

Mothers of Invention: Women in Technology

An old adage counsels, "Maternity is a matter of fact... paternity is a matter of opinion." And indeed, when it comes to people, the evidence of who physically bears the child is visible and undeniable. With the gestation of ideas, however, lineage is less clear.

The evidence for women's role in technology has been obscured historically. Only two percent of the five hundred Nobel Prize Laureates recognized for scientific achievement are women. As recently as the early 1980s, U.S. Patent and Trademark Office records show that only 2.8 percent of patents went to women each year. This participation rate did not differ much from the 1 percent or so of patents that went to women in the period from 1790 to 1895.¹

Young women have had relatively few role models to encourage their pursuit of scientific and technological adventures. That pattern has begun to change as women are increasingly present in all dimensions of the innovation life cycle: knowledge creation, technology transfer, commercialization, and clusters/networks. In 1996, women received nearly 16 percent of patents for chemical technologies, especially for biotechnology and pharmaceuticals. Patentees in these fields include Janet L.

Rideout (AZT), M. Katherine Holloway and Chen Zhao (protease inhibitors), and Diane Pennica (tissue plasminogen activator).²

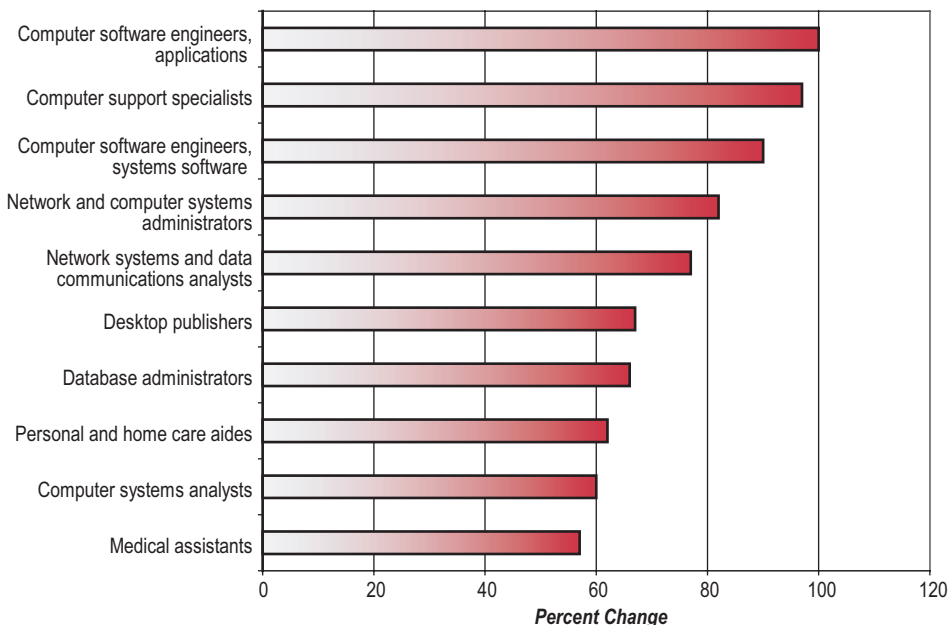
By 1998, women accounted for 10.3 percent of all U.S.-origin patents granted annually. Innovation professionals believe this percentage will continue to increase. A recent survey of one thousand U.S. researchers yielded the names of twenty U.S. scientists under the age of forty who have demonstrated once-in-a-generation insight. Nine of them—almost half—are women.³

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Women must increasingly pursue science and technology to ensure that the future needs for a skilled U.S. workforce be met.

Figure 1
Ten Fastest Growing Occupations, 2000 to 2010



Need for Women in Technology

Dr. Carol B. Muller, founder of MentorNet, a nonprofit dedicated to promoting women's participation in science and technology, notes: "Until women are fully represented in the fields of science and engineering, society is losing out on the talents of a vast number of potential contributors. Academic institutions are losing out. Corporations are losing out. Individuals are losing out. We all lose out."

Women must increasingly pursue science and technology to ensure that the future needs for a skilled U.S. workforce be met. Based on U.S. Bureau of Labor Statistics data analyzed by *Business 2.0* staff,⁴ the ten fastest growing occupations in this decade are in information technology (eight job categories) and life sciences (two job categories), as shown in Figure 1. In contrast to an anticipated average growth of 15.2 percent for all occupations through 2010, growth in employee demand is projected to range from 52 percent to 100 percent for medical assistants, database administrators, network/systems administrators, and software engineers.

