A Short History of Women in Science: From Stone Walls to Invisible Walls

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Where are the women in science? This oft-repeated question is still being asked today, especially with regards to the presence of female tenured professors at elite universities. Some answers echoing ages-old rationalizations for women’s relatively poor performance in science can still be heard: history tells us that women have never made significant contributions to math or science; women are innately ill equipped for high-level math and science careers; women who pursue demanding careers in science will jeopardize their well-being and that of their families. However, some answers are different, reflecting both societal changes and recent empirical data. For example, new evidence suggests that women’s chances for success in science depend on the structure of the organization within which they work.1 Women scientists, especially those working outside of hierarchical worlds of the academy and of large scientific establishments, are increasingly likely to hold high-level leadership positions.

One path to understanding women’s still disappointing success at least in some fields of science and at least in some scientific establishments is to look back over time and see what lessons can be learned from an historical perspective on women’s role in science. By situating women’s experiences through time and noticing how opportunities in scientific fields have shifted based on social norms, as well as on educational and organizational structures, we can then focus on the steps that can help overcome the barriers that still remain.

We begin this chapter with the golden age of science: The European Renaissance. What was the situation for women in the 14th-17th centuries when scientific endeavors were flourishing all across Western Europe? What was the situation for women in the sciences in early nineteenth century America when educational opportunities were expanding, especially for young males? What has been the trajectory of American women scientists’ to education, employment, and recognition in science throughout the nineteenth and twentieth centuries? Finally, what is the situation for women in science today?

The Renaissance

Why should a serious discussion of the relative absence of women in science today start with a discussion of the Renaissance? Surely so much has changed since then that insights from that long-ago period are of little use today. While much has of changed, we argue that this journey through time is pertinent. Specifically, it is instructive to learn that although the question of “where are the women in science?” has long been asked, some rationalizations for the “situation” of women in science are strikingly similar to those offered in past. Perhaps this historical glimpse will help us move past the simplistic explanations put forth today and lead us to a better understanding of why we are asking this question in the way we are asking it and whether we are even asking the right questions.

Arguably, the blossoming of science in Europe was at its peak during the 14th through 17th centuries. During that period there was a fundamental transformation in scientific ideas in such fields as physics, mathematics, physiology, astronomy, and biology, in institutions supporting scientific investigation, and in the more widely held picture of universe. As a result, the scientific revolution that occurred during the Renaissance is widely viewed as the foundation of modern science.

Men and Science

The names of many of the scientists who lived during that incredible period are household names today, four centuries later. These luminaries include:

**Nicholas Copernicus** (1473 - 1543), who is said to be the founder of modern astronomy. Copernicus was a Polish astronomer and mathematician who was a proponent of the view that the Earth was in daily motion about its axis and in yearly motion around a stationary sun.

**Galileo Galilei** (1564-1642) has been called the “father of modern observational astronomy,” the “father of modern physics,” and the “father of science.” He was an Italian physicist, mathematician, astronomer, and philosopher. His achievements include the first systematic studies of uniformly accelerated motion, improvements to the telescope, a variety of astronomical observations, and support for Copernicanism. Galileo’s experiment-based work was a significant break from the abstract Aristotelian approach of his time.

**Johannes Kepler** (1571-1630) was one of the most important scientist in the field of astronomy. He was the founder of “celestial mechanics,” having been the first to explain planetary motion. Moreover, in addition to his theories on the structure of the universe, Kepler made important headway into the field of optics, his publication *Stereometria Dolorum* formed the basis of integral calculus, and he also made important advances in geometry. In addition to these major breakthroughs, Kepler explained how the tides were influenced by the Moon and is responsible for finding the three laws of planetary motion.

**Sir Isaac Newton** (1642-1727) was a mathematician and physicist, who is considered one of the foremost scientific intellects of all time. Newton has been regarded for almost 300 years as the founder of modern physical science. He has been called the greatest English mathematician of his generation. He laid the foundation for differential and integral calculus. His work on optics and gravitation make him one of the greatest scientists the world has known. Newton also made major contributions to chemistry, mechanics, and mathematics, especially calculus.

**Gottfried Leibniz** (1646 - 1716) was a German mathematician, philosopher, and logician who is probably most well known for having invented the differential and integral calculus (independently of Sir Isaac Newton).

**René Descartes** (1596-1650) is one of the most important Western philosophers of the past few centuries. During his lifetime, Descartes was just as famous as an original physicist, physiologist, and mathematician.

