WOMEN IN SCIENCE: HISTORICAL PERSPECTIVES

Londa Schiebinger[1]

Before I turn to the substance of my remarks let me test your knowledge of women in science by looking at what every American should know about milestones in the history of women in science. Let us begin with the world's major scientific academies of science. These were founded in the seventeenth century—the Royal Society of London (the oldest continuous society of science) in 1660, the Parisian Académie Royale der Sciences (perhaps the most prestigious academy of science) in 1666, the Akademie des Wissenschaften in Berlin in 1700. These academies are today over 300 years old. Here's the question. When was the first woman admitted to the prestigious Académie des Sciences in Paris? Not until 1979, just 13 years ago, when physicist and mathematician Yvonne Choquet-Bruhat was admitted, and she was the daughter of a prominent mathematician and the wife of an academy member.

A second question. When was the first book written on the problem of women in science? Extra credit if you know what it was. Already in 1405, Christine de Pizan asked in her *Book of the City of Ladies* if women had made original contributions in the arts and sciences. She answered the question positively by emphasizing women's contribution to the invention of writing and calculation, and also to practical arts such as the making of bread, the invention of knitting, and making of fine tapestries.

Women scientists have become the objects of a new field of study in the academy. In the last fifteen years a whole new field of inquiry known differently as "women and science," "gender in science," or any combination of those, has sprung up in the US. Many books have been published on the subject; you can take University courses in it. These new studies ask a number of questions—each looking in a different way at the inequalities women suffer in the professional world of science. First—a historical question—is women's participation in science ancient, or has it become important only in the twentieth century? In other words, have women been scientists for a long time and we just don't know about them, or is women's participation a phenomenon of the twentieth century? A second question: where is women's participation the greatest—in Britain, India, the U.S., China, or France? More important than the empirical questions are the analytical ones. How could greater participation of women in science be achieved? What conditions foster greater participation of women in the sciences? And a final question, one which is the subject of hot debate and one which alarms a number of people because our culture has invested so heavily in it not being true: Would science be any different if women played a greater role—are men's and women's style of scholarship different, or are their research interests, priorities, and ways of looking at problems completely interchangeable as we have been led to believe? In other words, would women tackle different problems and go at it a bit differently if their presence in science were the norm and not the exception?

I want at least to touch on each of these questions, but let's begin with a historical excursion. The first point to appreciate is that women's participation is not new, or the achievement of the modern world, but is, in fact, ancient. One of the earliest women

in science in the West was the mathematician and astronomer Hypatia. Hypatia lived in Alexandria (part of modern Egypt) in the 4th century. She followed her father as a professor of mathematics and philosophy at the university. According to Socrates, students flocked to hear her lectures. Hypatia authored a number of mathematical texts, though most were lost to history when the great Alexandrian library was sacked and burned. All was well—Hypatia was well respected at the university and among civic leaders—but she had not long to live. Hypatia was murdered, not because she was a woman but because she had become enmeshed in the political struggle between neo-platonists and Christians dividing Alexandria at the time. Christian leaders in the city considered Hypatia's philosophy heretical and, Hypatia—an outspoken teacher and exponent of ancient philosophy—lost her life in the repression of the neo-platonists in 412. As the report tells us: During the holy season of Lent, Hypatia was torn from her chariot, stripped naked, dragged to the church and killed by the mob.

During the middle ages, the church dominated learning in the West, and contributions by women came mostly from learned nuns. I'll mention only Hildegard von Bingen, the noted cosmologist of the twelfth century.[2]

