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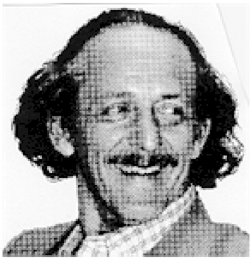

Current Comments

Why Aren't There More Women in Science?

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For many people, the epitome of female success in science is Marie Curie. She was the first person to be awarded two Nobel prizes for science. In 1903, she shared the physics award with her husband, Pierre, and with Henri Becquerel, for their discovery of radioactivity. Marie Curie also received the chemistry award in 1911, for the discovery of radium and polonium. Ironically, though, she was not admitted to France's Académie des Sciences, although her husband was in 1905. In 1980, mathematician Yvonne Choquet-Bruhat became the first female full member of the academy in its 300-year existence.[1] Today three of the academy's 130 members are women.

I mention this not to single out the French, but because it seems to symbolize the condition of women in science even today. In the US only 33 women are members of the 1,329-member National Academy of Sciences (NAS). The Royal Society in London has 29 female fellows, out of a total of 909. We checked the five state academies in the Federal Republic of Germany by telephone. Together they have only 13 female full and corresponding members, out of a total of about 1,100 members. The Deutsche Akademie der Naturforscher Leopoldina, in the German Democratic Republic, told us it had 21 female full members, out of a total of about 1,000.

Women have made great contributions to science. Yet it is only in recent decades that their representation in the scientific community has greatly increased. Even so, women still face barriers to scientific achievement, and women in science remains a controversial topic.

So many women are involved in science today that it's easy to forget it was not always so. There was only a handful of women scientists at any given time before the twentieth century. Only a few names of female scientists survive from ancient times. Arate of Cyrene, for example, taught natural philosophy in Attica in the fifth century BC. The Pythagorean school in the sixth century BC admitted women as equal members. Theano, the wife of Pythagoras, assumed leadership of the school after his death. Hypatia of Alexandria was one of the leading philosophers and mathematicians of the early fifth century AD. Her murder at the hands of Christian fanatics coincided with Alexandria's decline as a world center of learning. St. Hildegard, the Benedictine abbess of Bingen-on-the-Rhine in the twelfth century AD, wrote that the earth revolves around the sun and published an early intimation of gravitation.[2]

An 1898 article in *Popular Science Monthly*[3] reflected somewhat more modern attitudes toward women in science. It estimated that there had been only about 600 "more or less distinguished" women scientists since Miriam, the sister of Moses who practiced alchemy. Most of the women mentioned by name were mathematicians or philosophers. The writer, Henrietta Irving Bolton, included Voltaire's friend, the Marquise de Châtelet, and the Russian mathematician and novelist, Sofya Kovalevskaya (1850-1891).

Other noteworthy early female scientific figures include Amalie Emmy Noether, who did important mathematical work in the field of relativity,[4] and Augusta Ada Byron, the daughter of Lord Byron who worked with English mathematician Charles Babbage and developed the first computer program.[5] The Pentagon named its proposed universal computer language, Ada, after her.

Before 1920, at least 504 living American women were deemed to be pursuing science seriously. This figure is based on listings in the first three editions of *American Men of Science*.[6] It is noteworthy that this reference work did not change its name to *American Men and Women of Science* until 1971. But the situation has improved greatly during this century, particularly in the past 15 years. A study published in December 1981 by the Scientific Manpower Commission, Washington, DC, documents this. Between 1965 and 1980, women earned more than 36,500 doctorates in science and engineering; 31,000 of these were awarded between 1970 and 1980. Women made up seven percent of the science and engineering work force in 1965. By 1980, this rose to 23 percent.[7]

More women are *seeking* science and engineering degrees as well. In 1977, 31 percent of those enrolled in American graduate schools in these fields were women. By 1979, enrollment of women had reached 43 percent. In full-time engineering enrollment alone, women's representation rose from 3,569 in 1970 to about 49,000 in 1980. That's a thirteenfold increase.[7]

