BOOK REVIEWS

The Posthumous Nobel Prize in Chemistry. Volume 2. Ladies in Waiting for the Nobel Prize, E. Thomas Strom and Vera V. Mainz, Eds., American Chemical Society, Washington, DC, ACS Symposium Series 1311, Distributed in Print by Oxford University Press, 2018, xiii + 328 pp, ISBN 9780841233911 (ebook ISBN 9780841233904) $150 (Print).

The concept for this book emerged prior to publication of the *Posthumous Nobel Prize in Chemistry. Volume 1*, based upon the ACS symposium in March 2016, when it was noted with justifiable chagrin that all thirteen scientists profiled in Volume 1 were males. A second symposium, "Ladies in Waiting for the Nobel Prize in Chemistry. Overlooked Accomplishments of Women Chemists" took place in August 2017. The most obvious example is Lise Meitner, who co-discovered nuclear fission with Otto Hahn in 1939, yet did not share the 1944 Nobel Prize in Chemistry with Hahn. Rosalind Franklin was cheated not by the Nobel Committee, but by her own tragic premature death at the age of 40. Probably the most famous of all thirteen female scientists presented is Rachel Carson.

The Preface, by the co-editors, notes that all women featured in the 2017 symposium are discussed therein, except for Martha Chase, Joan Folkes, Thérèse Tréfouël, and Dorothy Wrinch. Added are chapters about Marjory Stephenson, Margherita Hack, and Isabella Karle. Table 1 in the Preface neatly summarizes Nobel prizes awarded in chemistry and physics awarded to women before 1965 including number of times nominated in these fields. The 1965 date was dictated by the requirement that the nomination material in the Nobel Prize archive can only be accessed fifty years after nominations were submitted. Istvan Hargittai has published a book, *The Road to Stockholm: Nobel Prizes, Science, and Scientists* (Oxford University Press, 2002), with great detail about the history and regulations pertaining to the Nobel prizes. Alfred Nobel's will was quite brief, and the *Statues of the Nobel Foundation* are more detailed and have been amended throughout the century-plus years that followed. (See A.W. Levinovitz and N. Ringertz, Eds, *The Nobel Prize. The First 100 Years*, Imperial College Press and World Scientific Publishing Co. Pte Ltd, 2001.) A leitmotif in the present book is the so-called "rule of three:" no more than three persons (distinct from named organizations) can share a Nobel Prize. Although this practice was rigorously adhered to from the start in 1901, Levinovitz and Ringertz document (p 17) that it was finally formalized in the *Statutes* in 1968. Through 1965 only twelve women were nominated for the Nobel Prize in Chemistry with three winners (Marie Curie (1911), Irène Joliot-Curie (1935), and Dorothy Crowfoot Hodgkin (1964)), and two women were awarded Nobel Prizes in Physics: Marie Curie (1903) and Maria Goeppert-Mayer (1963). The Preface updates the Nobel Prize in Chemistry to include Ada Yonath (2009). Following publication, Frances Arnold was awarded a Nobel Prize in Chemistry in 2018 (featured in a fascinating profile in *The New York Times* "Science Times" May 28, 2019). And in 2018, Donna Strickland was awarded a Nobel Prize in Physics. Briefly mentioned in the Preface is the award-winning screen actor Hedy Lamarr. Recent books and films have documented her scientific genius, having been posthumously inducted into the National Inventor's Hall of Fame for her design, during World War II, of a new communication system for guiding torpedoes and preventing interception of radio frequencies, today considered a forerunner of modern wireless communication.