With the emergence of modern science in the 17th century, the institutional base of science shifted. The domination of learning by monasteries and universities gave way to scientific academies—the Royal Society of London, the Académie des Sciences in Paris, and the Akademie der Wissenschaften in Berlin. As noted earlier, women were not to become members of these societies for over 300 years. Why were women denied membership in the scientific academies of Europe for so long? Were there no qualified women scientists when these academies first opened their doors? Evidence from the seventeenth and eighteenth centuries does in fact reveal a small, but significant number of women active in science waiting to take their place in the new institutions of science. The German astronomer Maria Winkelmann is a case in point. Again Winkelmann was not an exception: as extraordinary as it seems to us today, of German astronomers working in the early eighteenth-century, 14 percent were women. In 1710, Maria Winkelmann petitioned the Berlin Academy for an appointment as assistant astronomer and calendar-maker. Already a seasoned astronomer when her husband and Academy astronomer (Gottfried Kirch) died in 1710, Winkelmann asked the Academy to appoint her calendar-maker in her husband's stead. She had, in fact, published astronomical observations under her husband's name while he was ill and dying. Despite the fact that the great Leibniz, then President of the Academy, was among her backers, her request was denied. In denying her request, Academy officials set an important negative precedent for women's participation in scientific institutions. The first working woman scientist to become a member of this academy was physicist Lise Meitner (who along with Otto Hahn discovered nuclear fission) in the 1940s–and then she was admitted only as a corresponding member.[3]

Last example from the eighteenth century—Bassi. Laura Bassi became the first woman in modern times to teach at a university; again her field is one which by modern standards is difficult for women to enter—physics. After a public disputation in Latin (the usual practice at the time) she was awarded her doctorate and appointed by the Pope to teach at the University of Bologna. Bassi is also reported to have had twelve children, a burden which seems not to have interfered with her scientific productivity—each year she published the results of a new study on electricity, the effects of air pressure, and the like.

The example of Laura Bassi raises two further issues. First, how did she manage to have twelve children and also remain active in research and teaching. In part, no one knows; hers is a story that remains to be told. In part, different ways of dealing with child rearing made it possible. It is important to remember that child care was perhaps less a burden for upper-class women of the eighteenth century than it is for upper-class women today. In the eighteenth century, the child was handed over soon after birth to a governess or wet nurse and reared in the countryside. A mother might not see the child again until age seven—about the time boys were sent away to boarding school.

Though prerogatives of class allowed Bassi to be both scientist and mother, the important point is that the burden of child care most commonly falls on the woman. One could study different solutions women have devised across the centuries for dealing with the uneasy fit between reproduction and professional life. Yet the fact remains that science, like professional life in general, has been organized around the assumption that society need not reproduce itself, or that scientists are not among those involved in reproduction. This assumption has structured institutions of science. If women had been fully integrated into science from the beginning, we might not now be faced with the kinds of conflicts women find themselves in concerning child-bearing/rearing and professional life.

The issue goes deeper than child bearing and rearing. Women themselves have long been considered disruptive of serious intellectual endeavor—scientific or otherwise. Ancient Hebrew traditions held that by virtue of contact with women, men lost the power of prophecy. In the middle-ages, the life of the mind was a celibate one. Intellectual life took place in monasteries. Monastic traditions influenced their successors—university life. Professors at the Universities of Oxford and Cambridge, for example, were not allowed to marry; until late into the nineteenth century celibacy was required. As an English historian noted in the late-eighteenth century:

> The learned and studious have often objected to female company, because it so enervates and relaxes the mind, and gives it such a turn for trifling, levity, and dissipation, as renders it altogether unfit for that application which is necessary in order to become eminent in any of the sciences. In proof of this they allege, that the greatest philosophers seldom or never were men who enjoyed, or were fit for the company or conversation of women. Sir Isaac Newton hardly ever conversed with any of the sex... ([he] died a stranger to love). Bacon, Boyle, Des Cartes, and a variety of others, conspicuous for their learning and application, were but indifferent companions to the fair.

It is interesting to reflect upon the number of scientists who, for whatever reasons, never married.[4] Francis Bacon, for example, considered wife and children impediments to great enterprises. And there is a historian of science at Harvard (who shall remain nameless) who still believes that the recipe for great science is to be a genius, to get no sleep, and to have no sex.

Another issue raised by Bassi's preeminence in physics is what we call the "math anxiety" among women. These days we are often told that women are not scientists because they have a special fear of mathematics. By studying the great women scientists of the past, we can document that a large proportion of those women were, indeed, mathematicians. In addition to the women I have already mentioned, there was the Italian mathematician, Marie Agnesi, who became famous for her 1738 text on calculus.

