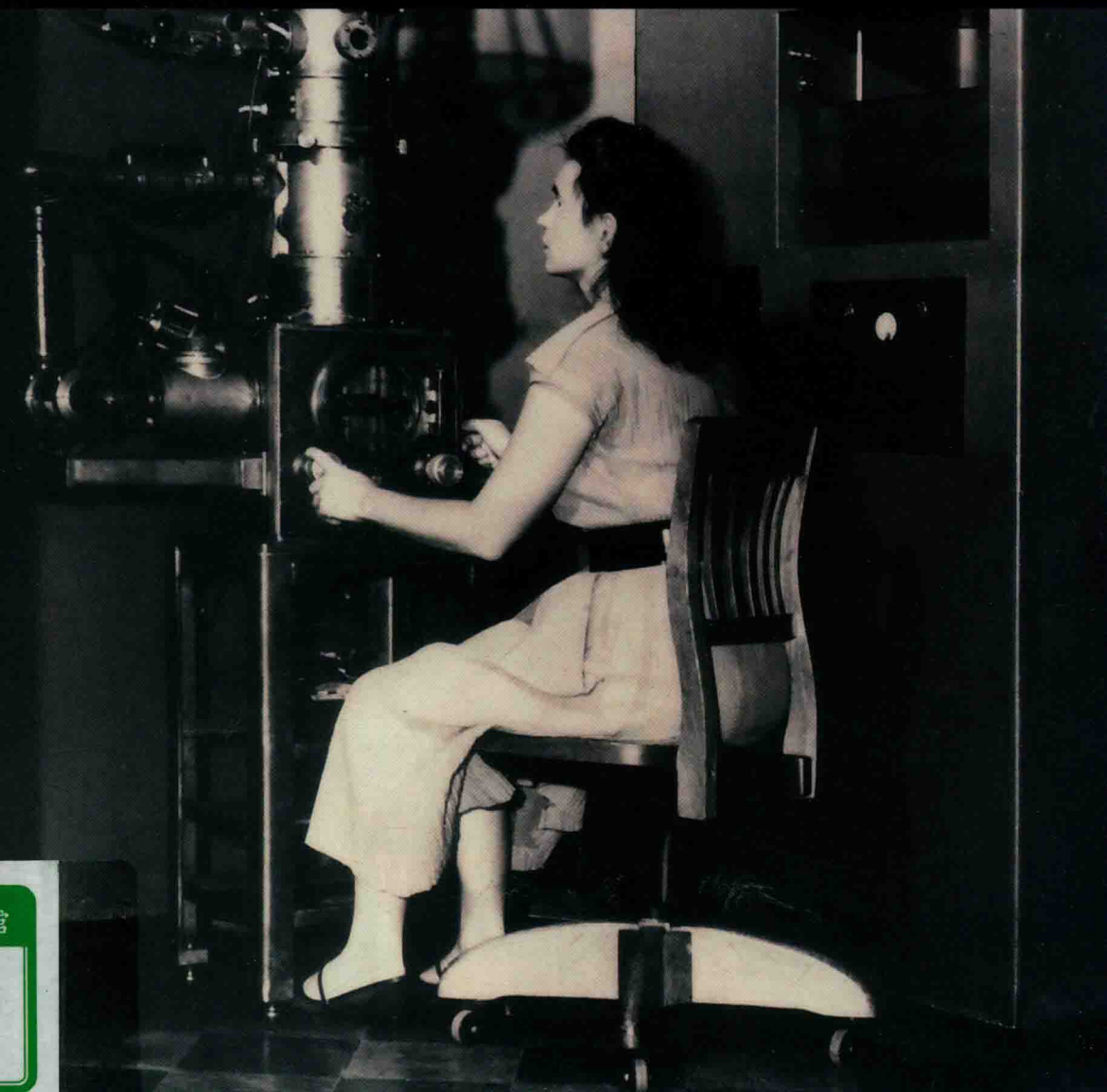
# Women Scientists

## Reflections, Challenges, and Breaking Boundaries

Magdolna Hargittai



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## Also by the Author

*Great Minds: Reflections of 111 Top Scientists* (Oxford University Press, 2014, with B. Hargittai and I. Hargittai)

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*Visual Symmetry* (World Scientific, 2009, with I. Hargittai)

*Candid Science IV, VI: Conversations with Famous Scientists* (Imperial College Press, 2004, 2006, with I. Hargittai)