Chapter 1, "Women Scientists: An Uphill Battle for Recognition," by Magdolna Hargittai, describes obstacles that have faced brilliant female scientists over centuries, especially female astronomers. She mentions, as well, Marie Paulze Lavoisier, Antoine's gifted wife. To this, the present reviewer would add Elizabeth Fulhame, who published *An Essay on Combustion* (London, 1794). Hargittai, author of *Women Scientists: Reflections, Challenges, and Breaking Boundaries* (Oxford University Press, 2015), focuses on six distinguished scientists (Isabella Karle, Lise Meitner, Marietta Blau, Ida Noddack, Rosalind Franklin, and Charlotte Auerbach); each, with the exception of Auerbach, is treated in depth in subsequent chapters. Hargittai is an independent, accomplished scientist as well as a collaborator with her scientist husband, a mother of two accomplished children and has first-hand knowledge of the gender and "life-balance" issues that add challenges (and joys) to a career. World War II plays a significant role in the careers of four of the scientists in this chapter. Both Meitner and Blau were Jews whose careers were drastically affected by Nazi persecution. A citizen of Austria, Meitner worked occasionally with Otto Hahn at the Kaiser Wilhelm Institute in Berlin over a thirty-year period having achieved the rank of Professor in 1925. They were co-equal discoverers of nuclear fission but when Germany annexed Austria (the Anschluss) in March 1938, she became a German citizen and fled to Stockholm. No longer working with Hahn in Berlin, important scientific correspondence continued that further supported her sharing the Nobel Prize which was awarded solely to Hahn in 1944. Marietta Blau, a Jewish Austrian physicist, developed the photographic method for detecting nuclear processes in 1925. This had the advantage compared to the Wilson cloud chamber of detecting short-lived particles. Blau and her former student Hertha Wambacher developed an improved emulsion that made a major contribution to the study of newly discovered cosmic rays—in particular "fixing" the "disintegration stars" that recorded collisions between cosmic rays and heavy nuclei. Working at the Radium Institute in Vienna since 1923, she left Vienna days before the Anschluss, moving to Norway, Mexico, then the United States before returning to Vienna in 1954. Blau and Wambacher were nominated by Erwin Schrödinger in 1950, but the 1950 Nobel Prize went to Cecil Powell for related work, for his discovery of the π-meson using the photographic technique. Ida Noddack (née Tacke), a German chemist, co-discovered with her husband Walter, the element rhenium. In 1934 she reinterpreted Enrico Fermi's results from bombarding uranium with neutrons and postulated nuclear fission. The Noddacks also claimed discovery of the missing element 43—"masurium" subsequently disproven. Charlotte Auerbach, a German-Jewish geneticist, was forced to leave Germany in 1933, making her way to Edinburgh, where she earned her Ph.D. at the age of 36. Although never nominated for a Nobel Prize, she is considered to be the founder of the field of chemical mutagenesis. Much has been written about Rosalind Franklin and further discussion is reserved until later in this review. Particularly interesting is Hargittai's discussion of Isabella Karle. Magdolna and Istvan Hargittai have been close friends of Isabella and Jerome Karle for decades. The Karles, both American-born, met as students at the University of Michigan. Jerome Karle and Herbert Hauptman developed the mathematical technique to solve the so-called "phase problem" that allowed solution of X-ray crystallographic data previously considered unsolvable. However, it was Isabella Karle who worked out the methods to experimentally solve structures and prove to skeptical scientists that the phase problem had been solved. Jerome Karle and Hauptman shared the 1985 Nobel Prize in Chemistry. Jerome Karle was deeply disappointed and Hauptman very surprised that Isabella Karle did not share the Prize. Hargittai quotes the distinguished British crystallographer Alan Mackay: "Isabella Karle should have been included because it was her work that made the whole thing believable."

Chapter 2, "Politics, Persecution, and the Prize: Lise Meitner and the Discovery of Nuclear Fission," by Ruth Lewin Sime, focuses on the woman most unjustifiably denied a Nobel Prize. Meitner (1878-1968) was nominated 19 times for the Nobel Prize in Chemistry and 29 times for the Nobel Prize in Physics. Otto Hahn and Meitner were friends and colleagues whose collaborative research started in 1907. They discovered the element protactinium in 1918.Their research interests diverged in the 1920s but they began to collaborate in 1934 on uranium chemistry and physics. Soon Fritz Strassmann, an analytical chemist, joined them in Berlin. In 1934 Ida Noddack had advanced the heretical idea that hitting a uranium atom with a neutron could cause fission. By 1937 the Berlin team attempted to explain their results by postulating creation of transuranium elements as Enrico Fermi had earlier. The Anschluss forced Meitner to escape Germany, smuggled across the Dutch border, and she joined the Nobel Institute for Physics in Stockholm, a very negative experience, and the author examines the Manne Siegbahn-Meitner relationship. But more critical is the fact that, although geographically separated from Hahn and Strassmann, correspondence and collaboration continued, including a secret meeting between Hahn and Meitner in Copenhagen in November 1938. The discovery in Berlin that upon capture of a neutron uranium-238 does not produce radium as originally thought but rather barium stimulated Meitner and her cousin Otto Robert Frisch, also a physicist, to develop a theory of fission. Sime points out that it took decades and access to historical records to fully uncover the co-equal partnership between Hahn and Meitner. This chapter certainly makes the strong case supporting Meitner as appropriately a Nobel Laureate.