Sophie Germain, Madame du Chatelet, and Maria Winkelmann were all women working in math-based sciences in the eighteenth century. Math anxiety—if such a thing exists—is not inherent in women but a product of their education.

Throughout the nineteenth century, there continued to be the exceptional scientific woman. Notable among them was the Russian-born Sophie Kovaleskia, famous for her work in partial differential equations. Since women were not allowed to study at university in Russia, Kovaleskia resolved to go abroad. At the time (1870s) unmarried women could not cross Russia's borders unless accompanied by their parents or a husband. Thus, Kovaleskia took the solution of radicals of her day and contracted what was known as a "white" marriage: a marriage of convenience which allowed her freedom of movement. She left Russia to study mathematics at Heidelberg. Kovaleskia completed her doctorate with Weierstrass in Berlin, but since that university did not grant degrees to women, Kovaleskia was granted a doctorate from the University of Göttingen in 1874. She went on to win the much coveted Bordin prize from the Académie des Sciences in Paris in 1888 and, in 1889, was appointed professor of mathematics at the University of Stockholm.[5]

It is interesting to note that Kovaleskia was a mathematician of such stature that her brain was weighed at the height of craniological investigations (the study of skull and brain size as a measure of intelligence). Her brain (after sitting already four years in alcohol) weighed in at 1385 grams—this was compared to the 1440 grams of the brain of her contemporary Helmholtz. The greater weight of Helmholtz's brain represented for Helmholtz but a pyrrhic victory, for Kovaleskia's proved larger in proportion to her total body weight than did Helmholtz. Craniology, a respectable science in the nineteenth century, had fallen into disrepute in the 20th, since it was found that there is no correlation between brain size and intelligence. Nonetheless, Einstein's brain is still preserved somewhere in the Midwest—I think.

We now come to the first person ever to win two Nobel prizes—yes, you guessed it, Marie Curie. Born in Poland the future Madame Curie traveled to Paris in the 1870s to continue her study of mathematics and physics. There she met and married Pierre Curie. As was the case with so many women in this period, Curie's legitimization in the field came through her husband. He had the professional contacts, while she worked initially as his assistant. Their joint work in radiation brought them a Nobel prize (shared also with Becquerel) in 1903. After her husband's death, Marie Curie not only continued their common work, but also assumed his professorship at the Sorbonne. She was awarded the Nobel prize again in 1911, this time in inorganic chemistry, for the discovery and isolation of the elements radium and polonium (the latter named after her native Poland). Despite the fact that Curie was the first to win two Nobel prizes, she did not succeed in her application to the Académie des Sciences in Paris. A spokesman for the Academy held it "eminently wise to respect the immutable tradition against the election of women."

In the twentieth century, things have improved. But it would be incorrect to imagine that the situation for women in science improves in a slow and steady manner. After women gained admittance to graduate schools in the U.S. at the beginning of the century, they flooded Ph.D. programs in all fields. By the 1920s their numbers were high. Between 1930 and 1960, however, with the rise of fascism and the conservatism surrounding the cold war, the proportion of women Ph.D.s and faculty in the sciences

plummeted and 1920s levels were not regained until the 1970s. Women's gains in science come through continued work; it does not happen gradually as the result of some sort of social evolution.