*In Our Own Image: Personal Symmetry in Discovery* (Plenum/Kluwer, 2000; Springer, 2012; with I. Hargittai)

*Symmetry: A Unifying Concept* (Shelter Publications, 1994, with I. Hargittai)

*Cooking the Hungarian Way*, 2nd edition (Lerner, 2002)

*The Molecular Geometry of Coordination Compounds in the Vapor Phase* (Elsevier, 1977, with I. Hargittai)

## Edited Volumes

*Candid Science I, II, III: Conversations with Famous Scientists* (Imperial College Press, 2000–2003, with I. Hargittai)

*Advances in Molecular Structure Research,* Vols. 1–6 (JAI Press, 1995–2000, with I. Hargittai)

*Stereochemical Applications of Gas-Phase Electron Diffraction*, Parts A and B (VCH, 1988, with I. Hargittai)

To the memory of my mother, Magdolna Reven Vámhidy;
circumstances prevented her from getting the higher education that she strived for.

# PREFACE

This book grew out of my encounters with famous women—physicists, chemists, biomedical researchers, and other scientists—during the past fifteen years. They are from eighteen countries on four continents. For a number of years, we had a family project of recording and publishing conversations with famous scientists, and we collected most of them in our six-volume *Candid Science* book series.[a] Each volume contained at least thirty-six conversations, and at least half of them were with Nobel laureates. There were too few women in this collection, although we had no bias in selecting our interviewees. This led me to the realization of what others had noticed long before me: the unjustifiable underrepresentation of women at the higher levels of academia. When I was a student, majoring in chemistry, there were about the same number of women and men in our class. Then, moving up the academic ladder, the balance kept changing in favor of men. I myself could have fallen off this ladder at two important stages of my career, but luckily, I did not.

My future husband, Istvan, and I started seeing each other when he was a beginning researcher in a laboratory of the Hungarian Academy of Sciences in Budapest and I was a sophomore in my university studies. We got married just before my senior year. His enthusiasm for his project was contagious, and I joined him for my diploma work (master's degree equivalent) and continued after my graduation. He was an independent researcher who had initiated his own project and needed associates. When he showed success, it generated appreciation as well as jealousy among his colleagues in the laboratory.

One day—this happened in the early 1970s in pro-Soviet Hungary—the so-called quadrangle of the laboratory, the director, the party secretary, the chief of personnel, and the trade union secretary, invited Istvan for a talk. They told him that it was not right for a husband and wife to work together. They were not belligerent and told him candidly that had he been less successful in his project, it would have not generated such interest in his circumstances. Istvan calmly responded that he understood and would start looking for a new job for himself. He later told me that his quick response surprised not only the others, but himself as well, because he knew that he could not have found another place with the level of independence and support for his ideas that his current position offered. Looking for a position outside of Hungary

[a] *Candid Science*, Vols. I–VI, Imperial College Press, London, 2000–2006. A compilation of excerpts from a selection of interviews appeared recently: B. Hargittai, M. Hargittai, and I. Hargittai, *Great Minds: Reflections of 111 Top Scientists*, New York: Oxford University Press, 2014.

was unthinkable in those days; the borders were closed. Of course, the members of the "quadrangle" had taken it for granted that the wife—that is, I—would be the one to go, as indeed would have been logical to expect. After this exchange, they never brought up the issue again, and since there was no official rule excluding husband and wife working together, we kept doing so for quite a few years.

This arrangement gave me a tremendous advantage when our children were born. I stayed at home for about six months each time, but was not left behind in my work, because we never separated our activities at home and the laboratory.

Before a too idealistic picture emerges from my account, I must admit that our family developed in a traditional way in that Istvan's career was our focus. I found it natural that running the family was my duty, even though he helped in every way. However, the expression "helped" already gives the situation away; we were not equals in our duties at home. While our children were small, I put my career on the back burner; I did not want our son and daughter to suffer for having a scientist mother. I was slower in earning my higher scientific degrees than might have been the case had I not focused so much on raising our children, and my career took off around the time when our younger child entered high school. This was when I embarked on developing my independent research direction.

I had not wondered about the difficulties women scientists have to overcome until we were already well into our hobby, the *Candid Science* project. Eventually, though, I started wondering why there were hardly any women professors among my teachers, why I never encountered a woman dean let alone rector or president during my studies, and why there were so few female Nobel laureates. Once I made these observations, I decided to look for patterns and the roots of the problem. I sought out prominent women scientists with whom I could discuss these issues in addition to learning about their science. I started giving talks about women scientists, and the interest these talks generated encouraged me to continue these activities and led to the idea of this book.