Chapter 3, "Marjory Stephenson: Founder of Microbial Biochemistry", by M. F. Rayner-Canham and G. W. Rayner-Canham, provides an illustration of a mother's faith, intellectual gifts, and inspired mentorship overcoming disadvantages of opportunities and expectations for a woman born in 1885 England. The Rayner-Canhams have published extensively about women in chemistry. The insistence of Stephenson's mother that her daughter obtain a university education (Newnham College, a women's college at the University of Cambridge) led to her exposure to the inspiring Newnham Lecturer of Chemistry, Ida Freund. Barred from obtaining a formal degree, Stephenson passed her final examination and took a teaching position at the Gloucester School of Domestic Science. In 1910 she took a position at King's College for Women in London, but in 1911 accepted an invitation to work with Robert Plimmer, University College London to teach advanced courses in the chemistry of nutrition and conduct research which gained her a Beit Memorial Fellowship in 1913. After the outbreak of war in 1914, Stephenson used her domestic science skills to serve as a cook in France for soldiers returning from the front. Her skills led to leadership positions in hospitals in Europe. She returned to England at war's end by which time she was 33. Such a four-year hiatus would have side-tracked the careers of most, but Stephenson was able to reactivate her Beit Fellowship and had the great good fortune of joining the Cambridge research group of Sir Frederick Gowland Hopkins (1929 Nobel Prize in Medicine and Physiology). "Hoppie's" research group was renowned for its incredibly supportive environment and Stephenson thrived and independently chose to explore and then pioneer the field of bacterial metabolism. The Rayner-Canhams address early success of women in biochemistry, a new field, not yet fully enshrined, yet needing considerable human resources. But they aver that "…having a mentor is always an important factor for women scientists." Amen to that! The Rayner-Canhams describe her research, around 1930, on hydrogenase and methane fermentation in a river polluted by a sugar-beet factory. This led to studies of adaptive enzymes in bacteria growing in the presence of an external influence. Her 1930 monograph on *Bacterial Metabolism* became the classic in the field. In 1944 Stephenson cofounded the Society for General Microbiology and became its President in 1948. In 1945, she along with Kathleen Lonsdale became the first two women elected as Fellows of the Royal Society. Stephenson died of breast cancer in December 1948. As the founder of bacterial biochemistry, the Rayner-Canhams feel strongly that she was fully worthy of a Nobel Prize.

Chapter 4, "Marietta Blau: A Near but Justifiable Miss?" was written in a delightful sui generis manner by Virginia Trimble, who even composed a narrative of the youth and appearance of Blau (1894-1970). The author asks rhetorically: "…why comment on her [Blau's] appearance? Because Marietta Blau was a Jewish woman at a place and time (1920-1930s Vienna) where both could be considered disadvantages." Incidentally, in 2018 asteroid 9271Trimble was named to honor the author, who commented: "With roughly 7 billion people in the world and 700,000 known asteroids one person in 10,000 could have one of those entities named after them, so it's not that big a deal." Trimble comments that Blau was "…never paid for her years at the Radium Institute, either before 1938 or after 1960." (Indeed, Lise Meitner came to Berlin in 1907 as an "unpaid 'guest'" (Chapter 2).) Blau's quite complex story has been very helpfully organized into a table as well as a section, "A Sort of Timeline," along with an Appendix. Blau and her doctoral student and subsequent colleague Hertha Wambacher at the Radium Institute in Vienna developed the nuclear emulsion plate, a thick film layer including silver chloride, having very uniform grain size, which was effective in photographing extremely fast phenomena including collisions of gamma rays with nuclei in the plate leading to "disintegration stars." The method was superior to the Wilson Cloud chamber since it could record and preserve super-fast events. The breakthrough paper presented images obtained on a plate exposed at an altitude of 2300 m. With Anschluss, Blau was ultimately helped to resettle at the Mexican Instituto Politécnico Nacional, for a teaching position without serious research opportunity. She arrived in New York in 1944, had various industrial associations, moved to Columbia University in 1948, became a U.S. citizen and moved to Brookhaven National Laboratory. Although the significance of Blau's development of the nuclear emulsion plate was recognized by awards and five Nobel Prize nominations, the 1950 Nobel Prize in Physics was awarded to Cecil F. Powell. In 1947, the discovery of the pion (π-meson), using photographic emulsions, was announced in a publication authored by Cesare M. G. Lattes, Giuseppe P. S. Occhialini, and Powell. There was no mention of the development of this technique by Blau and Wambacher. Trimble concludes (perhaps ruefully) that the 1950 Prize was "a near but justifiable miss."

