Memories from a Life in Physics

by Mildred Dresselhaus

When I started out in physics only about two percent of the national Ph.D. graduating class were women, even though women had been studying physics and pursuing physics-related careers for well over a century. We like to think that we do the same physics as men and have the same passion for the subject, but our daily lives and career paths were very different then and, to a somewhat lesser extent, are different today. Each woman in my generation has a unique story and I was encouraged to tell something of my own story in the hope that it would be useful and interesting to others.

IN ADDITION TO LOVING PHYSICS, I love music and music has played a surprising role throughout my career. It played significant roles in my early education, my eventual study of physics, and my later appointment to the MIT faculty. I grew up in a low income neighborhood in the Bronx, an area that offered little cultural or intellectual stimulation. By good luck, when I was a pre-schooler I started violin study as a scholarship student at the Greenwich House Music School in New York City. My good luck was having an older

Millie Dresselhaus as an MIT junior faculty member in the late '60s.

brother who was a child prodigy. The teachers more or less assumed that I would also have talent for music. Not only did I get a free music education, but through my musical exposure I met middle class families who valued education.

New York City has some of the best schools in the country but also some of the worst. My education started in a very poor school, but through music I learned about the existence of excellent schools in New York City that were in principle open to all by examination. However, only one of the excellent high schools was open to girls—Hunter College High School—and I managed to win a place. My future was far from clear, however, for in the 1940s there were only three career paths for girls: secretarial work, school teaching, and nursing. Teaching was the most attractive to me and this eventually led me to Hunter College. There I met Rosalyn Yalow in a modern physics class in my second year, and she persuaded me to go in the direction of math/physics/science.

I loved math but was largely self-taught in it. In grade school our math text books for the semester were handed out on the first day of class. By the end of the first week I had gone all the way through the math book and soon after I had gone through the others. In high school I took one physics course but it was not until Rosalyn Yalow showed me the light that I got passionate about physics also. At the time we met, Rosalyn was teaching physics at Hunter College because she could not find a better job. Rosalyn introduced me to research and told me that I likely had a talent for it. After completing that semester with me, she took a job at the Veteran's Administration in New York to see if physics could contribute to medicine. This appointment for Rosalyn started one new branch of biomedical research, leading eventually to the discovery of radio immunoassay and the Nobel Prize in Medicine for Rosalyn in 1977.

My career switch from math to physics came through a notice on a bulletin board announcing the start of the Fulbright scholarship program. I had already accepted graduate entry in mathematics to work on the development of early

computers but I got side-tracked by the possibility of studying abroad. (At that point in my life I had not ventured outside of New York beyond the distance I could go on a bike trip with one of my college girlfriends.) My application to the Fulbright Fellowship program was in physics. I won a Fulbright fellowship and headed to the Cavendish Laboratory in Cambridge, England, to study physics. Rosalyn urged me to pursue graduate research after my study abroad. In 1958 I received a Ph.D. in physics from the University of Chicago. My personal, as well as my professional life, advanced that year, for I married a fellow physicist, Gene Dresselhaus.

Condensed matter physics was a newly emerging field and my thesis was on the effect of a magnetic field on the surface impedance of a superconductor. In my thesis work I discovered an effect that was unexpected and surprising because it could not be explained by the BCS (Bardeen-Cooper-Schriefer) theory of superconductivity (1957). In the last year of my graduate studies I was invited by Professor Bardeen to give the Physics Colloquium at the University of Illinois because he wanted to know more about what I had done. Under the Fermi system at the University of Chicago, students worked independently on their Ph.D. theses so nobody else knew much about what I had done or, for that matter, didn't do.

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After receiving my Ph.D. from Chicago, I won a two-year NSF post-doctoral fellowship to work at Cornell, where I joined Gene who was a junior faculty member in the Physics Department. There I continued research on the microwave properties of superconductors. However, when my two-year fellowship expired, so did any possibility for pursuing physics at Cornell because the nepotism rules—now thankfully extinct—forbade a husband and wife to work for the same employer. To my knowledge only two organizations did not have nepotism rules in those days. These were MIT and IBM; both of these were interested in hiring both of us. And thus serendipity brought Gene and me to MIT.

The advent of Sputnik in 1957 generated a sudden need for physicists in the U. S., and I obtained an excellent research position at the MIT

John A. Tucker

Millie's ad hoc quintet in concert, late November 1970. Physics graduate students seated with Millie are (from left): Bernd Neumann, Stephen D. Umans, Andrew C. Goldstein and Alan J. Grodzinsky.