Table 1
Fortune's Most Powerful Women in High-Tech and Life Sciences Companies, 2003

Name	Top 50 Women Rank	Company	Fortune 500 Company Rank	Most Profitable Company Rank (where noted)
Carleton (Carly) Fiorina	1	Hewlett-Packard	14	
Meg Whitman	2	eBay		
Anne Mulcahy	4	Xerox	116	
Karen Katen	6	Pfizer	37	6
Betsy Bernard	12	AT&T	22	
Doreen Toben	17	Verizon	10	19
Patricia Russo	21	Lucent Technologies	141	
Judy Lewent	23	Merck	17	9
Ann Livermore	24	Hewlett-Packard	14	
Christine Poon	27	Johnson & Johnson	34	10
Myrtle Potter	29	Genentech		
Susan Desmond-Hellmann	30	Genentech		
Susan Arnold	31	Procter & Gamble	31	17
Deb Henretta	34	Procter & Gamble	31	17
Ursula Burns	44	Xerox	116	
Louise Francesconi	47	Raytheon	105	

The number of women employed as engineers and health technologists and technicians increased by 44,000 between 2001 and 2002. The increase of 2,000 female engineers moved women's participation rate as employed engineers from approximately 10 percent to 11 percent. The number of female mathematical/computer scientists and non-health technicians declined, however, as did the number of men in these occupations.⁵

The significance of the projected job boom is not just quantitative (more job opportunities), but qualitative (more opportunity within jobs). The compensation gender gap has been decreasing steadily in technology fields over the past twenty years. This trend can be attributed to a combination of factors, including

- ▶ More women in senior management
- ▶ More women with advanced degrees
- ▶ More women holding patents

Women in Senior Management

Sixteen of *Fortune* magazine's fifty most powerful women in business for 2003 (vice president level and above) hail from high-tech or life sciences companies. These same companies rank high on the Fortune 500 list (see Table 1).

The 2003 readership survey tabulated by *Woman Engineer* magazine provides a

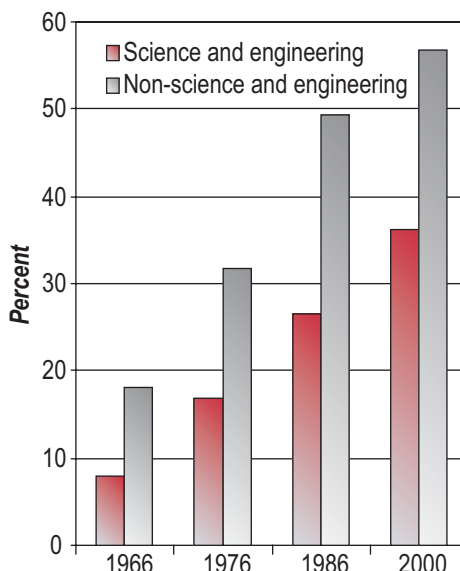
qualitative glimpse at the fifty most desirable work environments for female engineers.⁶ Four of the private sector companies ranked in the top ten are in the aeronautical/defense contracting sector. Nine IT/electronics companies ranked among the top twenty-five, as did two automotive manufacturers (Ford and GM), and one life sciences company (Johnson & Johnson).

A review of the top twenty-five company websites showed that this microcosm of technology companies resembles the larger U.S. economy:

- ▶ Just 11 percent of the top five hundred U.S. technology companies have women corporate officers.
- ▶ Only 1.4 percent of S&P 500 stock index companies are led by a female chief executive officer (CEO), including Carleton S. Fiorina of Hewlett-Packard, Meg Whitman of eBay, Anne Mulcahy of Xerox, and Patricia Russo of Lucent.⁷

Overall, participation by women at the executive management level of the twenty-five companies listed ranges from 0 percent to 36 percent, with a cluster around the 8 percent to 11 percent level. Having a woman in the top position seems to provide more opportunities for women in senior positions. Hewlett-Packard's CEO Fiorina has assembled a sixteen-member executive team of which six are women, including the General Counsel. Other companies on this list are more likely to have women at the second or third tier of management (the vice president level). One-third of DuPont's selected function vice presidents are women, for example, but only one-eighth of the group vice presidents are women. Kimberly-Clark shows a similar pattern: Executive Vice President Kathi Seifert is joined by two female senior vice presidents

Figure 2
Percent of Doctoral Degrees Awarded to Women



Field	1966	1976	1986	2000
Total: All fields	11.6	23.3	35.4	43.8
Total: Science and Engineering	8.0	16.8	26.6	36.2
Engineering	0.3	1.9	6.7	15.7
Physical sciences	4.5	8.5	16.3	24.5
Earth, atmospheric, and ocean sciences	3.0	9.7	17.0	30.4
Mathematics	6.1	11.3	16.6	24.6
Computer science	0.0	9.4	12.0	16.5
Agricultural science	1.4	6.3	17.3	29.1
Biological science	14.8	22.5	33.6	44.8
Psychology	21.5	32.8	51.2	66.6
Social sciences	10.5	21.2	33.6	42.9

Innovative Women

Thomas S. Kuhn's 1962 book, *The Structure of Scientific Revolutions*, explored how belief structures influence scientific inquiry and discovery. Legal and administrative structures dramatically distorted both the scope and record of women's research activities.