**Leonardo da Vinci** (1452- 1519) was born on April 15, 1452, just outside Florence, Italy. Over his lifetime, he produced numerous studies on such subjects as nature, flying machines, geometry, mechanics, municipal construction, canals and architecture (designing everything from churches to fortresses). His studies from this period designs for advanced weapons, including a tank and other war vehicles, various combat devices, and submarines. Also during this period, Leonardo produced his first anatomical studies. During the later part of his life, he recorded his studies in meticulously illustrated notebooks. His work covered four main themes: painting, architecture, the elements of mechanics, and human anatomy and physiology.

Remarkably, three famous mathematicians were born within three years of each other: Fermat, Roberval, and Cavalieri. **Pierre de Fermat** (1601 - 1665) is thought of today as one of the
greatest mathematicians of all times and perhaps the most famous number theorist who ever lived. Gilles Personne de Roberval (1602-1675) was a French scientist who developed powerful methods in the early study of integration. Finally, Bonaventura Francesco Cavalieri (1598 - 1647) was an Italian mathematician who made major contributions to geometry and calculus.

Of special note is the fact that not one of these super-star scientists was a woman! That fact is not lost on those who point to the historical record as proof that women do not have what it takes to achieve the pinnacle of success in math and science. Is it fair to conclude that the absence of women scientists during the Renaissance is due primarily to lack of ability, motivation, or drive? To answer this question, we need to look at what was happening to women during this historical period.

Women and Science

Ironically, as they watched the lives and rights of their husbands, sons and brothers expand during this period, women’s lives contracted. During the height of the Renaissance, when science was flourishing, women had only four life options: enter into a marriage, usually arranged; enter into a convent; work as a maid; or become a prostitute. To put these options into context, during the late 15th century, only approximately half of all eligible young Venetian women married. A major reason was that the prices of dowries paid to prospective husbands escalated, so in order to conserve their family fortunes, parents prohibited their daughters from marrying. Marriage dowries might be as much 400% higher than the fee to join the convent.

For daughters of the ruling class, only the first two options were available. Young patrician girls were routinely sent away to convents to be educated and kept secure until a good marriage could be arranged for them: many stayed. Indeed, many women, wealthy or not, chose to live out their lives in convents. One reason was the fear of dying in childbirth. Not surprisingly, convent life flourished throughout Europe.

To give you a feel for how prevalent convent life was, consider that during the Italian Renaissance, Venice, a city with a population of 86,000, had 50 convents and about 3,000 nuns. To put these numbers in context, one of us (RCB) lives in a town with a population of about 10,000, roughly one-tenth of the population of 16th-century Venice. We have one grocery store, one drug store, and one auto-mechanics shop. We would have to have 5 convents in my little town to have a number of convents proportionate to the number in Venice during the renaissance.

What were these young women taught behind the stone walls of the convent? Generally, they were taught poetry, music, embroidery, and other skills useful for managing a household. Some were taught art, others singing, but science was certainly not part of their instruction. Why would it be? Walled off as they were, women had no possibility of participating in the intellectual and scientific life of the times.

Consider for a minute how different the story of science might have been if half of the sons of the ruling classes were, as youngsters, sent away to spend their lives behind stone walls, while their sisters were free to pursue their intellectual interests. To understand some of the long-

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3 Laven, Virgins of Venice: Enclosed Lives and Broken Vows in the Renaissance Convent
term consequences of this extreme sex-segregation in science, we need to take a lesson from an important theory in social psychology: social-role theory. This theory teaches us that when occupations and other social roles (e.g., family roles) are as sex segregated as science was during the Renaissance, it is human nature to infer that there must be something inherent about men that predisposes them toward math and science; something that women clearly do not possess. Today, we hear various “explanations” of what those inherent differences might be. Some point to differences in genetic makeup, others to hormonal differences, others to differences in brain structures, and still others to differences in motivation. These “difference” advocates fail to acknowledge the role of differences in opportunities, social norms, and expectations that surely accounted, in large part, for the dearth of women scientists in the Renaissance and, in all likelihood, account, at least in part, for the under-representation of women in leadership positions in science today.

Before moving ahead, we want to share two brief vignettes. One has to do with the other with Leonardo Da Vinci. Galileo, arguably one of the most illustrious of the Renaissance scientists, had three illegitimate children: two daughters and one son. Of the three, his oldest, Virginia, was the only one who “mirrored his own brilliance, industry, sensibility, and virtue,” and was, in his words, “a woman of exquisite mind.” Galileo deemed her unmarriageable, because he had not married her mother. So at age 13, he placed her and her 12-year-old sister in a convent, where they lived out their lives in poverty and seclusion. In contrast, his son was legitimized in a flat by the grand duke of Tuscany and went off to study law at the University. Illegitimacy also played a central role in the second vignette. Leonardo Da Vinci was the illegitimate son of a 25-year-old notary and a peasant woman. Had he been born a girl, he would have been deemed unmarried and would surely have been sent off to spend his life behind convent walls. Thus, even the most gifted scientist will not develop his/her talents without congenial social norms, high expectations, and support.