Chapter 5, "Ida Noddack: Foreteller of Nuclear Fission," by James L. Marshall, is an extensively researched presentation of the discovery of nuclear fission, presaged by the suggestion in 1934 by Ida Noddack that the observations by Fermi and associates from hitting uranium with neutrons was not formation of transuranium plutonium but rather fission. This "heretical" suggestion, widely discounted, was proven in 1938 by Hahn, Meitner, and their associates Strassmann and Frisch. In addition to very considerable documentation of correspondence, this chapter is enhanced by seventeen photographs, including ten from the author. As many readers will know, James L. Marshall and his wife Virginia (Jenny) Louise Marshall, who passed away in 2014, were collaborators on their "Rediscovery of the Elements" project, which contributed numerous photographs and essays toward enhancing our knowledge of the history of the periodic table and the chemical elements. A very brief outline of the Noddack story is presented in chapter one of this monograph and the extensive citations in Marshall's chapter cannot simply be summarized. As previously described, Walter and Ida Noddack were among other distinguished chemists who erroneously identified element 43 ("eka-manganese"). Another missing element was right below 43—"dvi-manganese", element 75. Marshall informs readers that "eka" and "dvi" signify "1" and "2" in Sanskrit. The Noddacks published their discovery of elements 43 ("masurium") and 75 (rhenium) in 1925. The experimental results for "masurium" could not be replicated by other researchers. However, rhenium was a successful discovery. As Marshall shows graphically, it is more closely related to molybdenum than manganese chemically, an example of the diagonal relationships often observed in the periodic table. In co-discovering nuclear fission, Hahn dismissed Ida Noddack's 1934 theory by saying "one mistake is enough"—a thinly-vailed allusion to "masurium." Among many interesting details, Marshall refers to a comment by Emilio Segrè, who claimed to observe Walther Noddack in a Nazi uniform. Noddack's affiliation with the Nazi party is discussed in this chapter.

"The Remarkable Life and Work of Katharine Burr Blodgett (1898-1979)," by Margaret E. Schott, Chapter 6, describes the lifework of a pioneer of surface science and what would become decades later nanoscience. In 1893 George Reddington Blodgett became head of the patent department of General Electric, which had recently relocated to Schenectady. That year he married Katharine Buchanan Burr. Schott writes: "Sadly, he died at age 35, leaving behind his wife, a son George, and an unborn child, Katherine." Katharine was raised in privileged circumstances, was precocious, and entered Bryn Mawr College at age fifteen. Opened in 1885, its vision was to provide its students "all the advantages of a college education offered to young men." Over Christmas break during her senior year she returned to Schenectady and was given a tour by Dr. Irving Langmuir. Completing her A.B. in physics in 1917, she pursued masters degree research on the surface of activated carbon for gas masks as part of the war effort and completed her degree in 1918. Blodgett then worked with Langmuir at GE, improving tungsten filaments for light lamps, until 1924 when she would commence her doctoral studies at Cambridge with Ernest Rutherford, recommended to him by Langmuir. Rutherford was known for treating junior colleagues respectfully and advocating for women in science. Clearly, this is one of many instances in this monograph demonstrating that very positive mentoring aids in the development of outstanding women scientists. Blodgett's research involved study of the movement of electrons through mercury vapor, an area of interest to GE as well. She completed her doctorate in 1926 and returned to GE. Years earlier Langmuir began to employ apparatus designed by Agnes Pockels (1862-1935) that deposits a soap monolayer on water. Blodgett began work with Langmuir's apparatus and demonstrated the transfer of a soap (e.g. sodium stearate) molecular monolayer onto the surface of a glass slide substrate. She demonstrated the ability to build films from successive layers using the Langmuir-Blodgett technique and designed a film thickness gauge capable of measuring millionths of an inch using step-wise layers of calibrated thickness. Schott's descriptions, figures and photos very nicely clarify these processes. During World War II, Langmuir and Blodgett worked on the design of particles used for smoke screens. Among numerous honors, Blodgett received the ACS Francis P. Garvan Medal in 1951. She retired from GE in 1962. Blodgett was never recommended for a Nobel Prize. Among the reasons the author considers is that Langmuir received the Nobel Prize in Chemistry in 1932, therefore explicitly recognizing surface science. Additionally, the full impact of Blodgett's research would only be recognized decades later, some of it beyond her lifetime.

