such as physics and chemistry, where gender appears not to play a role; and requiring training in gender analysis at the undergraduate and graduate levels. It must be emphasized that gender analysis requires rigorous training; there is no recipe that can be simply plugged into the design of a research project. It must also be emphasized that the tools for gender analysis are as diverse as the variants of feminism and of science. As with any set of tools, new ones will be fashioned and others discarded as circumstances change. Some transfer easily from science to science, others do not. The brilliance of their implementation depends, as with other research methods, on the creativity of the research team. Training in gender analysis is something that must become part of undergraduate and graduate education also in the sciences—for everyone. Gender analysis acts as yet another experimental control to heighten critical rigor.

Perhaps the best way to understand how gender analysis works is to study examples where this type of analysis has opened new perspectives or

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[29] MARY BELENKY ET AL., WOMEN'S WAYS OF KNOWING: THE DEVELOPMENT OF SELF, VOICE, AND MIND (1986); KNOWLEDGE, DIFFERENCE, AND POWER: ESSAYS INSPIRED BY WOMEN'S WAYS OF KNOWING (Nancy Goldberger et al. eds., 1996).

[30] *See* SCHIEBINGER, *supra* note 10, at 214–64.

[31] See SCHIEBINGER, *supra* note 9, at 4–8.

insights in particular areas. The best example of how gender analysis has changed science comes from the biomedical sciences, where we have witnessed a revolution in women's health research. Since the 1960s, the U.S. has had an active women's health movement; women of all classes and backgrounds demanded better health care. By the 1980s, scholars had documented that many medical studies funded by the federal government included few female subjects.[32] Critics found, for example, that a number of large and influential medical studies had omitted women completely—most notably the 1982 "Physicians Health Study of Aspirin and Cardiovascular Disease" performed on 22,071 male physicians and on zero women.[33] Scholars documented that research conducted primarily among men had for many years been generalized to women, even though outcomes for women in terms of disease, diagnosis, prevention, and treatment were not known.

The net effect of gender bias in medical research and education is that adverse drug reactions occur more frequently in women than in men.[34] For example, over-the-counter antihistamines, initially tested in men, can lead to potentially fatal heart arrhythmias in women.[35] It is important to point out that no self-correcting mechanism of scientific research kicked in to correct for gender bias in medical research. It seems fairly evident that studying drugs in non-representative populations is just bad science. Correction of the situation in this case required conscious intervention and training. Importantly, in 1993 Congress passed a federal law requiring that women must be included in clinical drug trials, and that cost could not be used as a justification for excluding them.[36]

In the 1990s, this situation began to improve. The National Institutes of Health ("NIH") founded the Office of Research on Women's Health. This office has two missions: to increase the number of women in the medical profession and to reconceptualize medical research to include women. In 1991, the federal government announced the Women's Health Initiative, a fourteen-year, $625 million study of diseases unique to or prevalent in women. This is the largest single study ever undertaken by NIH.[37] As Bernadine Healy, former head of NIH who oversaw these innovations, put it:

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[32] *See* WOMEN'S HEALTH: COMPLEXITIES AND DIFFERENCES (Sheryl Ruzek et al. eds., 1997).

[33] SUE V. ROSSER, WOMEN'S HEALTH: MISSING FROM U.S. MEDICINE 6 (1994). Recent studies have shown that while aspirin significantly lowered the risk of heart attack in men, it did not in women. Eliot Marshall, *From Dearth to Deluge*, 308 SCIENCE 1570 (2005).

[34] ANNA MASTROIANNI ET AL., INSTITUTE OF MEDICINE, WOMEN AND HEALTH RESEARCH: ETHICAL AND LEGAL ISSUES OF INCLUDING WOMEN IN CLINICAL STUDIES, VOLUME II 37 (1994).

[35] Jocelyn Kaiser, *Gender in the Pharmacy: Does it Matter?*, 308 SCIENCE 1572 (2005).

[36] Lesley Primmer, *Women's Health Research: Congressional Action and Legislative Gains: 1990–1994*, *in* WOMEN'S HEALTH RESEARCH: A MEDICAL AND POLICY PRIMER 301, 309–10 (Florence Haseltine & Beverly Jacobson eds., 1997).

[37] *Id.* at 314.