Access to Education for Women in Science

Convent life never took hold in non-catholic America as it did in pre-Reformation Europe. Although there were no stone convent walls to limit women’s access to science education in the U.S., women found themselves locked out of higher education by the stone walls of male-only colleges and universities. At that time in our history, education was largely the preserve of sons of wealthy

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5 “Difference” arguments are still alive and well today. Presumed psychological differences between women and men have been used to explain unequal gender representation in a number of contexts and roles, including leadership roles (e.g., women are less ambitious than men). In a recent research article, however, psychologist Janet Hyde shows strong support for a “gender similarities hypothesis,” indicating that women and men are more similar than different on a large number of psychological variables. For more details, see Janet S. Hyde, The gender similarities hypothesis, American Psychologist, vol 60, n. 6 (2005) 581-592. For a specific discussion of similarities between boys’ and girls’ math and science abilities, also see Janet S. Hyde & Marcia C. Linn, Gender similarities in mathematics and science. Science, vol. 314, no. 5799 (2006): p.599-600.

families who were being prepared for the ministry.

An important and recurring rationalization for limiting girls’ access to education was that learning would have serious negative effects on their capacity. Medical wisdom had it that learning to read would damage their ovaries. Echoes of such concerns can be heard today in the rationalization that managing a career and family negatively affects women’s (but not men’s) health and that women don’t have the physical stamina to pursue demanding work at the highest levels in math and science7.

Until the early 19th century, girls’ education was restricted to informal learning at “Dame Schools” where instruction was offered by female teachers, usually in their homes. Young girls were taught basic reading and writing, embroidery, and other “feminine” skills. From the mid-1820s there was such a rapid spread of education for women in the U.S. that the U.S. led the rest of the world in public and private education for girls and women. However, girls were locked out of science education by the stone walls of the male-only colleges. In spite of these barriers, the early 19th century saw a groundswell of popular books and textbooks written for women by men and women on such scientific subjects as botany, chemistry, and geology.8 And there was an enormous audience hungry for such books as reflected in their sales figures: Conversations on Chemistry (Marcet, 1806) which went through more than 15 editions in the U.S. before 1860; Familiar lectures on Botany (Phelps, 1829) which went through at least 17 editions and sold over 275,000 copies by 1872; Introduction to Botany, in a Series of Familiar Letters (Wakefield, 1796) which had at least nine English editions by 1841. Clearly, women’s interest in pursuing science was not deterred, although it was severely hampered, by the restrictive educational and social norms of the times.

Employment for Women Scientists

In the 19th century, women’s desire for access to education in science and opportunities for employment in science were greatly accelerated by the advent of the women’s colleges, as is well-documented in the encyclopedic historical work of Margaret Rossiter (1982, 1995), upon which we rely for much of the material in this section. The mid-1800s saw the opening of several such colleges, many of which offered extensive courses in the sciences, especially astronomy, botany, and chemistry.9 These schools prospered and women graduates were often hired on as teachers of the next generation. Thus, women had gained access to education in science and had some limited opportunities for employment in science. These employment opportunities, however, came at a considerable personal price. All women college faculty had to be single; if they decided to marry, they had to resign, a practice that in some parts of the Western world continued well into the 20th century.

7 Although beyond the scope of this chapter, it seems important to note that rationalizations that appear to “protect” women or advocate for women’s health and well being by regulating their commitments actually limit women’s opportunities and constitute a form of discrimination (for a discussion of this type of “benevolent” sexism, Peter Glick and Susan T. Fiske, 2001).
8 Margaret W. Rossiter, Women Scientists in America: Struggles and Strategies to 1940 (Baltimore, MD: John Hopkins University Press, 1982).
century. Once again we see a clear manifestation of the belief that women could not both professional and family responsibilities. In addition, the women’s colleges had very heavy teaching loads, precluding faculty from doing publishable research. Nevertheless, these were the best jobs women could aspire to in science and women were happy to have them.