However, inequality still exists. In November 1981, the NAS released figures that strongly suggest sex discrimination is still a powerful force in academe. Women remain underrepresented in science. Of men and women who received PhDs 20 years ago, 87 percent of the men are full professors. But only 64 percent of the women have reached that rank. And among all who received doctorates from 1970 to 1974, one-half of the men, but only one-third of the women, hold senior faculty posts. The NAS also notes that women in academe earn less than their male colleagues. Women who received doctorates before 1969 earned, on the average, 11 percent less than men.[8]

Other countries show similar patterns in women's position in science. A recent survey of British medical researchers with nonmedical degrees uncovered inequalities in the placement of PhDs. Sixty-two percent of males have a permanent academic job, but only 35 percent of females do.[9] In Australia, women hold only one in six academic teaching positions. They usually occupy lower posts, too.[10] The USSR claims that women constitute about 40 percent of its scientific population.[11] (p. 118) However, it is noteworthy that the Academy of Sciences of the USSR has three females who are full members and 11 who are corresponding members, according to a spokesman for the academy.[12] The academy has about 700 members.

Many reasons have been offered for the relative paucity of women in science. In 1975, Harriet Zuckerman and Jonathan R. Cole, Columbia University, suggested that women encounter a "triple penalty" which hinders their scientific productivity.[13] First, they wrote, society discourages women from entering science simply because science is "culturally defined as an inappropriate career for women." Second, women who do enter science suffer ambivalence toward their work because they've been told that women are less competent than men. The third barrier is "actual discrimination against women in the scientific community."[13]

In his 1979 book, *Fair Science*, a study of 12 years in the careers of 565 men and women who received their doctorates in 1957 and 1958, Cole reiterated that the "triple penalty" remains a barrier for many women.[14] (p. 255) But he did spark controversy with the statement, "Although there do appear to be pockets of patterned sex-based discrimination in the academic-science community (most notably in the effects of gender historically and in the present-day on promotion of women to high rank), to an extraordinary degree the scientific community distributes its resources and rewards in an equitable fashion."[14] (p. 300)

Some reviewers, such as Barbara F. Reskin, Indiana University, thought Cole downplayed the role of blatant sex discrimination.[15] Reskin herself has suggested that the scientific community reflects to some degree the sexism of society in general.[16] Female students and technicians rise more slowly through the academic ranks than their male counterparts because sex stereotypes are carried over from nonscientific situations. Interestingly, Reskin does not claim that male scientists usually discriminate either deliberately or unconsciously. Rather, she theorizes, inequality occurs because people have a hard time reconciling how they should behave toward the opposite sex outside the scientific community with the normal interaction that occurs between scientists.[16]

Another reason women are hindered from advancing in science, according to Reskin, is that they have limited access to informal means of communication. Women with lower-status academic positions do not mix as readily as their higher-status colleagues. Since a lot of valuable information is exchanged informally, those who are left out suffer accordingly. Reskin notes, "Even today, the prevailing wisdom among women in male-dominated fields is to talk with coworkers' wives at social gatherings, even though they may miss some professionally valuable conversations with fellow researchers." Reskin also notes that male scientists may avoid working with female colleagues to avoid connotations of sexual involvement.[16]

Other aspects of traditional female roles may also work against women in science. For example, it is often suggested that women scientists who are wives and mothers are held back in their careers. In 1980, the American Chemical Society (ACS) surveyed all of its 8,500 women members and 25 percent of ACS men to see what accounted for salary discrepancies. The ACS found that women chemists are much more likely to defer their careers for family reasons. About half of the women spent time out of the chemistry work force, compared with 20 percent of the men. Married women chemists spent an average of a year or two away from work. That's three times the amount of time unmarried women were absent. The ACS also found that 90 percent of the men or unmarried women with 20-40 years of experience have tenure. But only 72 percent of married women chemists do.[17]

