WOMEN WHO RUN WITH PHYSICISTS

Breaking into the men's club of physics takes love, grit, determination and a talent for blending in

BY ANN K. FINKBEINER

A MATTER OF CHOICES:
MEMOIRS OF A FEMALE PHYSICIST
by Fay Ajzenberg-Selove
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To women who wish to become professional scientists I am also suggesting that they remember, in a paraphrase of Hillel's words: "If you are not for yourself, who will be? And if not now, when?"

—Fay Ajzenberg-Selove

FAY AJZENBERG-SELOVE BEGINS HER AUTOBIOGRAPHY by coming right to the point. "I am a professor of physics at the University of Pennsylvania. I am sixty-seven years old," she writes. "When I began to work in physics, only one in forty American physicists was a woman; now the number is about one in ten. In the United States fewer women work in physics than in any other scientific field. Why is this the case?"

Recently W. Y. Megaw of York University in Toronto compiled a surprising table that lists, by country, the percentage of academic physicists in 1990 who were women. Hungary is first; 47 percent of its academic physicists were women. The Philippines is second, with 31 percent. The former Soviet Union is third, with 30 percent. Turkey, Italy and France each have 23 percent; Brazil has 18 percent; India, 10 percent. And tied with Korea for dead last is the United States: 3 percent.

What is going on here? Surely the country at the bottom of that list must have a pallid scientific establishment or lack legal and social sanctions against discrimination by sex? No, the U.S. scientific establishment is the most robust in the world, with legal and social support of equal opportunity in academia. Perhaps the country had a bad year? No, not particularly. In 1982, the percentage of academic women physicists in the U.S. was also 3 percent. Maybe women are physicists but not academics? Those numbers are better but still surprising: of all physicists with jobs in academia, industry or government, women hold only around 8 percent.

Women in the U.S. are scientists but not physicists. Of all practicing physicians, 18 percent are women, and of practicing life scientists, 25 percent are women. And consider these numbers, from 1989:

Percentage of physics Ph.D.'s to women: 8
Percentage of mathematics Ph.D.'s to women: 19
Percentage of chemistry Ph.D.'s to women: 25
Percentage of biology Ph.D.'s to women: 38
Percentage of psychology Ph.D.'s to women: 56

Demographic data must be taken with a grain of salt. They are collected by different organizations at different times, and invariably they are somewhat out of date. Most important, definitions of *practice* differ; although counting numbers of degrees granted by institutions is reliable, counting numbers of employed practitioners can be dicey. But even with salt, the number of American women physicists remains low. "There aren't many," says the physicist Mildred S. Dresselhaus of the Massachusetts Institute of Technology. "There haven't been historically, and there still aren't." Why not?

Demographics can outline a problem, but they rarely tell a complete story. Ajzenberg-Selove's autobiography, *A Matter of Choices*, shifts the entire convoluted question from the statistical to the personal, a move often enlightening and always more interesting. She refocuses the question so that answers are more useful: Why do some women make it in physics?

Ajzenberg-Selove is an experimental nuclear physicist who trained and began her research in the 1950s and 1960s, when nuclear physics was what particle physics is now: the main arena for studying nature at its most basic. Ajzenberg-Selove and her colleagues used low-energy accelerators to hit atomic nuclei with beams of protons or other nuclei. The nucleus—like the electrons that orbit it—assumes any of a number of states of different energy

levels. When the accelerated particle slams into a nucleus, the nucleus jumps to a higher, less-stable energy level. A moment later the nucleus gives up its extra energy and decays back to a lower, more stable energy state.

By studying that process, nuclear physicists learned why certain nuclei are stable and others are subject to radioactive decay, and they deduced the details of the so-called strong force, which binds protons and neutrons in place inside the nucleus. Basic research into the workings of the nucleus became the underpinnings of nuclear power, nuclear weapons and nuclear medicine, and it provided theorists with data that illuminated the most fundamental constituents of matter then known. Ultimately the work became the basis for understanding even more fundamental particles of matter, the constituents of the neutrons and protons known as quarks.