The employment situation for women in science took a turn for the worse as the women’s colleges began to focus on improving their prestige. One important step was to require Ph.D. degrees, another was to recruit male faculty. In order to attract males they had to offer strong incentives, including no restriction on marriage, indeed, young married men with families were preferred candidates. The men were also offered reduced teaching loads, higher salaries, college-funded support for their research, and allowances for family expenses. This two-tier hiring system produced several negative consequences for women faculty. First, few women scientists at the time had doctorate degrees. Why? Because, at the time, most European and U.S. universities refused to allow women to matriculate into their graduate schools. Second, male faculty began publishing research, whereas women science faculty, still burdened by lack of support and heavy teaching schedules, did not. Finally, women’s colleges ceased to be the primary employer for women scientists; their mission became to educate women scientists, not hire them.

Even after some graduate schools opened their doors to women, beginning in the 1890s, not all were so welcoming. Indeed, Princeton, New York University, and Harvard did not grant women Ph.D.s until the 1960s. As was true over and over again, as some barriers fell, others arose. For example, as the marriage ban was phased out (as was the pregnancy ban), anti-nepotism rules took hold. A woman scientist married to a male scientist would not be hired by the same department and was often refused employment at the same college or university. The result: many highly educated married women scientists could not find employment, especially in small cities and towns with only one academic institution.

As anti-nepotism rules came and went, the two-body problem arose and is still a barrier to women’s advancement in science. What is the two-body problem? Simply stated, when one partner in an academic couple is offered a position at a university, the other spouse (typically the woman) also needs to find appropriate employment. Rarely is it possible to place two high-level academics at the same university. More often than not, in such situations, the female is offered no position or a position at a lower level than the one she left. Thus relocating is often beneficial to the male in the couple and detrimental to the career advancement of the “trailing spouse."

Another barrier for women was created by the G.I. Bill. After World War II, veterans were granted preferential treatment at all educational institutions, including women’s colleges, and at all levels of the educational system. As a result, the number of males earning Ph.D.’s in the post-war period sky-rocketed, whereas there was no appreciable difference the figures for women. Indeed, women were often rejected in order to accommodate male veterans who, although deserving of special consideration, may have been less able and less qualified.

In these myriad ways, the academy has not been a hospitable employer for women in

10 Italy, for example, passed a law addressing this very issue in 1963 to challenge the then common practice of dismissing women upon marriage so to avoid covering maternity leave. Wendy Pojmann Emancipation or Liberation?: Women's Associations and the Italian Movement, The Historian, 67, 2005
11 Rossiter, Women Scientists in America: Before Affirmative Action 1940-1972
science. Too many structural barriers, too many un-scalable walls, some of which remain today. Many of the women who could leave the academy, did so. Indeed, the most well-known women scientists of the 20th century were not members of any academic faculty. These women scientists include Margaret Mead, who was never offered a tenured position and worked for most of her professional life at the American Museum of Natural History; Rachel Carson, perhaps the most influential women scientist of the 20th century who supported herself by writing best-selling books, including the international best-seller, Silent Spring; Barbara McClintock, a cytogeneticist, who was denied tenure at the University of Missouri and went to work at Cold Spring Harbor Laboratory, where she won the Nobel Prize in Physiology and Medicine; and Dian Fossey who completed her ground-breaking field work in Rwanda before getting her doctorate degree.

Data collected over the last 20 years have shown that despite increasing numbers of women with science and engineering degrees, gender representation in the academy remains uneven, with men still outnumbering women at all faculty levels. Recent research suggests that even today women scientists’ chances for advancement in the academy and other hierarchically organized scientific establishments are relatively poor. Women employed full time in academia are less likely than men to be tenured and, on average, earn less than their men counterparts. Furthermore, women are less likely than men to be employed at the highest-tiered academic institutions.

A comparative study found that flatter, more inter-organizationally connected biotechnology firms are better workplaces for female scientists. Smith-Doerr found that for male scientists, the odds of achieving supervisory rank were unrelated to the structure of the organization in which they worked. In contrast, for female scientists, organizational structure made an enormous difference: females in biotech firms were eight times more likely than their male counterparts in hierarchical settings to have supervisory positions. Similarly, Joy (2008) found few differences in the promotional opportunities of women and men scientists employed in industrial and healthcare sectors in the United States.

