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## Preface

### *No Universal Constants?*

*In physics, there are certain values that are the same all over the physical universe. Among these are: the speed of light in vacuum, the gravitational constant, and Planck's constant. These are known as universal constants.\**

Is it a parent or teacher who sparks a young woman's interest in science or engineering? Or is it a pure love of nature, a hunger for finding out how things work, the desire to help others, or a passion for numbers that starts a young scientist or engineer on her career path? The factors and circumstances are as diverse as the women profiled in our book. Though their paths have been diverse, their destinations are all the same: they are where they want to be, doing what they love.

In titling our book *Journeys of Women in Science and Engineering: No Universal Constants*, we are not questioning the existence or validity of certain physical truths about the universe. What we are seeking to do is to encourage people to question the unstated assumption that the practitioners of science and engineering have a uniform look and follow one particular path through life. The journeys of the eighty-eight women profiled in this book have no universal constants: committed, hardworking women of different races, ethnicities, socioeconomic backgrounds, sexual orientations, or those with disabilities, can find rewarding careers. It may be more challenging

for women, especially minority women, than for men. It may take more stamina to succeed, but women of all backgrounds are surviving and thriving as scientists and engineers.

### Gathering the Stories

Our team of authors came together over several years. When anthropologist Barbara Lazarus, the daughter of a physicist and a community activist, arrived at Carnegie Mellon University from Wellesley College, she was struck by the dramatic differences between an educational environment oriented to women and a coeducational one. Susan Ambrose, social historian and director of Carnegie Mellon's Eberly Center for Teaching Excellence, was interested in women's lives and how class origin, sex, race and ethnicity, social conceptions of women, and other variables come together to influence women's life decisions and careers. Educated as a physicist and teaching in Carnegie Mellon's Department of Engineering and Public Policy, Indira Nair was interested in women students' attitudes toward science and engineering and factors that affect their success in these fields. Susan Ambrose, Barbara Lazarus, and Indira Nair collaborated for a number of years on a series of support programs for Carnegie Mellon women in engineering and science. When Barbara Lazarus suggested that a "field guide" to women working in science and engineering might be an important resource for women, they decided that they wanted to do something concrete to showcase the lives of many different women in these fields.

Deborah Harkus and Kristin Dunkle soon

\*The complete set of universal constants are: the speed of light in vacuum, the permeability of space; the permittivity of space, the gravitational constant, and Planck's constant. See E. Richard Cohen and Barry N. Taylor, "The Fundamental Physical Constants," *Physics Today*, August 1995.

joined the team. Deborah, who had been working as Barbara's assistant, had been fascinated by the work from the beginning. A single mother and nontraditional undergraduate student, she was particularly interested in the alternative paths women can take to rewarding careers in male-dominated fields. Kristin Dunkle came on board as the project's research assistant, initially under a grant from the Alfred P. Sloan Foundation; but soon she became the team's anchor and the book's second author. She was interested in bridging her experience as a laboratory technician in neuropharmacology, her enthusiasm for writing, and her commitment to feminism and minority advocacy.

Together we were concerned about the difficulty women contemplating and pursuing science and engineering careers face in looking for effective role models—the fact that typically there are too few women in any one place to show the real richness of diversity. We found that the interplay of our collective expertise in history, physics and engineering, anthropology, writing, and biological science, as well as the different perspectives resulting from our varied life experiences, provided a good balance to address the challenge we set ourselves: to illustrate the varied paths taken by women working in science and engineering.

Rather than emphasize traditional markers of achievement, we wanted to focus in this book on how women define success for themselves. The reader will find here stories of individual women who have won Nobel Prizes and other distinctions, and many stories of women who have found satisfaction in engineering and science without becoming famous. These women also tell of other fulfilling life activities such as raising children, following a partner's career, and dedicating oneself to activism or public service. The diversity includes women who always knew they wanted to be scientists or engineers; women who had an interest in these fields, were discouraged from pursuing them, and later found their way back; and women who had lengthy careers in other fields altogether be-

fore choosing to start on the path to a technical career.