Let's turn now to the situation of American women in science today. Women in science (as in most other professions) suffer from what Margaret Rossiter calls hierarchical discrimination: as one moves up the ladder of power and prestige, the female faces disappear. There are many women at the bottom—lots of women post-docs, assistant professors and the like—but few women at the top, in high government posts, as deans of engineering colleges, or as heads of major research laboratories. This is directly reflected in women's salaries. In 1986, salaries for women scientists and engineers averaged only 75 percent of those for men. Some people mistakenly assume that the number of women employed in science is so low because not enough women are trained to do science. This, however, is not true. Women scientists are two to five times as likely to be unemployed or underemployed as men scientists. Similarly, women more often work in lower-prestige jobs than men with identical education and work experience.[6]

There is a second concept that Rossiter has developed for thinking about the problem of women in science, and that is the notion of territorial discrimination or the sex-typing of occupations. The most striking example of territorial discrimination used to be that women stayed at home and men went out to work. With 45 percent women in the labor force that is no longer true. There is, however, territorial discrimination within academic fields—we all know that more women do literature and history, and that fewer do science and engineering. But there is also territorial discrimination within the sciences. In the 1920s the three big sciences for men were chemistry (number one), medical sciences, and engineering; for women the big three were botany, zoology, and psychology–sciences with less prestige and less money. Today women are concentrated in the life sciences and psychology, fields where salaries are relatively low regardless of sex. Fields, by contrast, where prestige and pay are high have few women. This explains the appalling fact that women's representation in physics stands at only 4 percent.

How about minority women? Of the 700,000 women employed in U.S. science and engineering, roughly 5 percent are black. Blacks, either men or women, are represented equally to their proportion of the population (about 10%). Asian men and women are represented about equally among scientists and engineers–about 5 percent in each case, and both men and women native Americans constitute less then 1 percent of American scientists and engineers.

Those are the facts concerning the participation of women. How do we explain these low numbers? The oldest and most suspect explanation is that women simply can't do science as well as men. These arguments—known collectively as biological determinism—teach that something in the physical, psychological, and intellectual nature of women prohibits them from producing great science. This attempt to trace woman's social inferiority to her supposed biological inferiority is an old one, dating back at least to Aristotle. In the ancient world, Hippocrates, Aristotle, and Galen drew a picture of the nature of woman which provided a thorough-going justification of women's inferior social status. Aristotle argued that women are colder and weaker than men, and that women do not have sufficient heat to cook the blood and thus purify the soul. In the late eighteenth and nineteenth centuries, craniologists tried to account for sexual differences in intellectual achievement by measuring the skull. Anatomists assumed that the larger male skull was loaded with a heavier and more powerful brain.

At mid-nineteenth century, Social Darwinists invoked evolutionary biology to argue that woman was a man whose evolution—both physical and mental had been arrested in a primitive stage. One of my all-time favorite arguments came in the late-nineteenth century, when a Harvard doctor argued that women should not be admitted to university. Edward Clark in a carefully worked out scientific study showed that women's intellectual development would proceed only at great cost to their reproductive development. If women exercise their brains, this doctor held, their ovaries shrivel. This kind of nonsense did not end in the twentieth century. In the 1920s and 30s, arguments for women's different (and inferior) nature have been based on hormonal research.

Today we are still inundated with the argument that biology is destiny. Studies of brain lateralization try to persuade us that women do poorly in math because their brains aren't as highly specialized as men's. Sociobiologists, such as Harvard's E. O. Wilson, teach that genes dictate social inequalities; even in "the most free and egalitarian of future societies," he writes, "... men are likely to continue to play a disproportionate role in political life, business, and science." These studies aren't profoundly different from those of Aristotle or Edward Clark. They seek to provide scientific justification for enduring divisions in power and privilege between the sexes.

The biological case against women has yet to be proven. Books like Anne Fausto-Sterling's *Myths of Gender* and Ruth Hubbard's *The Politics of Biology* reveals how many of these studies are merely examples of bad science.[7]

Before we accept the arguments of biological determinists, we should investigate the other reasons for women's poor standing in science. Women, as we have seen, have historically been excluded from the institutions of science. It is one of the most amazing facts of history that women have been excluded from universities for over 700 years—since their founding in the 12th century until the nineteenth century. It is only about a century now since universities in America and Europe reluctantly opened their doors to women, but the problems did not end then. Nor did problems end after sexual discrimination was outlawed in the U.S. with the Civil Right's Act of the 1960s. Women's failure to achieve equality in science has deep cultural roots, ranging from the kind of toys children play with to the kind of education they receive.