"Erika Cremer and the Origins of Gas-Solid Adsorption Chromatography, 1944-1947," Chapter 7, by Jeffrey Allan Johnson, is a tale of destruction and lost opportunities for a brilliant physical chemist on the German side of World War II. Unlike the existential threats to the lives of Marietta Blau and Lise Meitner, the war "only" severely impacted the research efforts of Erika Cremer (1900-1996) and, the author argues, cost her a share of the 1952 Nobel Prize in Chemistry awarded to Archer J. P. Martin and Richard L. M. Synge for the development of gas liquid partition chromatography (GLPC). Cremer was born to a family of academicians, and the need for men in World War I opened German universities to women. Cremer attended the University of Berlin to study physical chemistry and her first lecturer was Walther Nernst (Nobel Prize 1920). She remained in Berlin and completed doctoral studies in 1927 with the expert in thermodynamics and kinetics Max Bodenstein and published her thesis as sole author. As outstanding as her thesis was, it gained her only limited opportunities and she spent a decade moving from research lab to research lab, including periods in Fritz Haber's Kaiser Wilhelm Institute, George de Hevesy (Nobel in Chemistry, 1943), Michael Polanyi, Nikolai N. Semenov (Nobel in Chemistry, 1956), and Kasimir Fajans among others. With Polanyi she applied quantum theory to the kinetics and thermodynamics of interconversion of the two spin nuclear states of molecular hydrogen. Johnson describes Cremer as "…demonstrating a flair both for using complex theory as well as technical apparatus in experimentation." In addition to having to work extended periods without pay, Cremer had to hide when the Director of the national physics laboratory PTR, Johannes Stark, a Nazi who tolerated no women in his institute, entered the area. Once again, as men were needed for the war effort, opportunities opened for Cremer and in 1940 she was given teaching privileges (in 1942 instructor's rank) at the new physical chemistry institute in Innsbruck. Although not an absolute requirement, Cremer was pushed by colleagues and "registered" with the Nazi party in 1941. (Johnson notes that in 1947 she was cleared of being a formal member of the Nazi party.) At Innsbruck she tackled the important problem of separation of ethylene from acetylene. Interested in the thermodynamics of adsorption, her research evolved into a separation technique. She submitted her key manuscript to the final war issue of *Naturwissenschaften*, the equivalent of *Nature*, in fall 1944. It was accepted but never published due to the war. In December 1944, allied bombing heavily destroyed the institute and what could be salvaged was rebuilt about eight miles from Innsbruck. In 1947, Cremer and her student had a functioning gas chromatograph. In 1951 Cremer was promoted to Associate Professor, in 1959 to a chaired professorship. She retired in 1970. The author argues that the delays and the lack of publicity were factors in thwarting Cremer's share of the 1952 Nobel Prize.

Chapter 8, "Dame Kathleen Lonsdale: Scientist, Pacifist, Prison Reformer," by Maureen M. Julian and Mary Virginia Orna describes the impactful and eventful career of the first distinguished female crystallographer Kathleen Lonsdale (née Yardley, 1903-1971). Lonsdale's career is also of significance to the sociology of science. One of the co-authors, Professor Julian, has written extensively about her post-doctoral mentor—Lonsdale. X-ray crystallography has benefitted from a series of distinguished women over the course of nearly a century (G. Ferry, *Nature*, **2014**, *505*, 609-611). The authors describe Yardley's brilliant performance as a physics undergraduate, which inspired Nobel Laureate William Henry Bragg to invite her to pursue graduate research with him at the University of London. J. D. Bernal was also working with Bragg. In future years Dorothy Crowfoot Hodgkin worked with Bernal. She won the 1964 Nobel Prize in Chemistry for determining the structures of penicillin and vitamin B12. Ferry comments: "Bragg protégés such as Lonsdale and Bernal and their students fostered egalitarian lab cultures." Olga Kennard, née Weisz, worked with Bernal. She founded the Cambridge Crystallographic Data Centre. Yardley married Thomas Lonsdale in 1927 and it is clear he was very supportive of her career. During the late 1920s they were attracted to Quakerism and in 1936 embraced it. During World War II she resisted the requirement to register for civil defense duties and was jailed in Holloway Prison for thirty days. The experience inspired Lonsdale to be an activist for prison reform. Following the atomic bomb attacks on Japan, Lonsdale was a charter member of the Atomic Scientists Association. Her activism continued throughout her life until her death in April 1971. The authors list nine significant scientific achievements. Lonsdale is perhaps best known for establishing that the benzene ring is planar. The authors provide detail into the history and significance of her work in this area. Benzene is a liquid at room temperature and this required difficult lower-temperature studies. In 1928 E. Gordon Cox determined only that benzene had a center of symmetry. In 1929 Lonsdale performed the very challenging accurate study of crystalline hexamethylbenzene and determined unambiguously that the ring is planar. Beginning in 1935 and fully concluded in 1946 following the war years, Christopher Kelk Ingold using deuterated benzene isomers, infrared and Raman to determine that benzene itself is a planar hexagon. But Lonsdale's studies of diamagnetic susceptibilities on aromatics, as well as amides, esters, among other crystalline compounds demonstrated the delocalization of π-bonding in these species. This furnished experimental verification of theoretical models of π- and σ-bonding. As noted earlier, in 1945 Marjory Stephenson and Kathleen Lonsdale became the first two women elected as Fellows of the Royal Society. The authors conclude: "Linus Pauling received the Nobel Prize in both Chemistry and Peace. Surely, Dame Kathleen Lonsdale deserved no less."