I have recorded about one hundred conversations with famous women scientists. All these women have excelled in their scientific fields. Some of them decided at one point in their career that they would take another challenge, and became involved with science administration. This aspect is of additional interest because such leadership roles have also been traditionally male-dominated.

Literature on women scientists is extensive and has fulfilled a useful mission in alerting people to the potentials of women and their achievements, as well as to the challenges they are facing even today. My book puts emphasis on the scientific, geographical, and social diversity of its women heroes. I was privileged to learn a great deal of exciting science from my excellent partners in conversation, and I tried to convey some of this as well.

My mother was a most intelligent woman, but her circumstances prevented her from getting a higher education. She was determined that I should get one. My daughter has found it natural to feel comfortable in academia. I do not know whether my granddaughter will have academic aspirations. If so, I hope she will have no barriers. I thought of them a great deal while writing this book.

# ACKNOWLEDGMENTS

Putting together such a volume requires the involvement of many people.

First, I have to express my thanks to all those women scientists who accepted my invitation and took the time to talk with me about their life, their science, and the difficulties they faced during their career. I appreciate their candor in sharing with me their thoughts about the question of women in science.

I received invaluable assistance from many people in the most diverse capacities—in giving me information about their relatives or former colleagues, arranging for meetings, helping with pictures, discussing with me the situation of women scientists in their country, and reading and commenting on certain chapters: Ernest Ambler, Mátyás Baló, Anders Bárány, Annarita Campanelli, Charusita Chakravarty, Janet Denlinger, Natalia Engelhardt, Richard Garwin, Rohini Godbole, Boris Gorobets, Kolbjørn Hagen, Evans Hayward, Drahomir Hnyk, Dale Hoppes, William Jenkins, Jan Kandror, Roger Kornberg, Karl Maramorosh, Shobhana Narasimhan, Oleg Nefedov, Ramakrishna Ramaswamy, Ladislas Robert, Sobhona Sharma, Manfred Stern, Svetlana Sycheva, K. VijayRaghavan, Pal Venetianer, Clara Viñas i Teixidor, Brigitte Van Tiggelen, Olga Valkova, Larissa Zasurskaya. Bob Weintrub, and Irwin Weintrub read the entire manuscript and made valuable suggestions. I am grateful to them all.

The loving interest of our children, Eszter and Balazs, and our spirited discussions concerning this project meant a great deal to me.

My special thanks go to my husband. Ever since Istvan and I met, decades ago, we have been partners in all aspects of life. We have faced hardships together and have shared fantastic adventures, many of which were connected with science. As a student, I learned from him that it is worthwhile to be a scientist only if we adhere to the highest standards in research. I learned from him the pleasure of making a discovery and to look beyond one's narrow field of research to see the larger picture. It was also through him that I became interested in the lives of scientists, which eventually led me to this project.

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# Women Scientists

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# INTRODUCTION

For centuries the expression "woman scientist" could be regarded as an oxymoron—two words appearing together that are contradictory. However, already in ancient times there were women who had interest in and talent for natural philosophy. One of the first women recorded for her involvement with mathematics and astronomy was EnHedu'Anna, around 2350 BCE, a priestess in Babylon. According to legend, Xi Lingshi was a Chinese empress around 2700 BCE who figured out how to make silk and thus originated the silk industry in China. Two women from ancient Egypt are well known. Maria (sometimes called Mary or Miriam) the Jewess lived in the first century CE and is considered the first woman alchemist. For many centuries, she was one of the greatest authorities in this profession.[1] She designed and built chemical instruments, for example the water bath—the double boiler is still called "bain-marie" in French. Her name is also preserved in the pigment "Marie's black," a lead-copper sulfide compound synthesized by her. The best-known woman from this age is Hypatia (ca. 370–415) of Alexandria, a mathematician and astronomer, who had a chair at the Neoplatonic Academy. She was also versed in other sciences, such as physics, chemistry, and medicine.