How can we account for these differences between academia and the industry? One explanation is that networked organizations rely on partnerships to succeed and are more flexible and transparent than hierarchical organizations. As a result, advancement is based on input from a wide range of people rather than a few as is typical in hierarchical organizations. Consequently, there are fewer chances for sexism to thrive and more opportunities to create work environments that are

16 Smith-Doerr, Women’s Work: Gender Equality vs. Hierarchy in the Life Sciences.
17 As we discuss later, however, Joy (2008) also found that gender gaps in managers’ pay persisted despite the fewer barriers to promotion.
welcoming to women.18 Joy (2008) also argues that the criteria for promotion in academia are especially susceptible to the influence of subjective evaluations (and hence to gender bias), whereas the industry’s pressure to achieve specific business results (e.g., creating new products) shifts the focus onto more explicit and somewhat less subjective standards, such as the ability to bring new discoveries and successful products to the market.

Coincidentally, women scientists are increasingly choosing to work in non-academic settings. In 2002, only 42% of women Ph.D.s worked at universities and 4-year colleges. In fact, the number of U.S. life scientists working outside the academy grew from 83,000 in 1980 to 181,000 in 2000.19 In spite of the fact that the greatest growth in employment and some of the most remarkable developments in medicine have come from the private sector, analyses of gender relations in science are largely based on studies of the academy. This imbalance reflects the persistent idea that any Ph.D. worth her salt obtains a university position; other options are second-best.20

Advancement Opportunities

In both academic and business settings, women continue to be underrepresented in key decision-making, administrative, and management positions in the sciences. As recently as 2000, women only held 4% of all department-head positions at the top 50 chemistry University programs in the United States, and there were no women department heads in the top 50 chemical engineering or top 50 physics programs.21 In non-academic settings, in 2003, women constituted only 27.5% of all engineering management/administration professionals employed the industry22 and 17% of senior management positions at life sciences companies, where no increase has been recorded for the past 5 years.23

Research looking at gender representation among doctoral-level scientists employed in the technology sector has also shown that women were 50% less likely than their men counterparts to be employed in Science and Engineering (S&E) jobs and, even when they did, received 20% less in pay.24 Catalyst Census research shows that, in 2006, women in the

21 Quickstake AWIS, “Utilization of Chemistry, Chemical Engineering, Physics, and Biological Sciences PhD Recipients in Faculties of Those ‘Top 50’ Departments.”
22 Quickstake. National Science Foundation, “TABLE H-33: Primary or secondary work activity of scientists and engineers employed in business or industry, by age, sex, race/ethnicity, and disability status: 2003”.
23 EDGE study
professional, scientific, and technical industries held only 10% of the board of director positions and between 13 and 14% of the highest executive positions among the larger U.S. manufacturing and technology firms; women were similarly underrepresented on the boards and in corporate officer positions in the largest utilities, information technology, and healthcare institutions.25 These numbers are especially low considering that, in 2007, women represented more than 40 percent of biological and medical scientists, 40% of chemist and materials scientists.26

Despite these challenges and other barriers that they face both at various educational stages and at work, the number of women receiving degrees in science and engineering has increased over the past few decades. In 2006, for example, the National Academy of Sciences reported that Massachusetts Institute of Technology (MIT) science and engineering undergraduates included 51% and 35% women, respectively. Joy (2008) also calculated that women’s share on doctoral, masters, and bachelor degrees in the Science and Engineering (S&E) fields has tripled, on average, in the past decades. For example, between 1966 and 2004 the percentage of women completing a Ph.D. went from 5.8 to 30.3; similarly, the proportion of women completing a S&E masters program went from 9.6% to 32%.27 It seems hence important that we understand the factors that keep women from advancing in the field or that may dissuade them from pursuing careers in the sciences, even after obtaining a degree.

Receiving Appropriate Recognition For Their Scientific Accomplishments

The historical record is clear: Women scientists, despite their outstanding contributions, have rarely received commensurate recognition. Among the women “almost” Nobel laureates are:

- Physicist C. S. Wu of Columbia University, who performed the crucial experiments proving the theory that won her colleagues, Lee and Yang, the 1957 Nobel Prize in physics.

- Biochemist Viola Graham, who helped James Sumner of Cornell synthesize urease, for which he shared the 1946 Nobel prize in chemistry with two other men.

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26 Specifically, in 2007 percentages of women in the labor force included 42.6% of biological scientists, 49.1% of medical scientists, 40.8% of chemists and material scientists. Women’s representation was lower among computer and mathematical occupations, 25.6%. Current Population Survey, Bureau of Labor Statistics, “Table 11: Employed persons by detailed occupation, sex, race, and Hispanic or Latino ethnicity 2007,” Annual Averages (2008). http://www.bls.gov/cps/cpssa011.pdf
Geneticist Esther Lederberg, who helped her then husband Joshua with the microbial research that won him and two other men the Nobel Prize in 1958.