Chapter 9, "Rachel Carson: The Right Person, at the Right Time, with the Right Message," by Amanda Hofacker Coffman, is a rather unique chapter in that Rachel Carson (1907-1964) would never have been a serious contender for the Nobel Prize in Chemistry. She notes that Carson published few purely scientific papers. However, Carson's impacts on the public perception of ecology and human health and its subsequent impact are worldwide and extremely consequential. The present reviewer wonders why not a Nobel Prize in Literature or, for that matter, a Nobel Peace Prize? While most of the Nobel Prizes in Literature have been awarded for fiction or poetry, Sir Winston Churchill's 1953 Nobel in Literature, for example, was awarded for historical and biographical description and brilliant oratory. Linus Pauling received the 1962 Nobel Peace Prize for his campaign against nuclear weapons testing. As Professor Coffman notes, Carson's 1941 *Under the Sea-Wind* and its 1951 sequel *The Sea Around Us* did much to stimulate public interest in the oceans and its wildlife. *The Sea Around Us* was the number one bestseller on *The New York Times* non-fiction list for six months. This was followed by another best-seller, *The Edge of the Sea*, in 1955. Toward the end of the fifties, Carson agreed to write an investigative article for *The New Yorker* on the impact of DDT and other pesticides. This project evolved into her masterwork, *Silent Spring*, published by Houghton Mifflin in 1962. For context, Dr. Paul Hermann Müller was awarded the Nobel Prize for Physiology or Medicine in 1948 for discovery of the high efficacy of DDT against arthropods, including mosquitos. DDT has most certainly saved millions of lives, including World War II soldiers and citizens of tropical climates, from malaria. However, *Silent Spring* disclosed the nefarious nature of DDT and other pesticides on ecology and on human health. It popularized the concept of bioconcentration explaining the impact upon apex predators such as eagles whose eggs had shells thinned to the point of non-viability. Coffman presents the social and political atmosphere of the 1950s and 1960s and documents reactions positive and negative. Predictably, Carson's conclusions were attacked by industry interests as well as some political conservatives. In 1964, Carson died of breast cancer at the age of 56, still too early to witness the full impact of her book. In 1980, President Jimmy Carter awarded Carson posthumously the Presidential Medal of Freedom. The year 2012 marked the fiftieth anniversary of *Silent Spring*. The American Chemical Society designated the book a National Historic Chemical Landmark. And all-too-predictably, many of the same sources attacked her work as pseudo-science. Sadly, such revisionist history is ascendant today.

Chapter 10, "Marguerite Perey (1909-1975): Discoverer of Francium," by Sarah S. Preston, explicitly raises the question: is discovery of a new element, as difficult and important as that is, sufficient to merit a Nobel Prize in Chemistry or Physics? Tragedy struck Marguerite Perey's family when her father died in 1914 and a stock market crash caused loss of the family's flour mill. Instead of pursuing a medical career she enrolled at École d'Enseignement Technique Féminine, a vocational school for training female chemical technicians. But fortune smiled upon her in 1929 when Marie Curie, Professor at the Radium Institute in Paris, requested the top person in the graduating class as her assistant. Perey became personal laboratory assistant to the frail scientist who would die of radiation poisoning in 1934. With Madame Curie, Perey began her life-long study of actinium (Ac, atomic number 89), discovered by Andre-Louis Debierne in 1899 from pitchblende residue remaining from Curie's isolation of radium and polonium. Very difficult to purify, Perey's samples were employed for Pieter Zeeman's spectroscopic characterization of the metal. The discovery of atomic number by Henry G. J. Moseley in 1913 exposed seven remaining "holes" to be filled in the periodic table and the race was on! Preston's chapter describes several false alarms in the hunt for missing element 87. When Marie Curie died, Debierne became Director of the Radium Institute but Perey worked closely with Irène Joliot-Curie. Her subtle, laborious work on radiation by-products is detailed by Preston. In late 1938 Perey became convinced that she was observing radiation from a new element. In early 1939, Jean Perrin was asked to make the announcement of her discovery, but he remained unconvinced. Others also questioned the discovery, and it was only in 1946 that it was accepted and the name Francium, favored by Irène Joliot-Curie and Frédèric Joliot, was adopted by her. Honors followed: she was nominated in 1949 to become Chair of Nuclear Chemistry at the University of Strasbourg. In 1955 the University and the CNRS formed the Centre de