However, the NAS questions whether it is family obligations that hold back the career advancement of women scientists. The NAS reports that regardless of whether women scientists marry or have children, their career mobility is at least equal to that of men. Fewer than half of all women PhDs have children and of those, only ten percent of women scientists with small children interrupt their work.[18] In light of this, it is interesting to note Cole's report that marriage and motherhood do not affect women's publication rates.[14] (p. 62)

Another reason often advanced concerns the attitudes of parents and teachers toward science education. Some believe that girls are not given the same encouragement as boys to excel in science and math. If this is the case, then early encouragement should help girls get better grades in science, spark an interest in science, and encourage them to pursue scientific careers.[19]

But according to at least one very controversial study, girls are less likely than boys to display exceptional talent in math. In 1980, Camilla Persson Benbow and Julian C. Stanley, Johns Hopkins University, published in *Science* their report on sex differences among exceptional junior high school students. From 1972 to 1980, the researchers administered the Scholastic Aptitude Test (SAT) to 20,000 advanced boy and girl students. They found that boys and girls did equally well on the verbal section of the SAT, but that boys significantly outperformed girls on the math section of the test. Benbow and Stanley speculate that innate biological differences may account at least in part for the gap in math scores.[20]

This suggestion was criticized in the pages of *Science* for a number of reasons. Among them were the difficulty in quantifying math ability, differences in out-of-class experiences, and differences in encouragement from teachers and parents.[21-23] Benbow and Stanley replied that they do not rule out social factors, but that possible innate factors should not be ruled out either.[24]

A new report promises to add fuel to this controversy. Sharon Senk and Zalman Usiskin, University of Chicago, recently tested 1,364 high school students for their ability to write geometry proofs. Senk and Usiskin comment, "Our results with proof, together with our analysis of other studies, lead us to believe that boys and girls are of equal mathematical ability."[25]

The controversy over biological and other reasons for women's underrepresentation in science can only be expected to continue. Whatever the reasons for women's lower place in science, there is no doubt that they can do high-impact science. Our recent study of the 1,000 most-cited contemporary scientists enabled us to identify the 28 most-cited female scientists for the period 1965-1978.[26] The names of these scientists, their year of birth, their institutions, and their fields appear in Table 1. Their most-cited work for that period appears in Table 2.

Since the basis for selection was anything but random, we can't draw any conclusion about the discipline composition of the women we studied. Practically all are working in the life sciences. There isn't a single physical or organic chemist on the list but we'll know more about that aspect of the demographics when we are able to extend our study to several thousand scientists.

Some readers may be disheartened that there are only 28 women from a list of 1,000 names. It should be emphasized, however, that some prominent living women scientists are not on this list. The list covers a relatively short period of time and ends before some women scientists were working long enough to produce high-impact work. If, in a future study, we examine the most-cited women from a later but comparable span of time, we will no doubt find a higher percentage of highly cited women.

I should also mention that the list probably represents a *slight* undercounting of women on the 1,000-author list. We made an effort to determine the gender of authors with androgynous names, but it is possible that a few women are missing from this list. We apologize to anybody who might have been inadvertently left out. However, the relatively small percentage of women on the 1,000-author list is an unfortunate fact. We do not consider our 28 names to be the last word on citation analysis and women in science. We offer them as the first data we have compiled on the subject. We hope to use them as a springboard from which to explore the topic further.

Toward this end, we conducted a small, informal telephone survey to ask some of these highly cited women what they thought about women's position in science. We realize our sample is biased, but think the opinions of those who did high-impact science are of value.

Some of the women we talked to spoke of lack of early encouragement and lack of role models. Cardiologist Harriet P. Dustan said that she was discouraged by some teachers, but, "I had such a one-track mind that as far as science was concerned I was undeterred." She had only male role models, because male scientists "were the only ones who were there."[27]

Biophysicist Jacqueline A. Reynolds told us that she decided early in her career to switch from premed to chemistry. But she does not regret the decision, or feel that it was unfair that she had to make it. She simply decided that it would be impossible to raise a family

Table 1: The 27 most-cited female scientists, for the period 1965-1978.