Marguerite Vogt, a molecular biologist, was the “colleague and close collaborator for 20 years” on DNA tumor viruses and cell growth of Renato Dulbecco, who shared the Nobel prize with two other men in 1975.

Economist Anna Schwartz coauthored several books with Milton Friedman and worked for decades on the detailed economic data that formed the basis for the work that won him (alone) the economics prize in 1976.

Crystallographer Isabella Karle worked for a lifetime with her husband, also a crystallographer, though he and two other men shared the chemistry prize in 1985.

Biochemist Rosalind Franklin was responsible for much of the research and discovery work that led to the understanding of the structure of DNA, for which Watson, Crick, and Wilkins received a Nobel Prize for the double-helix model of DNA in 1962.

Biochemist Ruth Hubbard had done important work on the chemistry of vision before marrying her husband, George Wald in 1958. Wald won the 1967 Nobel for work in the same area. Many assumed that they had always collaborated and that he deserved most of the credit for her earlier independent work as well. “Once she married a scientist of greater reputation, a woman’s own independent work would all too easily be dismissed as merely a small part of his.” 28

Even though women scientists today are more likely than in the past to receive the recognition they deserve, their situation is far from especially in the academy. The problem of gender-bias received national attention when it was discovered that women senior faculty at MIT were treated far less well than their male counterparts. In comparison with male senior faculty, women faculty, with equal professional accomplishments, were less likely to receive equitable salaries, laboratory space, research grants and awards, support, and other resources. Moreover, they were increasingly marginalized by their departments, and over time, excluded from playing significant roles. 29 The most likely explanation for their treatment was the deeply entrenched (albeit unconscious) gender bias of academic science, including work environments that are inhospitable to

28 Rossiter, Women Scientists in America: Struggles and Strategies to 1940, 331.
29 Nancy Hopkins, Lotte Bailyn, Lorna Gibson and Evelyn Hammonds, “The Status of Women Faculty at MIT: An Overview of Reports From the Schools of Architecture and Planning; Engineering; Humanities; Arts, and Social Sciences; and the Sloan School of Management,” in The MIT Faculty Newsletter XIV, no. 4 (2002), 1-28.
women, gender stereotypes, bias in performance evaluations, and other structural barriers. Although the details differ, these obstacles echo well-documented and deeply entrenched gender bias of academic science since the 19th century.

Despite these invisible walls, women scientists have made important inroads into the top ranks of leadership at the university level:

- Shirley Ann Jackson a theoretical physicist is president of Rensselaer Polytechnic Institute and the first African-American woman to receive a doctorate from the Massachusetts Institute of Technology.
- Shirley M. Tilghman, a molecular biologist is president of Princeton University.
- Mary Sue Coleman, a biochemist, is president of the University of Michigan.
- M.R.C. Greenwood, an expert in genetics and nutrition, as provost and senior vice president of academic affairs, holds the second highest post in the University of California system.
- Kim Bottomly, an immunobiologist, is president of Wellesley College.

Moreover, outside of the academy a growing number of women scientists now head major scientific and engineering institutes. For example, Claire Fraser, President and Director of The Institute for Genomic Research (TIGR) leads research teams which have sequenced the genomes of several microbial organisms that causes anthrax, Lyme syphilis, tuberculosis, cholera, meningitis, pneumonia, and ulcers, among others. Judith Rodin, a research psychologist, is president of the Rockefeller Foundation. In addition, as of 2006, at the U.S. National Institutes Health four of 27 institute directors are women. This overview is not exhaustive; it is merely meant to illustrate that there are many organizations other than universities that provide opportunities for women scientists to achieve prominent positions of leadership.

While this overview is obviously not exhaustive; it is merely meant to illustrate that there are many organizations other than universities that provide opportunities for women scientists to achieve prominent positions of leadership. It is certainly encouraging that some women scientists are breaking through the “glass ceiling,” research suggests that many invisible walls still block the advancement of many others. One of the most telling such research studies was conducted in Sweden, arguably the country with the best record on gender equity. The researchers, Wenneras and Wold, were curious about the poor success rate among women applicants for prestigious fellowships offered by the Swedish Medical Research Council. They noted that during the 1990s

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female scientists applying for these sought-after fellowships had been less than half as successful as male applicants. They wondered whether gender bias might be affecting the selection process. To find out, they obtained the evaluations made by the teams of peer reviewers who evaluated the applications. Applicants had to submit their curriculum vitae and their proposals for the work they intend to do if their application was successful. The peer reviewers rated each application on three subjective criteria: relevance of the research proposal, scientific competence, and the quality of the proposed methodology.