Recherches Nucléaires and Perey was appointed Director of the Département de Chimie Nucléaire. Perey was the first woman elected to the French Academy of Sciences (1962), an honor that eluded Marie Curie (two Nobel Prizes) and her daughter Irène (one Nobel Prize). Even so, Perey's election as corresponding member fell short of an "academician seat"—a full member. She received, as of 1968 (reported in 2018), five Nobel Prize nominations but, as in the case of others who discovered the other six "missing elements," no Nobel Prize. Marguerite Perey died of cancer in early 1975 sharing the fate of her first mentor Marie Curie. (Irène Joliot-Curie died of leukemia in 1956 at the age of 58.)

In Chapter 11, "Rosalind Franklin: Her Pathway to DNA," Bertron H. Davis and E. Thomas Strom employ the love of the young Rosalind Franklin (1920-1958) for mountain climbing as their organizing metaphor. The public came to know Franklin through James D. Watson's 1968 bestseller *The Double Helix*. Davis and Strom aver that "A memorable book should have memorable heroes." In this case, Watson and Crick the heroes, Linus Pauling the wily competitor, and Rosalind Franklin as the villain. While somewhat overstated here, despite a mild apology at the end, Watson's portrait of Franklin is certainly a negative one. But a 1987 BBC film, hard to find today, *The Race for the Double Helix*, depicts a vivacious, flesh-and-blood, Rosalind Franklin. The authors have Franklin climbing three "mountains": 1) structure of coal, 2) crystallographic study of the structure of DNA, 3) structure of the tobacco mosaic virus (TMV). In 1941 Franklin obtained her degree in physical chemistry from Newnham College at Cambridge. Awarded a research scholarship with Ronald G. W. Norrish (Nobel Prize in Chemistry, 1967), she felt disrespected and took a position at the British Coal Utilization Research Association (CURA) and remained until 1947, completing her Ph.D. in physical chemistry. From there Franklin moved to Paris, where she enjoyed a supportive supervisor, Jacques Mering, and during this period thrived and learned X-ray crystallographic techniques. In late 1950 she moved to King's College expecting to work with John Randall's department on proteins but was told in December 1950 that her assignment was structural study of DNA. Here was the origin of the Franklin-Maurice Wilkins misunderstanding described in part by Watson. Davis and Strom provide other views as presented in books by Anne Sayre and others. What is abundantly clear is that Wilkins' sharing Franklin's excellent crystallographic photo of the B-form of DNA without her knowledge clearly violated the norms of professional scientific ethics. Although Watson painted a picture of Franklin's approach as being systematic, accurate but unimaginative, subsequent authors clearly established that she understood DNA was a helix with the deoxyribose polymer chain outside and the bases inside. The third mountain was her crystallographic work on TMV with her student Aaron Klug. Franklin and Klug, corresponding professionally with Watson and Crick, proved that the helical RNA in TMV is not in the center of the virus protein core but intimately associated within the proteins. Tragically, Franklin died in 1958 of ovarian cancer. The authors note that the first nomination for solving the structure of DNA (Watson, Crick, and Wilkins) was submitted in 1960. In 1962, there were five nominations for Watson and Crick and the trio won the 1962 Nobel Prize in Physiology or Medicine. Davis and Strom consider various Nobel Prize scenarios for the DNA discovery had Franklin lived six more years or beyond. They also offer one other intriguing scenario, sharing the Nobel Prize with her former student and passionate advocate Aaron Klug who was the 1982 Nobel laureate.