But the story Ajzenberg-Selove tells in her autobiography focuses less on her physics and more, as she puts it, on "why I came to be what I am." Why does a woman go into physics in the first place? Once there, how does she flourish in a field dominated by men?

THESE ARE NO LONGER THE BAD OLD DAYS: when the young Lise Meitner, who would become one of the discoverers of nuclear fission, hid under furniture at the Chemistry Institute in Berlin to listen to lectures; when the University of California at Berkeley declined to hire the future Nobel laureate Chien S. Wu; when Princeton University ignored a request for a catalogue from Vera C. Rubin, who later charted dark matter around galaxies. Nowadays, deans, admissions boards and department chairs all eagerly welcome women students and faculty. Scientific-funding agencies have programs for encouraging women. Committees meet about the status of women. But though the climate for women in physics has improved and their numbers have increased, the rate of increase compared with other sciences has been glacial. Most recently, the growth has stalled.

One explanation of the low numbers is that women simply are not mentally equipped to do physics. Physicists are either mechanically talented experimenters or mathematically talented theorists able to create conceptual pictures. Girls grow up neglecting mechanical things. Women test lower than men do on spatial relations and—beginning in adolescence—they test lower in mathematics, too. Those are the building blocks of physics, and they seem to be women's educational weaknesses. Those observations might be valid, but they do not add up to an explanation. Why, for example, do so many fewer women earn Ph.D.'s in physics than in chemistry or biology, each of which relies on mechanically minded tinkerers and pictorial thinkers? And if women have such a problem with mathematics, why do more women earn Ph.D.'s in mathematics than in physics?

Another explanation might be that women lack the required social and emotional characteristics. Physicists are self-confident, individualistic and competitive; women, compared with men, are not. Physicists do not mind looking nerdy; women do mind. Physicists must dedicate long hours every day and years of their lives to education, training and career; women get sidetracked by marriage and children. All that may also be true, but, still, it does not hold water. Women do well in physics in other countries. As for being sidetracked, what about the Ph.D.'s in the other hard sciences, and why do 5,000 women, yearly, earn M.D.'s?

The only explanations that make sense are not explanations at all but restatements of the problem. The first is that women do not feel welcome in physics. Female graduate students say they are excluded from class discussions and study groups; they are not encouraged by male faculty members, are sometimes actively *dis*couraged and occasionally sexually harassed. Many say they do not want to attend institutions without other women—a nice catch-22, because half of university physics departments are entirely male.

The second explanation is that physics may not attract women. "Many women aren't sufficiently excited by physics to put up with the difficult experiences," says Gloria B. Lubkin, formerly a nuclear physicist and now editor of the magazine *Physics Today*. "You have to want it very much." Every physicist—male or female—has had to want it very much; women seem to have to want it even more. Apparently they do not.

YOUNG FAY AJZENBERG'S UPBRINGING SUPplied her with some unexpected requisites for working in an all-male field. She was born in Berlin in 1926 to well-off, educated Russian and Polish Jews. In 1930 her family was caught in the Great Depression and moved to the village of Moissy-Cramayel, just outside Paris, where they lived for ten years. Her father, an engineer, taught her mathematics and science and encouraged her to be smart, confident, independent and adaptable. Her beautiful but emotionally extravagant mother taught her that "a bored woman could be enormously destructive to herself and to the people around her." Both parents discouraged her from talking about sex, a habit that Ajzenberg-Selove claims was helpful. "My sexual inhibitions," she says, "helped me to have deep and wonderful platonic friendships with men in my almost entirely male field."

She resolved to become another Amelia Earhart and to "live a life that I would not regret as I lay dying." But as a Jewish ten-year-old in Europe in 1936, she "lived with a sharp awareness that I was unlikely to survive my teens." When the Nazis invaded France, the Ajzenbergs fled to Brittany, Toulouse, Lisbon, Cuba and finally New York. Along the way they were strafed by German airplanes and jailed; they slept in cars, lived in underground garages, stood in food lines and got lice. Ajzenberg's father instructed his daughter how, if captured, to cut her wrists. But unlike many, including most of their relatives, the Ajzenbergs made it out of Europe alive.