An examination of the evaluations indicated that the peer reviewers rated the women applicants lower on all three criteria, but especially lower on scientific competence, typically reflecting the number and quality of their scientific publications. The inference was that the female applicants were less productive than the male applicants. But were they? To answer that question, Wenneras and Wold scored each of the applications on six objective criteria: (1) total number of scientific publications; (2) the number of publications on which the applicant was the first author; and four indicators of the impact of the applicant’s publications. Impact refers to the “number of times the average paper in a particular journal is cited during one year: articles in high impact journals are cited more often and therefore have greater impact that articles in low impact journals.”

When the researchers compared the scores on the six objective criteria to the subjective scores the applicants received from the peer reviewers, they found clear evidence of egregious gender bias! “The most productive group of female applicants, containing those with 100 or more, was the only group of women judged to be as competent as men, although only as competent as the least productive group of male applicants (the one whose member had fewer than 20 total impact points).” Further analyses revealed that in order for a female applicant to be awarded the same competence score as a male colleague, she would have to produce approximately three extra papers in high-impact journals such as Nature or Science, or 20 extra papers in excellent specialist journals such as Atherosclerosis, Gut, Infection and Immunity, Neuroscience or Radiology. Thus, a female applicant had to be 2.5 times more productive than the average male applicant to receive the same competence score.

This extraordinary study provides direct evidence that the peer-review system is subject to sex bias. Wenneras and Wold cast a light on what would otherwise have been an “invisible wall” impeding the advancement of women in science. Such sex bias had demonstrably negative effects on the female applicants’ odds of obtaining important research fellowships and thus increasing their chances for future advancement and recognition. Recall that these results were obtained in Sweden where gender bias is reputedly low. Not surprisingly, scientists, even in Sweden, are no less immune than other human beings to the effects of prejudice. Just imagine what the results would be like if the study were to be replicated in other, less gender-equitable countries!

Obviously, changes need to be made to the peer-review system as well as to other “invisible” walls if we are to avoid wasting the promising talent of many highly able women scientists. As we have seen, women scientists have broken through many stone walls, but clearly much has to happen before the invisible walls come down.

Organizational and structural approaches are the best way to address invisible barriers and

stereotyped perceptions of women in the sciences. Focusing on the structural constraints helps tackle the problem at its root – structural barriers within work and academic environments – and discourage the view that women’s individual interests and cognitive abilities are to blame for gender differences in the science.34 As we discuss in the next session, structural solutions to advancing women in the sciences can help create work environment that are more inclusive and less amenable to the negative effects of these invisible walls.

Addressing Gender Inequality in Science: A Structural Approach

The under-representation of women in the sciences – both in academia and in industry – has important consequences at all levels: for women, educational institutions, and businesses. Take the low numbers of women in decision making roles that we discussed earlier. To the extent to which managers and administrators oversee institutional (financial, human capital) as well as strategic resources, they also influence scientific knowledge and production. For non-academic industries, this influence includes making decisions about the production and development of market goods.35 It follows that not only do women’s perspectives and contributions in the sciences remain under-appreciated but gender inequality at the very top can have significant and possibly negative consequences for the growth of scientific knowledge, productivity, and profitability.

Research suggests that gender diverse research and development teams are better equipped than other teams to create innovative products and even lead to improved individual performance.36 According to a recent benchmarking study by the Healthcare Business Women’s Association, companies in the life sciences industry and marketplace that proactively attract and develop women’s talent have considerable advantage over their competitors.37 All in all, as it is the case for other types of diversity, gender diversity is important to keep in touch with consumer markets, help attract talented scientists from a variety of backgrounds, and enhance productivity and creativity.38

Implementing strategies and programs that directly address structural barriers is a good first step to promoting gender equality. Although programs and practices to increase the representation of women in the sciences have been around for some time, their scope and objectives have evolved as research started to uncover the root causes while challenging some of the previous assumptions as to why more women weren’t entering these fields. Gilbert (2001)39, for example, notes that early practices-focused mainly on the educational pipeline and on increasing women’s interest in science. These strategies include providing girls and women with access to important information about science-related careers, as well as to positive women role models. Other educational programs seek to build women’s background knowledge and skills that they (presumably) lack. While educational programs that support women can indeed be beneficial to individuals and provide them with important tools and information, these programs do not address the root causes of women’s underrepresentation in science. More systematic approaches should address the invisible walls and barriers that women still have to face even after they decide to pursue a career in the field.