Lincoln Laboratory. There I was encouraged to move into a new research field, magneto-optics. To establish my own line of research I directed my magneto-optics studies toward graphite rather than semiconductors, which everybody else was studying. I liked graphite because it was different, and because others considered it too hard. Also, graphite was a perfect topic for me because it was out of the mainstream and there was little competition, an important consideration for a woman pursuing research while a mother with four children. I was very happy with my staff position at the MIT Lincoln Laboratory until 1964 when the Mansfield Amendment was passed by the U. S. Congress. This required staff members at national laboratories such as the MIT Lincoln Laboratory to engage only in research deemed to be federally-relevant. In 1966, this was interpreted to require researchers to start work at eight o'clock in the morning. With four very young children (all under the age of seven) at home, this was a daunting task.

Fortunately, by that time I was known on the MIT campus. Some of my research had been carried out on campus at the MIT Magnet Lab, and I had occasionally done substitute teaching for friends there. In addition, I had musical connections with members of the Von Hippel Laboratory. As a result, I knew people on campus and this opened the way to a visiting faculty appointment in the MIT Electrical Engineering Department—which was Von Hippel's academic department—under the auspices of the Abby Mauze

Rockefeller Fund. I thought if I could just have a year or two without having to meet the 8:00 a.m. arrival dictum, my children would grow up enough while I was on leave for me to happily resume work at Lincoln Laboratory.

For my visiting faculty fellowship I have to thank the Abby Rockefeller Mauze Fund that was set up by the Rockefeller family at MIT to promote the scholarship of women in science and engineering; the kindness of Professor George Pratt of the Electrical Engineering Department, who wrote a letter nominating me for the fellowship; and Professor Louis Smullin, Head of the Electrical Engineering Department at that time, who took a big risk in supporting my case. My interest and experience in teaching played some role in taking this risk, as did my involvement in the von Hippel quartet. However, all the activities that led to my appointment were unknown to me until much later.

In the mid 1960s, I got to know Professor von Hippel of the MIT Electrical Engineering Department, who was well known for his research in ferroelectric materials and many other kinds of advanced materials. He might have been interested in my research work in graphite, which was becoming well known in the carbon-materials world, but he was really more interested in my musical ability. Von Hippel was an avid music fan and he had created the von Hippel quartet to perform for group activities. The quartet was managed by Joe Stein, an administrative member of the von Hippel group, who was an excellent cellist and an important figure in the international world of chamber music. I played quartets with Joe Stein quite regularly and one fine day Joe decided that I should join the von Hippel quartet as a viola player "to bring more humanity to the EE Department." This was how von Hippel came to offer support for my coming to MIT as a visiting professor, although this, too, I did not learn until later.

My visiting appointment became permanent in the fall of 1968 when I was appointed a full professor, the first tenured woman in the School of Engineering. My career plan emphasized teaching condensed matter physics to engineering students and continuing my high magnetic field research, primarily on carbon-based and narrow gap semiconducting materials. On the side I was involved in von Hippel quartet activities with my colleagues in the EE Department and with student players. I had entered the fields of intercalation physics and carbon nanostructures in their infancy and as these fields developed and flourished, my work became known and I became known.

Being a woman at MIT and a holder of the Abby Rockefeller Chair, which emphasizes the scholarship of women, entails responsibilities. I felt responsible for reaching out and helping women students and young women

faculty at MIT and helping their careers through mentoring. Once again my music background was helpful, for this enabled me to meet many people and to befriend them through musical events and parties. Unfortunately, after I became the Head of the Center for Materials Science and Engineering in 1977 and then was elected to the Presidential line of the American Physical Society in 1982, I became too busy for music at MIT. In 1983 I joined the MIT Physics Department, and in 1985 I became an Institute Professor.

Perhaps the greatest pleasure from my long career at MIT has come from the many wonderful students I have worked with and the many discoveries we have made together. I have had about 75 Ph.D. students, including about 20% women and a significant number of Afro-American students. The young people from my group have gone on to have an impact on physics, education, and applied science. All of this has brought many scientific collaborators into my life and has given me an unbelievably rich experience through outreach activities worldwide. Every day when I wake up I am yet again excited by the prospect of all these activities.

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