Biochemistry
Benesch, Ruth Erica (1925)
Columbia University
College of Physicians & Surgeons
New York, NY

Vaughan, Martha (1926)
National Institutes of Health
National Heart, Lung & Blood Institute
Bethesda, MD

Biophysics
Karle, Isabella Lugoski (1921)
US Naval Research Lab.
Washington, DC

Reynolds, Jacqueline Ann (1930)
Duke University Medical Center
Durham, NC

Cardiology
Dustan, Harriet Pearson (1920)
University of Alabama Medical Center
Birmingham, AL

Cell Biology
Farquhar, Marilyn Gist (1928)
Yale University
School of Medicine
New Haven, CT

Osborn, Mary (1940)
Max Planck Institute for Biophysical Chemistry
Goettingen, Federal Republic of Germany

Endocrinology
Malaisse-Lagae, Francine (1936)
Free University of Brussels
Lab. of Experimental Medicine
Brussels, Belgium

Yalow, Rosalyn Sussman (1921)
Veterans Administration Medical Center
New York, NY

Murphy, Beverley Elaine Pearson (1929)
Montreal General Hospital
Montreal, Quebec, Canada

Gastroenterology
Sherlock, Sheila (1918)
University of London
Royal Free Hospital
London, UK

Genetics
Zech, Lore (1923)
Karolinska Institute
Dept. of Medical Cell Genetics
Stockholm, Sweden

Hematology
Giblett, Eloise Rosalie (1921)
Puget Sound Blood Center
Seattle, WA

Nilsson, Inga Marie (1923)
University of Lund
Allmänna Hospital
Malmö, Sweden

Packham, Marian Aitchison (1927)
University of Toronto
Dept. of Biochemistry
Toronto, Ontario, Canada

Histology
Dahlström, Annica B. (1941)
Gothenburg University
Institute of Neurobiology
Gothenburg, Sweden

Polak, Julia Margaret (1939)
University of London
Royal Postgraduate Medical School
London, UK

Immunology
Askonas, Brigitte Alice (1923)
National Institute for Medical Research
Immunology and Experimental Biology Lab. 1
London, UK

Hellström, Ingegerd E. (1932)
Fred Hutchinson Cancer Research Center
Div. of Tumor Immunology
Seattle, WA

Ishizaka, Teruko (1926)
Johns Hopkins University
Good Samaritan Hospital
Baltimore, MD

Klein, Eva (1925)
Karolinska Institute
Institute for Tumor Biology
Stockholm, Sweden

Molecular Biology
Datta, Naomi (1922)
University of London
Royal Postgraduate Medical School
London, UK

Oncology
Miller, Elizabeth Cavert (1920)
University of Wisconsin Medical School
Madison, WI

Pharmacology
Russell, Diane Haddock (1935)
University of Arizona
Health Sciences Center
Tucson, AZ

Physics
Hanson, Gail G. (1947)
Stanford University
Stanford Linear Accelerator Center
Stanford, CA

Lüth, Vera (1943)
Stanford University
Stanford Linear Accelerator Center
Stanford, CA

Virology
Hartley, Janet Wilson (1928)
National Institutes of Health
National Institute of Allergy & Infectious Diseases
Bethesda, MD

Henle, Gertrude (1912)
Children's Hospital of Philadelphia
Joseph Stokes Jr. Research Institute
Philadelphia, PA

Table 2: Most-cited works of the 27 most-cited female scientists, for the period 1965-1978.