Our original inclination was to collect as many stories as possible and to showcase two hundred or more women in brief profiles organized by each woman's field of specialization. Although we planned to include "women of distinction" from throughout the twentieth century, we wanted our book to be more than a simple biographical dictionary: We wanted personal accounts of the experiences that had shaped these women's lives and careers. But as we began to conduct interviews, we were struck by the breadth and fullness of each woman's life. The richness of their individual stories convinced us that we needed to reduce dramatically the number of stories we planned to include so that we could treat each one in more depth. Although each woman's story could fill a book, we retained our commitment to presenting a large and diverse group of women; thus we compromised on shorter, but fuller, descriptions. We wanted to feature women who represented a range of backgrounds, experiences, and career trajectories, who were at different stages in their careers, who represented different races and ethnic backgrounds, who were both disabled and able bodied, and who identified themselves as straight, lesbian, or bisexual. We wanted to move beyond mere token representation to show how women from similar backgrounds, women working in the same fields, and women with anything else in common could still have very different, although equally valuable, experiences.

We are honored that so many different women have joined us in our work, but we do not expect or even advise that a young woman reading this book will find one person with whom to identify; rather, she will be able to assemble a composite picture of herself and—more importantly—of the scientist or engineer she wants to become.

Choosing whom to include was not easy. We began with the idea of balancing the fields and subfields in which our women were practicing while assuring that there was sufficient

diversity in their backgrounds and lifestyles. To begin collecting this group, we solicited nominations from dozens of well-known professionals, as well as from students and younger women, to see whom they might have found particularly inspiring themselves. We also canvassed special-interest and minority-affiliated Internet resources and organizations.

We received more than a thousand enthusiastic nominations, far more than we could possibly use. We owe a great debt of gratitude to everyone who took the time to send a nomination. For every woman included, there are hundreds who are not and who easily could have been.

In such a lengthy project, it was not possible to collect all the nominations before making some selections. Collecting nominations, making selections, and conducting interviews was an ongoing process for over three years; and as we listened to the women's stories, we realized that our initial two-dimensional conception of balance was not adequate to the task. Creating balance came instead to resemble assembling a patchwork quilt and needing to keep various colors in balance—or in this case, areas of specialty and employment sectors; socioeconomic background, race, and ethnicity; education; work experience; and families of origin and families of choice. We began actively seeking people whose lives were known to have critical dimensions (for example, welfare experience or in maintaining a long-distance relationship). This made our task much more complicated but the resulting product (we hope!) also much richer. It was a continuing juggling act.

The eighty-eight profiles in our book show how science and engineering have been and can be an integral part of many different women's lives. The core of each profile is a first-person narrative describing what originally attracted the woman to her field, her career decisions and experiences, successes and difficulties, and the roles of significant people or events in her life. Many profiles explore the day-to-day details of the woman's professional life: what excites her about her work, what her

work environment is like, what is important about her work and her field from her own perspective, and why she remains committed to them. Of course, the precise balance of information presented varies from profile to profile, depending on what the woman emphasized in her interview and what seemed most appropriate to her story. Profiles range from 1,500 to 3,500 words in length, and they end with a listing of relevant biographical data including date of birth, colleges attended, and position currently held. These biographical synopses also include a sentence or two about the woman's household and/or family.

We originally intended to organize these profiles by field or specialty, but we changed our minds for **two** reasons. First, we began to see that no matter how broad our categories (biological science, physical science, and so forth), there were some women whose work simply would not fit into such arbitrary pigeonholes because women often tend to work in broader or interdisciplinary aspects of their fields. Our second impetus for change came from focus groups we conducted with high school students and middle school teachers, and from feedback we obtained from undergraduates, graduate students, and science and engineering faculty who read our drafts. Very few of our respondents felt that the book would be best organized by field, and many suggested that the juxtaposition of women from different fields would highlight both the common struggles and the unique experiences of women from different backgrounds or doing different work. We organized the profiles alphabetically, effectively creating an arbitrary mix.