The Empowerment, Diversity, Growth and Excellence (EDGE) in leadership study⁴⁰ provides organizations with a number of recommendations for addressing structural barriers to women’s advancement in the pharmaceutical and biotechnology industries. Many of these recommendations can be applied to other male-dominated fields and contexts in the workplace. Specifically, the EDGE study identifies six practices that seem essential to create a successful initiative and advance women in the industry, including:

- Senior leadership support for corporate changes
- Equitable performance evaluation processes
- Measures and accountability that focus on specific behaviors and drive results
- Recruitment practices that support equal representation of women
- Advancement programs for high-potential women
- Career and work flexibility to retain talent

To gain the most benefit in terms of women’s advancement, the EDGE study team suggests that employers should implement these six practices systematically, because relying on only one approach at a time might not work. Companies and educational institutions alike can support the six practices in a number of ways, such as by instituting mentoring and career development programs, setting clear objectives for advancing women, increasing accountability and transparency in talent management processes, as well as measuring progress along the way.

In order to overcome structural barriers it is also important to provide individual female and male employees with the necessary tools and infrastructures. Examples include high-potential employee programs and a set of clear expectations regarding advancement opportunities. Finally, workplace flexibility (including career paths flexibility) and inclusiveness are essential to retaining top talent, as they provide the opportunity for women and men from different backgrounds to excel.⁴¹

Structural approaches can also be helpful in academic institutions. In a recent analysis of faculty hiring processes at science, mathematics and engineering departments in a university setting and over a period of 5 years. For example, sociologists Glass and Minnottö (2008) identified a number of factors associated with the successful hiring of women in science faculty jobs. The most successful searches had at least one woman on the search committee, had advertised the positions in publications targeted at women scientists, and had comprised a larger pool of women applicant⁴². The research found that, despite their apparent willingness to hire more women, the university worked from a largely male-dominated pool and sometimes was at a loss in terms of how to appeal to more women for the position. Faculty searches that posted in publications focused on women in science attracted more female applicants into the pool than other searches. The authors argue that this approach may help compensate for men’s “information advantage” when it comes to learning about openings through informal networks and sources.

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To break down the invisible barriers discussed in this chapter, it is also important to continue raising awareness about gender inequities in science within academic and educational institutions. Economist Ginther (2004), for example, recommends that colleges and universities regularly evaluate the status of women in their science departments, as some of the larger institutions including MIT are already doing. Raising awareness among faculty, administrators, and students can also help draw attention to gender differences outside academia, including how salary, promotion, and attrition vary between academia and industry. An integrated approach that seeks to overcome existing barriers in both contexts is most likely to succeed.

Important steps toward creating-institutional support for advancing women in science are already being taken. These steps occur at different points along girls’ and women’s educational and professional pathways, and may include mentoring programs, proactive recruitment strategies, knowledge sharing, and scholarship programs. The following are some creative and interesting examples:

- The Junior Engineering Technical Society (JETS) leadership fund provides $5,000 academic scholarships to students who intend to study engineering courses in college, with an eye toward a career in the power generation industry. In 2008, the 4 awards were split evenly by gender. (http://www.redorbit.com/news/education/1478149/four_reasons_for_optimism/)

- The RAISE Project seeks to increase the status and visibility of professional women-through enhanced recognition of the achievements of women in science, medicine and engineering. The program includes more than 1,000 awards and features a database with information for applicants from different disciplines and at different levels in their career. (http://www.raiseproject.org/)

- The National Science Foundation ADVANCE grants have the stated goal of increasing the participation and advancement of women in academic science and engineering careers. The program also supports institutional efforts and other women’s leadership initiatives that seek to make academia more hospitable for women scientists. ADANCE’s Institutional Transformation Awards are granted to academic institutions that have implemented programs to promote women scientists and engineers. (http://research.cs.vt.edu/advance/index.htm)

- The Women’s Initiative at MIT seeks to encourage young women to pursue careers in engineering through a number of mentoring programs. The initiative is organized so that every year 11 MIT female engineering students visit thousands of high school students in 11 different school districts throughout the United States. By providing role models and more information on engineering degrees, the initiative seeks to motivate high school girls to take

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the most challenging math and science courses offered in their high schools. (Women’s Initiative at MIT).

Our hope is that a combination of efforts such as those described in this chapter will have the much desired effect of tearing down the invisible walls that now impede women’s progress in the sciences.
References

Engineering; Humanities; Arts and Social Sciences; and the Sloan School of Management.” The MIT Faculty Newsletter XIV, no. 4, 2002.