The Middle Ages spanned about a thousand years in human history during which science did not prosper. What was known by then was preserved mostly at the monasteries and convents. There were a number of physicians among nuns who were well respected for their knowledge. The German nun Hildegard of Bingen (1098–1179) was one of them. Jewish women doctors were also quite common throughout Europe for centuries. In the eleventh century, a medical school opened in Salerno, Italy; it was the first university in Europe, and women were also allowed to study there. Trota of Salerno, also known as Trota Platearius (eleventh century), who is thought to be the first woman professor of medicine, received her education there. She specialized in obstetrics, gynecology, dermatology, and epilepsy.[2] She published a book on women's diseases—known as the *Trotula*—that became the standard text for many centuries to come. The thirteenth century witnessed the foundation of universities in Bologna, Paris, Oxford, and other cities. Bologna and Salerno were still open for women students, but universities in other European countries did not allow women to enroll. Gradually, women were excluded from the medical profession.

During the time of the Scientific Revolution, women were still excluded from science and were not allowed to study (a few Italian universities provided exceptions). The new discoveries in science, however, stirred the imagination of some women of the aristocracy, who participated in the discussions in their salons and decided to learn from private tutors. The Englishwoman Margaret Cavendish (1617–1673)

studied astronomy and mathematics and wrote books on a variety of scientific topics. In France, Émilie du Châtelet (1706–1749) was famous for her talent for languages, mathematics, and physics; she translated Isaac Newton's new theories into French. In Italy, Laura Bassi (1711–1778) received her doctoral degree in Bologna in 1732 and became the first woman to get a teaching position and professorship in physics at a university in Europe. Another Italian, Maria Agnesi (1718–1799), spoke seven languages and studied mathematics—including calculus—and held a chair in mathematics and natural philosophy at the University of Bologna.

Marie Paulze Lavoisier (1758–1836), Antoine Lavoisier's wife, became passionately interested in her husband's work—he was the leader of the eighteenth-century chemical revolution. She received formal training in chemistry and in drawing.[a] She learned English and translated the important literature into French for her husband. They spent much of their time in the laboratory together. This helped him understand that the then prevailing phlogiston theory of burning was wrong and to learn about the discovery of oxygen by the Englishman Joseph Priestley and the Swede Carl Wilhelm Scheele. Marie recorded all the experiments carried out in their laboratory, complemented with detailed pictures of all instruments and experiments. Her records helped future generations learn about the state-of-the-art chemical techniques and equipment of their time. His famous book, the *Elementary Treatise on Chemistry*, considered the first real textbook of chemistry, contained her thirteen engravings of laboratory instruments. Lavoisier was executed in 1794 during the French Revolution. His property, including all his scientific work, was confiscated. Marie was incarcerated for several months. Eventually, she recovered all his notes and published his *Memoirs*, which she had to complete. She held scientific salons where she explained the new chemistry to her guests.

During the seventeenth and eighteenth centuries, the relatively large number of women astronomers is noteworthy. In Germany, for example, about 14 percent of all the astronomers were women. Astronomy was ideal for women because it could be conducted at home. Most of these astronomer women were wives, sometimes sisters, of astronomers; the women worked as assistants to their husbands or brothers. The German Elisabetha Hevelius (1647–1693) was married to Johannes Hevelius, a well-known astronomer thirty-six years her senior, and she worked with him for twenty-seven years until his death. They discovered many stars. After his death, she completed and published their joint work in a book which catalogued and gave the position for almost 1,900 stars. It was their joint work, though the book carried his name alone.

Another German astronomer, Maria Kirch (1670–1720), was the first woman to discover a comet. She married the famous Gottfried Kirch and became his assistant at the Berlin Academy of Science for two decades until his death. Afterward, she tried to continue her work, but was not allowed to stay at the Academy. Sophia Brahe

[a] Her teacher was Jacques-Louis David, who also created the famous painting "Monsieur Lavoisier and his Wife" (1788), which is at the Metropolitan Museum of Art in New York (see http://www.metmuseum.org/collections/search-the-collections/436106).

(1556–1643) was a legendary Danish astronomer, working together with her brother, Tycho Brahe. Caroline Herschel (1750–1848) was a German-born British astronomer who worked all her life together with her brother, William Herschel; together they discovered many comets.

The nineteenth century brought major progress in the sciences—scientists gradually replaced the earlier natural philosophers. Great changes in women's position in society started taking place about one hundred and fifty years ago, in the second half of the nineteenth century, when the first waves of women's movements swept through Europe and the United States. Women demanded certain rights, among them the right to a higher education. Universities gradually opened their doors to women, a historic step. There were new women's colleges, such as Mount Holyoke (1861) and Smith College (1871) in the United States and Girton College at Cambridge (1869) and Lady Margaret Hall at Oxford (1878), both in England. Soon, some older universities became coeducational. Women were allowed to enroll at universities in several European countries, starting in the mid-1860s. Zurich and the German universities became favorite venues for women from places where they did not yet have this possibility. Within a decade, countries on other continents, such as New Zealand, Chile, and Australia, followed. I mention two women from this period. The American astronomer Maria Mitchel (1818–1889) discovered a comet and became the first astronomy professor at Vassar College in 1865. The Russian mathematician Sofia Kovalevsky was the first woman appointed to a professorial chair at Stockholm University in 1889.