Once a woman has entered science, subtle factors operate to keep her on the periphery. Barbara Reskin has shown that even when women are admitted to the laboratory, they are often excluded from the communication networks crucial to the development of their ideas and careers. Then, too, many women encounter what has been called the "little lady syndrome"—the assumption that female staff members are support personnel or that they won't be knowledgeable about complex scientific and political issues. Others feel that women can't be counted on in difficult times because their attention is divided between their work and their duties as wives and mothers. (I suspect that as husbands and fathers begin sharing domestic duties this will change.)

I could cite many more of these kinds of examples but let's turn now to a final question: Will women make a difference? If women become represented in the sciences in equal numbers with men, also in positions of leadership, will the institutions of science be different? Will research priorities and methods be different? Will codes of professional conduct be different? Most of the programs around the country that aim at getting more women into the scientific pipeline aim at reforming women. Their working assumption is that women need to be made more scientific, that the problem somehow rests with women. But shouldn't we perhaps reverse the question, asking not how to

fit women into science but how to better fit science to women. Further, will women make a difference in science? If women enter science in larger numbers so that we pass beyond the situation where there are one or two women among many men, will women make a difference?

The sex of participants in science should not necessarily be important to the results of science. But in western culture we must recognize (and this is what I have worked out in great length in my book *The Mind Has No Sex?*) that society is highly gendered. In the modern sexual division of labor which crystallized in the eighteenth century around the industrial revolution, science was part of the terrain that fell to the male sex. In the process, scientists sought to distance themselves from things defined as feminine. It is in this context that I believe it makes a difference who does science today. Our contemporary conceptions of femininity and science have been historically constructed in opposition to each other. If science has come to mean objectivity, reason, dispassion, and power, femininity has come to mean everything that science is not: subjectivity, feeling, passion, and impotence.[8]

If women, because of their socialization, do indeed see things differently, if (as even newspaper polls tell us) we as a group hold significantly different opinions and have different values, might women not bring an enriching perspective to science? For hundreds of years the institutions of Western science have systematically excluded women. If these outsiders are now embraced and allowed to cultivate their own interests (that is to say, not have to assimilate to the dominant scientific culture to be successful), might they not make a difference? Might they not have different priorities, use different methods, relate to colleagues and their research subjects differently?

Let me put this more concretely through an historical example. Has there been a time in history when women developed a science and were the majority of its practitioners, and was that science different than when men practiced it? Midwifery is the prime example of a science (or medical art) developed and practiced by women most often for the benefit of other women. Since ancient times and at least for two thousand years women have dominated the art of birthing and the whole field of women's health care. In the eighteenth century, midwifery was taken over by university-trained obstetricians, now primarily men. By the nineteenth century midwives, were banished to the countryside and the treatment of the poor.

I'm not interested here in the long and bloody battle between midwives and medical men.[9] What interests me is what difference did the removal of women from the field of midwifery make? The incursion of men into the field also coincided with abrupt changes in gynecological and obstetrical practice. Where the midwife had emphasized the natural character of childbirth and saw her role as one of assisting the mother in birthing, the new man-midwife, trained as a surgeon, tended to set to work with his surgical instruments (the newly developed forceps, etc). Because surgeons had traditionally been called in only in cases of emergency, few had ever seen a normal birth. At the same time, midwives and other women of the village or neighborhood had assisted the mother not only with the technical aspects of birthing but with other aspects of her daily regime, such as cooking and caring for the children, while the mother recuperated. Man-midwives, by contrast, attended the mother only during the hours of labor and eventually required women to give birth in hospitals—a process that

further undermined women's support systems. It was only in the 1960s and 1970s that the women's movement was able to begin to reverse these trends and return to women some control over their health care.

Let me close by suggesting that in addition to getting women into science, we should be sensitive to cultivating changes the newcomers propose. Changes might come at several levels. We are already seeing dramatic institutional changes. From times when the presence of a baby bottle (in the father's faculty mailbox!) might jeopardize prospects of tenure at Stanford, now there are prospects of baby rooms, and institutions sensitive to the fact that human beings—both male and female—reproduce. The notion of hiring companions undermines the assumption that scientists are atomistic individuals (or more properly, men with family units ready and willing to move with them) and recognizes that society is composed of interrelated cooperative groups in which the needs of each individual must be met.