Total Citations 1965-1978	Bibliographic Data
357	**Askonas B A** & Rhodes J M. Immunogenicity of antigen-containing ribonucleic acid preparations from macrophages. *Nature* 205:470-4, 1965.
670	Benesch R & **Benesch R E.** The effect of organic phosphates from the human erythrocyte on the allosteric properties of hemoglobin. *Biochem. Biophys. Res. Commun.* 26:162-7, 1967.
680	Andén N E, **Dahlström A,** Fuxe K, Larsson K, Olson L & Ungerstedt U. Ascending monoamine neurons to the telencephalon and diencephalon. *Acta Physiol. Scand.* 67:313-26, 1966.
261	Meynell E, Meynell G G & **Datta N.** Phylogenetic relationships of drug-resistance factors and other transmissible bacterial plasmids. *Bacteriol. Rev.* 32:55-83, 1968.
227	Tarazi R C & **Dustan H P.** Beta adrenergic blockade in hypertension. *Amer. J. Cardiol.* 29:633-40, 1972.
666	**Farquhar M G** & Palade G E. Cell junctions in amphibian skin. *J. Cell Biol.* 26:263-91, 1965.
253	**Giblett E R,** Anderson J E, Cohen F, Pollara B & Meuwissen H J. Adenosine-deaminase deficiency in two patients with severely impaired cellular immunity. *Lancet* 2:1067-9, 1972.
626	Augustin J E, Boyarski A M, Breidenbach M, Bulos F, Dakin J T, Feldman G J, Fischer G E, Fryberger D, **Hanson G,** Jean-Marie B, Larsen R R, **Lüth V, Lynch H L, Lyon D,** Morehouse C C, Paterson J M, Perl M L, Richter B, Rapidis P, Schwitters R F, Tanenbaum W M, Vannucci F, Abrams G S, Briggs D, Chinowsky W, Friedberg C E, Goldhaber G, Hollebeek R J, Kadyk J A, Lulu B, Pierre F, Trilling G H, Whitaker J S, Wiss J & Zipse J E. Discovery of a narrow resonance in e^+e^- annihilation. *Phys. Rev. Lett.* 33:1406-8, 1974.
533	Rowe W P, Pugh W E & **Hartley J W.** Plaque assay techniques for murine leukemia viruses. *Virology* 42:1136-9, 1970.
629	**Hellström I,** Hellström K E, Sjögren H O & Warner G A. Demonstration of cell-mediated immunity to human neoplasms of various histological types. *Int. J. Cancer* 7:1-16, 1971.
768	**Henle G** & Henle W. Immunofluorescence in cells derived from Burkitt's lymphoma. *J. Bacteriol.* 91:1248-56, 1966.
247	Ishizaka K & **Ishizaka T.** Identification of γE-antibodies as a carrier of reaginic activity. *J. Immunol.* 99:1187-98, 1967.
1172	Karle J & **Karle I L.** The symbolic addition procedure for phase determination for centrosymmetric and noncentrosymmetric crystals. *Acta Crystallogr.* 21:849-59, 1966.
438	Takasugi M & **Klein E.** A microassay for cell-mediated immunity. *Transplantation* 9:219-27, 1970.
320	Malaisse W J, **Malaisse-Lagae F** & Mayhew D. A possible role for the adenylcyclase system in insulin secretion. *J. Clin. Invest.* 46:1724-34, 1967.
266	**Miller E C** & Miller J A. Mechanisms of chemical carcinogenesis: nature of proximate carcinogens and interactions with macromolecules. *Pharmacol. Rev.* 18:805-38, 1966.
1464	**Murphy B E P.** Some studies of the protein-binding of steroids and their application to the routine micro and ultramicro measurement of various steroids in body fluids by competitive protein-binding radioassay. *J. Clin. Endocrinol. Metab.* 27:973-90, 1967.
117	Pandolfi M, **Nilsson I M,** Robertson B & Isacson S. Fibrinolytic activity of human veins. *Lancet* 2:127-8, 1967.
9224	Weber K & **Osborn M.** The reliability of molecular weight determinations by dodecyl sulfate-polyacrylamide gel electrophoresis. *J. Biol. Chem.* 244:4406-12, 1969.
485	Mustard J F & **Packham M A.** Factors influencing platelet function: adhesion, release, and aggregation. *Pharmacol. Rev.* 22:97-187, 1970.
210	**Polak J M,** Pearse A G E, Grimelius L, Bloom S R & Arimura A. Growth-hormone release-inhibiting hormone in gastrointestinal and pancreatic D cells. *Lancet* 1:1220-2, 1975.
390	**Reynolds J A** & Tanford C. The gross conformation of protein-sodium dodecyl sulfate complexes. *J. Biol. Chem.* 245:5161-5, 1970.
162	**Russell D H** & Snyder S H. Amine synthesis in regenerating rat liver: extremely rapid turnover of ornithine decarboxylase. *Mol. Pharmacol.* 5:253-62, 1969.
274	Dudley F J, Fox R A & **Sherlock S.** Cellular immunity and hepatitis-associated, Australia antigen liver disease. *Lancet* 1:723-6, 1972.
189	Murad F, Manganiello V & **Vaughan M.** A simple, sensitive protein-binding assay for guanosine 3':5'-monophosphate. *Proc. Nat. Acad. Sci. US* 68:736-9, 1971.
455	**Yalow R S** & Berson S A. Radioimmunoassay of gastrin. *Gastroenterology* 58:1-14, 1970.
599	Caspersson T, **Zech L,** Johansson C & Modest E J. Identification of human chromosomes by DNA-binding fluorescent agents. *Chromosoma* 30:215-27, 1970.