Prior to implementation of the Equal Employment Opportunity Act of 1972, state laws and university policies conspired to deny jobs to the wives of university employees. As a consequence, universities benefited from husband and wife scientist "teams" for which only the husband received compensation and recognition. In addition, universities in the U.S. permitted women as students and teachers, but not as researchers. Women were required to have male mentors to obtain access to labs. A few examples from Nobel Prize history illustrate the ensuing complications.¹⁰

- ▶ **Gerty Radnitz Cori** (Nobel Prize in Physiology and Medicine, 1947) was the third woman and the first American woman to win a Nobel Prize. University of Rochester administration told her husband and research partner that it was "un-American" for him to work with his wife. After leaving New York, they were allowed to work together at the private Washington University in St. Louis, supported by a grant from Eli Lilly & Company to continue studies in carbohydrate metabolism. Gerty and her husband shared the Nobel Prize for their work in enzyme research.
- ▶ **Maria Goeppert-Mayer** (Nobel Prize in Physics, 1963) received her prize thirteen years after making her pivotal discovery about the nuclear shell model—and just three years after finally landing a full-time paid university job at the University of California at La Jolla. She, along with other women, faced the challenge of being ineligible for university employment.
- ▶ **Barbara McClintock** (Nobel Prize in Physiology and Medicine, 1983) was the lone recipient of her prize for the discovery of genetic transposition. In 1936, while vice president and president-elect of the Genetics Society of America, she did not have a job because research was considered men's work.
- ▶ The other Nobel Prize awarded to date for genetics went to James Watson, Francis Crick, and Maurice Wilkins. The woman behind the scenes was **Rosalind Franklin**. It was her then unpublished X-ray diffraction pattern of the B form of DNA that provided the crucial evidence for the helical structure. Watson remembered its impact in his autobiography:
The instant I saw the picture, my mouth fell open and my pulse began to race... the black cross of reflections which dominated the picture could arise only from a helical structure... mere inspection of the X-ray picture gave several of the vital helical parameters.
Franklin died at the age of 38—four years before Watson, Crick, and Wilkins received the Nobel Prize. Their Nobel lectures cited ninety-eight references. Franklin was not cited among them, although Wilkins did mention her.
- ▶ Another young British woman, **Jocelyn Bell Burnell**, discovered pulsars as a graduate student, wrote up her thesis, and left academia for family life. Her thesis advisor received a Nobel Prize for the discovery of pulsars.
- ▶ Prior to 1977, only one woman (Gerty Cori) had received a Nobel Prize for Physiology and Medicine. Beginning with the 1977 award to **Rosalyn Sussman Yalow** for radioimmunoassay in investigative medicine, however, four women have received Nobel Prizes. The most recent woman on the list is **Christiane Nusslein-Volhard**, who was recognized in 1995 for her achievement in genetics (early embryo development).

(for human resources and the chief technology officer), out of a total of five senior vice presidents. There are no women at the group president level, however.

Women in senior management also tend to serve corporate functions, such as human resources and marketing/communications, rather than leading business product/service units. Of course, there are notable exceptions. Fortune 500 leader Wal-Mart boasts Linda Dillman as executive vice president and chief information officer. She and Meg Whitman were both named to the 2003 *BusinessWeek* e-business top twenty-five list of those who helped push the Dow Jones Internet Index up by 119 percent over the past year (the S&P 500 stock index was only up 18 percent).⁸

The percentage of science and engineering doctoral degrees awarded to women has grown from 8 percent in 1966 to 36.2 percent in 2000.

Christine Poon is chairman of Johnson & Johnson's worldwide pharmaceuticals group, the division that contributed 61 percent of the company's earnings most recently.⁹ Louise Francesconi is president of Raytheon's \$3 billion missile systems business.

Women with Advanced Degrees

In the *Government Performance and Results Act Strategic Plan FY 1997–2003*, the National Science Foundation (NSF) included as one of its strategic goals to "strive for a diverse, globally-oriented workforce of science and engineers." Dr. Rita R. Colwell, appointed eleventh director of the NSF in August 1998, has led its emphasis on science and math education in K-12, graduate training in science and engineering, and increased participation in studies by women and minorities. According to NSF data, the percentage of science and engineering doctoral degrees awarded to women increased dramatically between 1966 and 2000, growing from 8 percent to 36.2 percent (see **Figure 2**).¹¹

Table 2
Correlation Between Women Patentees with States' Research and Development Expenditures

State	Women Patentees Ranking (1977-1996)	Woman Engineer Top 25 Headquarter Locations (2003)	Total R&D Expenditures Ranking (2000)	Industrial R&D Ranking (2000)	Academic R&D Ranking (2001)
California	1	7	1	1	1
New York	2	3	3	5	2
New Jersey	3	1	4	3	17
Illinois	4	2	6	4	7
Pennsylvania	5	0	9	9	4
Texas	6	0	7	8	3
Ohio	7	1	11	10	11
Michigan	8	2	2	2	9
Massachusetts	9	1	5	6	6

Female scientists and engineers still earn less than male colleagues, although the salary gap may close as a higher percentage of women obtain doctoral degrees.