"Let's face it, the way to get scientists to move into a certain area is to fund that area."[38]

Removing gender bias from medicine has helped to improve women's health and well-being. Uncovering gender bias, however, can also lead to improvements in human knowledge more generally. Some tools of gender analysis examine hypothesis-generating metaphors used in science. Take, for example, the wide-spread practice in zoology of calling herds—of horses, antelope, elephant seals, etc.—"harems." The assumption is that one mighty male, acting as sultan, safeguards his females, who reserve their sexual services for him alone. Gender analysis has called such assumptions into question. It has long been thought that horses, for example, run in harems. Questioning the governing metaphor has led to new scientific understandings of equine breeding and behaviors. Recent DNA studies of mustangs, for example, show that a stallion typically sires less than a third of the foals in a band. If he were a sultan, he did not guard his females well; the females seemed to have minds of their own and certainly mated outside the band.[39]

Second to medicine, biology is a field that has been much transformed by gender analysis. These transformations have not been driven by policies of granting agencies, but by a growing awareness that removing gender bias can improve science. Because biology deals with sex and gender, and because biology has been open to women (currently 45 percent of Ph.D.s are women), biologists have moved swiftly to remove glaring cultural bias. In addition, textbooks have been revised to include the contributions of women scientists and to remove outmoded and sexist metaphors (of the heroic sperm capturing demure and passive eggs, for example).[40]

Philosopher of science Sarah Richardson tells the powerful story of how gender analysis contributed to an overhaul of theories of sex determinism that guide research in reproductive biology.[41] Tending to privilege things male in the 1980s, geneticists championed a "master-gene" model of sex determination (the notion that a single gene controls the development of an entire organ system).[42] Further, they saw the Y chromosome as a trigger gene that, in tandem with sex hormones, drove sexual dimorphism. In this model, a gene on the Y chromosome initiates testis formation, and testis formation was thought to determine sex.[43] In other words, the Y chromosome triggered development in males. Females, lacking this trigger, were thought to develop along a default pathway.

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[38] Trisha Gura, *Estrogen: Key Player in Heart Disease Among Women*, 269 SCIENCE 771, 773 (1995).

[39] SCHIEBINGER, *supra* note 9, at 149.

[40] *See* Emily Martin, *The Egg and the Sperm: How Science has Constructed a Romance Based on Stereotypical Male-Female Roles*, 16 SIGNS: J. WOMEN CULTURE & SOC'Y 485 (1991).

[41] *See* Richardson, *supra* note 1.

[42] *Id.*

[43] *Id.*

Richardson documents how the development of gender analysis in the 1990s, along with an active women's movement in both society and science, dethroned the master gene and put in its place a model of sex determination that takes into account the interactions of testes and ovaries in the co-production of sexual dimorphism.[44] Today biologists see male and female pathways both as highly interactive.[45] Richardson goes on to make the important point that although geneticists gradually became sensitive to gender issues, they did not credit feminism for the many insights it provided.[46] Often when gender becomes one among many tools of analysis in a research program, its feminist roots are ignored. We need better to understand why it is that when feminism enters the mainstream, it becomes "business as usual" and is no longer seen as feminist.

A final example comes from the work of paleoanthropologist Lori Hager. Hager has documented how unexamined assumptions about gender have contributed to sexism in sexing fossils—the prized "finds" for human origins research.[47] When viewed uncritically, fossils tend to tell us more about the assumptions of modern-day researchers than about our human ancestors. Working with partial and fragmented skeletons, paleoanthropologists have in the past tended to sex large and robust specimens male, and diminutive specimens female.[48] This bias is itself so robust that a whopping 90 percent of Australian Aboriginal skeletal remains have been sexed male—well over the expected sex ratio of about 50 percent.[49] It is scientifically improbable. Hager has discussed how gender analysis helped researchers better recognize that small and large fossils can represent either female and male members of one highly sexually dimorphic species, or individuals belonging to two different species, one robust and the other small.[50]

Moving Forward

It is abundantly clear that sexual divisions in physical and intellectual labor structure institutions, knowledge, and everyday objects in our own society, such as artificial hearts and shopping carts. It is also clear that gender analysis has not yielded results uniformly across the various fields of science. While examples of how gender has brought new insights abound in biomedicine, the life sciences, archaeology, primatology, and elsewhere, similar examples are not available for physics or chemistry, for example. The physical sciences have by and large resisted gender analysis. There are