Changes might also come in the methods of scientific research. Barbara McClintock is now well known for describing her "feeling for the organism," her great empathy for the subject.[10]

Finally, I feel certain that the most dramatic changes will come in the priorities of science. The first benefits may be felt for women. The National Institutes of Health have recently been censored for failing to test the effects of medication on women. Doctors have long prescribed an aspirin a day as a preventive measure against heart disease. All those tests, however, were done entirely with male subjects, no one can say whether it is beneficial for women to take a similar dose. But benefits will go beyond innovations in science directed primarily at women. Primatology, biology, and anthropology are three sciences that have been dramatically influenced by an influx of women.[11] Our knowledge of nature has been transformed by their efforts.

The goal in these transformations of science—whether they alter dramatically the style or substance of science—is not to produce a world that privileges women. These changes will also provide more choices and a wider range of opportunities for men. The goal, as Evelyn Fox Keller has put it, is to create a more human science—a science freed from the deformations caused by centuries of exclusion of more than half of humanity from its ranks.[12]

ENDNOTES

[1]Londa Schiebinger is Associate Professor of History and Women's Studies at The Pennsylvania State University. She is author of *The Mind Has No Sex? Women in the Origins of Modern Science* (Harvard University Press, 1989) and *Nature's Body: Gender in the Making of Modern Science* (Beacon Press, 1993).

[2]Barbara Newman, *Sister of Wisdom: St. Hildegard's Theology of the Feminine* (Berkeley: University of California Press, 1987).

[3]This along with much of the material in this paper is drawn from my book, *The Mind Has No Sex? Women in the Origins of Modern Science* (Cambridge, Mass.: Harvard University Press, 1989).

[4]See David Noble, *A World Without Women: The Christian Clerical Culture of Western Science* (New York: Alfred A. Knopf, 1992).

[5]Ann Koblitz, *A Convergence of Lives: Sofia Kovalevskaia, Scientist, Writer, Revolutionary* (Boston: Birkhäuser, 1983).

[6]Margaret Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins University, 1982). For an anthology of essays on women scientists, see Pnina Abir-Am and Dorinda Outram, ed., *Uneasy Careers and Intimate Lives: Women in Science, 1789–1979* (New Brunswick: Rutgers University Press, 1987).

[7]Anne Fausto-Sterling, *Myths of Gender: Biological Theories about Women and Men* (New York: Basic Books, 1985); Ruth Hubbard, *The Politics of Women's Biology* (New Brunswick: Rutgers University Press, 1990).

[8]For discussions of other aspects of this question, see Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (New York: Harper & Row, 1980); Sandra Harding, *Whose Science? Whose Knowledge? Thinking from Women's Lives* (Ithaca: Cornell University Press, 1991); Sandra Harding and Jean O'Barr, ed. *Sex and Scientific Inquiry* (Chicago: University of Chicago Press, 1987); Ludmilla Jordanova, *Sexual Visions: Images of Gender in Science and Medicine between the Eighteenth and Twentieth Centuries* (Madison: University of Wisconsin Press, 1989); and Helen Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton: Princeton University Press, 1990).

[9]Jean Donnison, *Midwives and Medical Men: A History of Inter-Professional Rivalries and Women's Rights* (London: Heinemann, 1977).

[10]Evelyn Fox Keller, *A Feeling for the Organism: The Life and Work of Barbara McClintock* (New York: W. H. Freeman, 1983).

[11]Donna Haraway, *Primate Visions: Gender, Race, and Nature in the World of Modern Science* (New York: Routledge, 1989).

[12]Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven: Yale University Press, 1985).

Londa Schiebinger: Pennsylvania State University, Dept. of Astronomy and Astrophysics, 525 Davey Lab, University Park, PA 16802