They came to New York City, where life settled down and Ajzenberg revived her dreams. She enrolled in aeronautical engineering at the University of Michigan, discovered she had "no talent whatsoever for flying" and then became interested in physics. Part of the reason was that her physics teacher enjoyed physics; part was that Marie Curie was a physicist. Although Ajzenberg did bad-

ly in her college physics courses, she says, "I was hooked." In fact, throughout her graduate career, at Michigan, then Columbia University and finally the University of Wisconsin at Madison, she was a mediocre student. Low grades never slowed her down, and now she tells her failing students "that if physics is what they *need* to do, they might well continue trying—that the odds are against them but they are not nil."

AFTER GETTING HER DOCTORATE IN 1952, Ajzenberg spent a summer working at the California Institute of Technology with the physicist Thomas Lauritsen, writing the first of their twenty-six annual reviews of the energy levels of light atomic nuclei. Light nuclei, nuclei having twenty or fewer neutrons and protons, are simpler to understand than are heavy nuclei. Ajzenberg-Selove is now known best for those annual reviews, mostly co-written with Lauritsen and published primarily in the journal *Nuclear Physics.* Each review compiled the best of the year's research on the energy levels of nuclei. The physicist D. Allan Bromley, who has returned to Yale University after serving as science adviser to President Bush, calls them the "nuclear physicists' bibles."

Later, when Ajzenberg joined the faculty at Boston University, and then, four years after, at Haverford College, she continued her exhaustive reading of current studies needed for the reviews. She would notice certain gaps and inconsistencies in the research and, she writes, "I would think of a way in which I might obtain the necessary information." Neither Boston nor Haverford had the accelerators she needed, so, recalls Bromley, "She'd decide which accelerator was best for the job, pick up the phone and call a friend at that accelerator."

Through her wide circle of friends, Ajzenberg-Selove used accelerators at MIT, the Oak Ridge National Laboratory, Princeton, the Los Alamos National Laboratory, Indiana University and the Lawrence Berkeley Laboratory. Through that work, she determined that bombarding beryllium foil with alpha particles does indeed produce the second excited state of carbon, which decays down into stable carbon. Her work was never revolutionary, but it was always reliable and complete. "What I could contribute best," she says, "was my expertise in knowing what was already known, having a well-developed taste for good physics (and good physicists), and being totally aware of what technical facilities were available, anywhere." Ajzenberg-Selove is a particular kind of physicist, not the kind who makes world-shattering discoveries but one who pulls together various strands of knowledge into a central repository. Her friends include many leading figures in contemporary physics: Aage N. Bohr, Allan Bromley, Herman Feshbach, William A. Fowler, Edward Teller, Victor F. Weisskopf, Eugene P. Wigner, and Chien S. Wu.

In 1955 Ajzenberg began the life of a two-career family by marrying the physicist Walter Selove, her first and only love, who would eventually name a particle after her, the f-zero, or, among friends, the faon. For the occasion of the marriage, the Nobel laureate physicist Maria Goeppert-Mayer—who was unable to secure a position at either Johns Hopkins University or the University of Chicago because her husband worked at both places—poured Ajzenberg-Selove a stiff whiskey and told her that being a woman physicist was hard, but being a married woman physicist was nearly impossible. Soon after marrying, Selove accepted a position at the University of Pennsylvania, while Ajzenberg-Selove taught at nearby Haverford.

Years later, hearing that the University of Pennsylvania was looking for women physicists, she proposed herself. She was told that at age forty-six, she was too old and insufficiently active in physics. The first reason was illegal. As for the second, Ajzenberg-Selove was about to become the first woman officer of the American Physical Society and—with the exception of the Nobel laureate J. Robert Schrieffer—had more publication citations than any other member of the department. After a knock-down-drag-out sex-discrimination case she joined the department and, once there, felt completely welcome. With men, she says, "if you win, you're in."

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Later, in addition to research and teaching, Ajzenberg-Selove became interested in physics policy and held positions at various national and international agencies. In 1971 she helped organize a meeting of the American Physical Society on "Women in Physics," an event that many physicists credit with turning their community's attention to the status of its women members. She has fought two battles with breast cancer and one with bladder cancer, but she stopped her research only in 1989, when the incessant traveling and thirty-hour runs on accelerators became too onerous. Ajzenberg-Selove ceased writing her review articles in 1990, when her health problems and fights with her funding agency prompted her to pass the pleasure on to younger physicists.