Women Holding Patents

Patents are another indicator for innovation. The percentage of female patentees is still about half what it could be, based on the percentage of women in science and engineering jobs generally. One factor is the rate of application: more men than women apply for National Institutes of Health (NIH) awards, for example. Although the average award rate was comparable, men applied twice as frequently for NIH First Awards between 1988 and 1997. Similarly, women made only one-third the applications as men for individual investigator research project grants in 1997.¹²

In terms of the distribution of patenting activity, there is a general correlation between the total state expenditure on research and development and the number of women patent holders (see **Table 2**). Patenting activity seems to beget patenting activity. Another observation that can be made is that the companies perceived as being more friendly to female engineers tend to be headquartered in states that spend more on research and development.

The nine states listed in **Table 2** account for about two-thirds of the national research and development effort. Also, two-thirds of the U.S.-origin patents held by women originated from these states, according to NSF studies.¹³

Women's participation among Nobel Prize Laureates and patentees should begin to approximate their participation rate in the workplace.

Conclusion

Changes in university policies regarding women's eligibility for tenure and research positions, increased graduate-level educational attainment by women in science and engineering, more leadership opportunities for women in high-tech companies, and the anticipated growth in employment demand are converging to make science and technology attractive for women. As a consequence, women's participation rate among Nobel Prize Laureates, and especially among patentees, should begin to approximate their participation rate in the workplace. As Pamela Lopker, the richest self-made woman in the Forbes 400 and founder/president of QAD, observed: "In some other industries that have more traditional ways of operating, it's sometimes hard for a woman to make headway. High technology is fast moving and fast growing—nothing is set in concrete. That gives everyone—including, of course, women—a lot of opportunity."¹⁴ ◀

Endnotes

1. Gary Stix, "Wanted: More Mothers of Invention," *Scientific American*, 13 May 2002.
2. Ibid.
3. Survey results published in *Discover*, October 2000.
4. Paul Kahlia, "The Coming Job Boom," *Business 2.0*, September 2003.
5. U.S. Bureau of Labor Statistics reference table is found at <ftp://ftp.bls.gov/pub/special.requests/l/aaat9.txt>.
6. In descending order of desirability: Lockheed Martin, Boeing, Microsoft, IBM, Northrop Grumman, Johnson & Johnson, Ford Motor Company, 3M, Raytheon, DuPont, Kimberly-Clark, General Motors, Computer Associates, CH2M Hill, BP Amoco Group, Medtronic, Agilent Technologies, Procter & Gamble, Seagate Technology, Symbol Technologies, Hewlett-Packard, Jacobs Sverdrup, General Electric, General Mills, Sun Microsystems, Honeywell, Southern Company, BE&K, Electric Boat, TRW, Texas Instruments, Dell Computer, Weyerhaeuser, Merck, Motorola, Panasonic, Qualcomm, Time Warner Telecom, Intel, Amerada Hess, Toyota, Corning, Alcatel, LSI Logic, Mitsubishi, Nissan, L-3 Communications, Ball Aerospace, Foster Wheeler, PeopleSoft.
7. Jane Black, "Special Report: The Women of Tech," *BusinessWeek Online*, 29 May 2003.
8. "The Comeback Kids," *BusinessWeek*, 29 September 2003.
9. Melanie Austria Farmer, "The Powerhouse Who Leads a Billion-Dollar Business," *DiversityInc*, July 2003.
10. The challenges faced by women whose work received Nobel Prize recognition are discussed by Sharon Bertsch McGrayne in *Nobel Prize Women in Science: Their Lives, Struggles, and Momentous Discoveries* (Washington, D.C.: Joseph Henry Press, 1998).
11. Additional information, including graphs of female participation in science and engineering occupations, can be found in NSF's Information Cards: Women, Minorities, and Persons with Disabilities (www.nsf.gov/sbe/srs/fc/nsf02334/wfig2.htm).
12. Data was compiled in "AXXS '99: Achieving XXcellence in Science" (www4.od.nih.gov/axxs).
13. "Buttons to Biotech: U.S. Patenting by Women, 1977 to 1996" (U.S. Patent and Trademark Office, 1998).
14. QAD Inc. is one of the world's leading producers of Enterprise Resource Planning (ERP) software. Quoted from Lopker's acceptance speech upon being named to the Women In Technology International Hall of Fame.