[44] *Id.*
[45] *Id.*
[46] *Id.*
[47] Lori D. Hager, *Sex Matters: Letting Skeletons Tell the Story, in* Gendered Innovations in Science and Engineering, *supra* note 1.
[48] *Id.*
[49] *Id.*
[50] *Id.*

several possible reasons why this is so. First, we observe that in disciplines such as biomedicine and biology, with a good number of women practitioners, more progress has been made in knowledge issues. But which came first—the openness of the discipline to new intellectual insights or the greater numbers of women in those disciplines? We do not know. One thing that is true is that the number of people trained in either physics or chemistry and gender studies is extremely small and is something that should be remedied. Second, the lack of interest in gender analysis in the physical sciences may also be due to the fact that objects and processes of the physical sciences are less obviously gendered, if at all. That no gender dimensions exist in physics or chemistry, however, is currently merely a well-formulated hypothesis. We need to run the research.

Once we have made some headway developing gender analysis useful to the natural sciences, how do we mainstream this type of analysis in the day-to-day work of science? There are two next steps. First, we need to train students, undergraduate and graduate, along with faculty in how to integrate gender analysis into their research. While most people agree that a student needs to learn molecular biology or particle physics in order to excel in those fields, many believe that one can just "pick up" an understanding of gender along the way. Understanding gender, however, requires research, development, and training, as in any other field of intellectual endeavor. The NIH programs I described earlier worked, for example, because a solid body of gender research on these issues was available from a number of leading institutions across the U.S. New possibilities are also on the horizon. If we are training faculty and graduate students about gender biases in scientific cultures through programs such as the University of Michigan's highly-successful Strategies and Tactics for Recruiting to Improve Diversity and Excellence ("STRIDE") program, adding a knowledge dimension is relatively easy.[51]

Second, and this is where policy kicks in, we need to move the NSF along towards requiring that federally-funded science and engineering integrate gender analysis into research design, where appropriate. The NSF is lagging behind other federal and international agencies in this regard. At the NIH, as noted above, the Office of Research on Women's Health requires proper consideration of sexual differences in medical research.[52] Also, at the European Commission, the Directorate General for Research requires that project design address "systematically whether, and in what sense, sex and gender are relevant in the objectives and methodology of projects" in addition to the requirements that research must address women's needs, as much

[51] Abigail J. Stewart et al., *Recruiting Women Faculty in Science and Engineering: Preliminary Evaluation of One Intervention Model*, 10 J. Women & Minorities Sci. & Eng'g 361 (2004).

[52] Office for Research on Women's Health, 2 Agenda for Research on Women's Health for the 21st Century 205–11 (1999), *available at* http://orwh.od.nih.gov/research/Agenda_Book_2.pdf.

as men's needs, and women's participation in research must be encouraged both as scientists/technologists and within the evaluation, consultation and implementation process.[53] Policy makers need to move NSF to this position. A number of countries in Europe, such as the Netherlands and Sweden, have made increasing the number of women along with integrating gender analysis into research design part of their national science policy. Even where this is the case, however, more training is needed in how to incorporate gender analysis into science research. On a recent visit to Sweden I learned that, although such policies are in place, few researchers know what exactly to do.

Let me conclude by suggesting that much work remains to be done. One of the many tasks at hand is to continue to collect empirical examples of how gender analysis has changed theory or practice in specific subfields of science.[54] We need also to continue to develop frameworks of gender analysis that address these issues for sciences, such as physics and chemistry, where gender appears not to play a role in knowledge. Let me emphasize again that this work is crucial to our efforts to recruit and retain women—we will not solve that problem until we solve the knowledge problem. It is intriguing that sciences, such as biomedicine, primatology, archaeology, and biology, where gender analysis has flourished, have relatively high numbers of women. In these fields and in many fields in the humanities, employing gender analysis has added spark and creativity by asking new questions and opening new areas to research. Can we afford to ignore such opportunities?

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[53] European Comm'n, *Annex 4: Integrating the Gender Dimension in FP6 Projects*, *in* Guide for Proposers, Research and Innovation: Structuring the European Research (2006). The requirement that gender analysis be mainstreamed in research design has been removed in the EU 7th framework. Question and Answer Session, German Federal Ministry of Education and Research/European Union Research Commission Conference (Apr. 18, 2007).

[54] *See* Schiebinger, *supra* note 9.