THE MOST VIVID SENSE OF AJZENBERG-SELOVE comes not through this recital of events but through her direct and occasionally jackhammer sentences. "My life has been fulfilling beyond my most unrealistic dreams," she concludes her book:

> I have been stubborn, competitive, and, above all, lucky. I love Wally and I am loved by him. I am a teacher. My scientific work has been useful to my field. I have made a difference in getting women to be better accepted in my field and at my university. My zest for life is as great as ever. . . . I would like more time but I have been privileged beyond measure. I have had a marvelous life.

What does this life say about the question of women in

physics? For one thing, backbone is essential. Ajzenberg-Selove's persistence through a war, low grades, blatant sexism in academic institutions (she did her experimental runs at Princeton during the night because women were not allowed in the building, and she could work at Caltech only because she did not tell the dean that she was a woman), and three cancers, not to mention the rigors of physics itself, is dumbfounding. Her backbone comes accompanied by an enduring love of physics: "We mustn't forget the fact that physics is beautiful," she said during the 1971 Women in Physics meeting, "that it's a great privilege to be a physicist."

In addition, the question of women in physics is complicated by two-career physics couples. Finding two good jobs in the same geographical area in the same small field is nearly impossible. According to the American Institute of Physics, as many as half the women who are physicists are married to other physicists. Even in my own circle of friends, only one of the seven physicist couples I know works in the same department. A second couple works in neighboring institutions. In two others the wife does not work, and in the remaining three, each partner has a job, but the couples are separated by half a continent or more.

Perhaps the most interesting thing Ajzenberg-Selove's life reveals about women in physics is also the most complicated and vague: people like to be around their own kind. For Ajzenberg-Selove, her own kind is not so much women but physicists. She refers to the men as her chums, drinks with them, ignores their occasional clumsy references to her sexuality, admires them, is grateful for their generosity (and they *are* generous to her) and is delighted when they refer to her as one of the guys. Her first and most profound role model was her father. That is not to say she has been unaware of discrimination or unconcerned about women scientists. It is simply to say that she fitted in well.

SO IS THIS WHAT WOMEN NEED TO DO TO STAY in physics: possess grit, love, stay single and blend in? Ajzenberg-Selove writes:

> I think that the traits that are particularly pronounced among successful physicists . . . are unappealing to young women (and, indeed, to some young men) who might consider physics as a career. . . . The social structure of physics is much like a pyramid, with a few successful people at the top, and many others below. . . . Physicists think of themselves as part of a super-elite. . . . They show an obsessive single-mindedness in their work; and they are intensely competitive.

It sounds plausible, but Ajzenberg-Selove adds another term to the equation when she says that Marie Curie showed her that women were not "inherently disqualified" from doing physics. Dresselhaus too says she stayed in physics because of the examples of a number of other women, including Ajzenberg-Selove: "She's a few years ahead of me and was practicing physics before me. I thought, 'They did it. I can too.'" That feeling is important. Women physicists—including Ajzenberg-Selove—advise women graduate students to avoid all-male departments. "It is my view," Ajzenberg-Selove writes, "and that of several of my women colleagues, that a woman is less likely to make it if these supports [from other women physicists] do not exist." Dresselhaus points out that when the percentage of women is above a "critical mass" of around 15 percent, women have a better chance of success. Once they earn their degrees, they stay in physics and perform.

So the question returns full circle: Why are so few women in physics? The answer seems also to be circular: more women are not in physics because more women are not already in physics. The U.S. population of working physicists is roughly 20,000, 8 percent of whom are women. If the percentage of women is to be raised to a sustainable critical mass of 15 percent, 1,400 more women must be found. At a rate of a hundred women Ph.D.'s a year—no attrition allowed—that would take fourteen years. Those hundred a year could do worse than to emulate Ajzenberg-Selove: unstoppable, generous, loyal to her own kind and deeply in love with physics. •

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