The challenge in preparing each profile was to capture the woman's story as well as her voice. While a handful of women chose to draft their own stories (and their results are quite wonderful), we wrote the vast majority of the profiles ourselves based on lengthy interviews (conducted either face to face or, more frequently, over the phone) supplemented with e-mail correspondence. We generally structured the interviews to address three broad ques-

tions: “What do you do?” “How did you get there?” and “What challenges or obstacles did you face along the way?”

After interviewing each woman, we tried to piece together her life story in her own voice. Because we chose to write in the first person and wanted each woman to feel that her story and her voice were accurately reflected, we sent the first draft of each profile to the woman for feedback. Then, if it seemed advisable, we made one or more rounds of revisions, until the woman felt comfortable with her story as presented.

Because these stories represent a point in time, many things may have changed since they were written. We have written in what anthropologists call the “ethnographic present”: the known “truth” at the time the data were collected.

One advantage of presenting the profiles as uninterrupted first-person narratives is that it allows the women to speak directly to the reader in an informal and often quite personal way. A disadvantage is that a book such as this constitutes public discourse, and some of our women needed to consider the personal and political ramifications of their statements. While we admire the honesty and candor of everyone featured, we must acknowledge that there are a few gaps in the narratives, especially around sensitive issues such as discrimination and abuse, which could only be filled by allowing anonymous presentation. Because anonymity would sacrifice the personal immediacy that is our purpose, we leave these matters to other authors and other books.

## Assistance and Resistance

Parents, teachers, and mentors were crucial in encouraging the women we interviewed to explore engineering and the sciences. Many women spoke of parents who provided them with science kits, took them to museums, or fostered science-related discussion around the kitchen table. Others talked of parents who treated them almost like sons, teaching them

how to use tools and fix things. Women who grew up on farms and ranches recall being outdoors and working with animals, crops, or equipment as being particularly good at fostering self-reliance and an ease with nature and the physical world. Others told how their parents simply encouraged them to follow their dreams and to believe that they could do anything they wanted to do. While some women had stories of parents who didn’t encourage their educations, others spoke of the sacrifices their parents made to put them through college.

Many women told us how just one teacher or counselor who took time to urge them to study science or engineering had made the crucial difference in their choice of a college major. For others, finding a role model was as simple as reading a book about Marie Curie; having someone to emulate helped these young women envision themselves in careers in technical fields.

We also spoke with women who at some point had attended all-female high schools or colleges, and with others who had attended or worked at historically black colleges. Many recalled these environments as particularly supportive. Without the presence of men or white people, they were able to develop their talents and leadership skills without having to contend with sexism or racism.

Almost all the women have faced the loneliness, frustration, and self-doubt that often result from discrimination and the relative isolation of women in science and engineering. They have found support in a number of places. Some have done so by creating or joining professional networks. For example, a woman in a relatively obscure subspecialty created an electronic mailing list and newsletter to keep geographically dispersed colleagues in touch with each other. Another assembled a mailing list of scientists from a particular minority group in order to discuss common concerns. Many women have joined groups that are specifically for women in science and engineering, and many have served as mentors to young women.

Almost every woman had something to say

about integrating her career with her personal life. The women we interviewed frequently credited their spouses or partners with providing essential practical and emotional support for their careers—being willing to relocate, helping with the children, or being the at-home spouse. Mothers often spoke of the flexibility and encouragement of their children; others spoke of help from their own mothers and the importance of having supportive friends to talk to during a crisis. Many women discussed the importance of having hobbies or other interests ranging from dance or musical performance to social activism. We found a pervasive theme among the women of wanting to be useful to society or to the world.

Finally, some women developed specific strategies for dealing with difficult interactions. While none left science or engineering altogether, some did switch specialties. Others did not recognize what was going on at the time or actively chose to ignore it. Some women said they had learned to pick their fights carefully and not waste energy on battles they were unlikely to win. Others learned to use humor constructively to point out to colleagues when they were behaving unfairly or inconsiderately.

And then there are the women who have decided to handle these uneasy situations proactively, straightforwardly announcing, “Yes, I’m a woman; so what! Let’s get to work.”