and attend medical school at the same time.[28] Biologist Marilyn G. Farquhar told us she switched from medical school to biological research because in biology it was easier to allot time between work and family.[29]

Some other highly cited women scientists played down the conflict between a career in science and traditional female roles. Physicist Gail G. Hanson told us about the time she brought her child to work in the first few months after his birth. She wanted to nurse him, but she wanted to continue her work, too. None of her colleagues at the Stanford Linear Accelerator Center objected after they realized his occasional crying wasn't too distracting. In fact, Hanson says, they missed him when she eventually made other child-care arrangements.[30]

At least one prominent woman scientist unequivocally labeled sexism a problem in science. Neuroscientist Candace Pert, National Institute of Mental Health, does not appear on our list because of its chronological limitations. But we sought her views, partly because of her outspokenness and partly because of the controversy over the 1978 Lasker Award for Basic Medical Research, awarded for the discovery of opiate receptors in the brain. Pert was not one of the scientists who received the award, but some observers thought she should have been.[31]

Pert told us that sexism was and is a problem in her career. But she also believes that women scientists have themselves to blame if they let sexism hold them back. She said, "Women have tendencies to be nice and to smile, and they do a lot of other things that make them very nice people, but make them less competitive with aggressive, hard-driving scientists. Sadly, women must manage somehow to short-circuit feminine wiring to achieve the recognition we call 'success.' "[32]

Farquhar comments, "The overly militant person is no longer seen as a scientist or a person in her own right. The best thing that a successful woman scientist can do is to provide a positive role model."[29] Biochemist Ruth E. Benesch advises, "Forget about the sex differences. . . . The best role of women in science is not as women but as scientists."[33]

Many feminists, of course, would reasonably argue that activism is necessary to erode the barriers that hinder women's progress in science. There is certainly room for disagreement on the value of affirmative action for women in science. However, there is no doubt that for the first time in history women now represent significantly more than a small fraction of the scientific community. There is every reason to hope and expect that their representation will continue to increase, until sex discrimination in science is eliminated completely.

(A postscript: As this essay was going to press, we noted an interesting *New Scientist* article on women in science. The author, Georgina Ferry, makes this point, "It is now clear that our failure to encourage girls to be scientists and technologists is not only detrimental to the economy—the first concern of government and industry—but cruelly unfair to the girls themselves. Apart from missing out on a rewarding field of study, girls with little or no science education are automatically excluded from fields of employment that are likely to be crucial in an increasingly technological society. Even if they choose careers in other fields, they can only profit from an understanding of technology's impact."[34])

* * * * *

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