The beginning of the twentieth century was marked with an enormous feat when in 1903 Marie Curie won the recently established Nobel Prize in Physics together with her husband, Pierre Curie. This success received great publicity and brought attention to women in science. It inspired many young women, but women still had enormous difficulties if they wanted a career in science. Although universities had opened for them a few decades before, to get a teaching or research position at a university was another matter. Numerous examples illustrate this. Emmy Noether, a successful mathematician, did not get a position at the University of Göttingen in the 1910s in spite of strong support from her colleagues. Hertha Sponer (1895–1968), by then already an associate professor at the same university, was fired in 1934 due to the Nazis' position against women in academia. The future Nobel laureate Gertrude Elion had great difficulties in finding her first job in the United States. We will see a number of other examples.

The most famous woman scientist of this period, besides Marie Curie, was Lise Meitner (1878–1968). She is well known not only for her groundbreaking achievement as a nuclear physicist but also for the fact that she was left out of the Nobel Prize awarded to her colleague, Otto Hahn. She received her doctoral degree in physics in 1905 from the University of Vienna, the second woman to have done so. Marietta Blau (1894–1970) was another Austrian physicist who made discoveries in nuclear physics, for which Erwin Schrödinger nominated her for the Nobel Prize, which she did not get. The prize went to Cecil Purcell, who further developed the method that

Blau and her coworker Hertha Wambacher had devised. Clara Immerwahr (1870–1915) was a German chemist, the wife of the famous chemist Fritz Haber. She was the first woman to receive a doctorate at the University of Breslau, but as the wife of a professor, she could not get a position—she could only assist her husband. After the poison gases developed by Haber were first used in World War I, Clara committed suicide.

During the first part of the twentieth century, more and more women studied sciences and received degrees, but they still faced difficulties when looking for jobs. The number of women graduates increased considerably in the second part of the century, but the popular expressions "leaky pipeline" and "glass ceiling" did not lose their validity. "Leaky pipeline" refers to the fact that the proportion of women falls off at every step of the way up the academic ladder. The "glass ceiling" is the point at which the advancement of women is blocked in an institution. In 1999, Professor Nancy Hopkins and her colleagues at the Massachusetts Institute of Technology (MIT) published a report, "A Study on the Status of Women Faculty in Science at MIT."[3] It showed how badly women were discriminated against at that institution. The report had a strong effect nationwide and brought about major changes in the working conditions, salaries, and other aspects for women in faculties. A few years later, the president of Harvard, Larry Summers, shocked the public by announcing that women's innate aptitude was the reason why there were so few women at the top. But it was a sign of change that a large outcry made him resign his presidency.

The bulk of this book is about women scientists whom I have met in person. I included a few others as well, because they usefully augmented the rest. In these cases, I tried to add something to their stories already known, to make them more complete. Thus, for example, Edward Teller's extended correspondence with Maria Goeppert Mayer showed the role other scientists played in Goeppert Mayer's life and vice versa. In case of Chien-Shiung Wu, her research area has always fascinated me, and my probing into her story made me see that the widespread lamentation about her not having received the Nobel Prize is misdirected. I did not include some other famous women scientists, like Lise Meitner or Rosalind Franklin, whose stories are no less fascinating, but where I did not have anything substantial to add to the accounts already available.

The women in this book represent a variety of scientific fields, mostly physics, chemistry, and the biomedical sciences, and to a lesser extent mathematics, astronomy, engineering, medicine, and other fields. Of course, there is considerable overlap between various fields, and such overlaps often characterize the activities of the scientists appearing in this book; hence, the designation assigned to them often does not describe the totality of their activities, in which they have invariably excelled.

An important feature of this book is its broadly international character. My heroes come from different backgrounds and different geographical regions, eighteen countries on four continents. A little less than half of them are from Europe, a third from the United States, and the rest from Asia and Australia.

I grouped the chapters into three loosely defined sections. Perhaps because of my own initial experience working jointly with my husband, I am interested in other