Chapter 12, "Isabella Karle: Crystallographer Par Excellence," by Lou Massa expands some of the scientific and personal details in Magdolna Hargittai's introductory chapter. As noted earlier, Isabella Karle (née Lugoski, 1921-2017) and Jerome Karle began their research in the field of gas-phase electron diffraction, under Lawrence Brockway, at the University of Michigan. Both worked on the Manhattan Project, where Isabella demonstrated experimental skills in inorganic chemistry totally distinct from her Michigan experience. The Karles then moved on to the Naval Research Laboratory where they spent the remainder of their careers. As Massa notes, around 1950, the electron and X-ray societies were small enough to hold joint meetings and this is where Jerome Karle and Herbert A. Hauptman, who had recently joined Jerome Karle's NRL group, learned of the phase problem of X-ray crystallography, thought to be mathematically unsolvable. The author, Massa, does a masterful job in outlining the difficulties and the solution to the phase problem—at least to a level somewhat accessible to the present reviewer. Still, there was widespread disbelief in the crystallography community. Isabella Karle, with assembled apparatus and lacking computer power, developed the direct methods for turning X-ray data into structures, supporting the theoretical solution to the phase problem and opening the modern era of X-ray crystallography. Massa also does a service to readers interested in the sociology of science. Jerome Karle and Herbert Hauptman were undergraduate friends at City College of New York. Not long after their shared award of the 1985 Nobel Prize in Chemistry there was estrangement between them. This also involved a third crystallographer, David Sayre, who developed an independent solution to the phase problem. Massa knew all the principals personally—especially a thirty-plus-year friendship between the Karle family and his own. At a 1985 meeting at the Fox Chase Cancer Center in Philadelphia, he was introduced by Miriam Rossi, a crystallographer at Vassar College to the Karles. Rossi, who was Massa's undergraduate student at Hunter College of CUNY, had been a postdoctoral researcher with the host, Jenny Glusker, herself, earlier a student and collaborator of Dorothy Hodgkin. Such is the beauty of science which is cosmopolitan and international and yet intimate in specialized groups. Massa strongly states that excluding Isabella Karle from sharing the Nobel Prize "…was an intellectual injustice for the simple reason that Isabella was responsible for the experimental proof that the mathematics of direct methods did indeed correctly predict crystal structure." The author observes: "What I admire most about Isabella is the greatness of her work, which carried on apace after the Nobel Prize. The work itself was the prize for her, not any external recognition for doing it."

"Margherita Hack: Friend of the Stars," by Marco Fontani and Mary Virginia Orna (Chapter 13), introduces readers to a woman whose scientific accomplishments and public outreach, radical leftist views, and popular interest gave her an almost outsize presence in the Italian public. Born in Florence 1922, she came of age during the emergence of fascist Italy. In the words of the co-authors: "Like any Florentine, 'La Hack'—even if of middle-class bourgeois extraction—was impressively different and proud of her freedom; averse to all forms of regimentation, be they cultural, social or academic." In short, a Force of Nature. The authors describe Hack's young days and the impact of the war in delaying her education, finally receiving her undergraduate degree in astrophysics from the University of Florence in 1945. In addition to studies, in 1941 and 1942 she won important national events in the long and high jumps. She married her childhood sweetheart, Aldo De Rosa, a classics scholar, in 1944. Thrown into career flux following the war, in 1950 Margherita Hack accepted a permanent staff position at the Arcetri Observatory (Florence), followed by a move to the Observatory of Brera, near Milan, and successive moves to Utrecht and Berkeley. In 1964 she settled at the University of Trieste where she remained until retirement in 1992. Hack remained very active and highly visible in communicating good science, including popular and technical monographs, and debunking pseudoscience. In 2002, she embarked on her political career. As late as 2013 she was still involved even as her views became "even more radical." Margherita Hack's principal contributions involved employing the ultraviolet spectrum to study stars. In the mid-1950s she began to examine the supergiant Epsilon Aurigae, 6500 light years away and 200,000 times brighter than the sun. In 1955 Hack proposed a model for this extraordinarily complex system. Ultraviolet light is typically divided into three ranges: UVA (315-400 nm), not absorbed by the atmosphere, UVB (280-315 nm), mostly absorbed by the atmosphere, and UVC (100-280 nm) which is virtually entirely absorbed by the atmosphere. Her model was largely supported in 1978 by the satellite International Ultraviolet Explorer (IUE) which had two spectrographs aboard for recording in the 115-200 nm and 185-320 nm ranges respectively. This reviewer wishes a bit more was said about the limitations of investigating the UV spectra of stars from the Earth. In Hack's honor, an asteroid discovered in 1995, was named 8558Hack. Hack died in 2013 following years of illness. Aldo De Rosa, her husband of 69 years, died in 2014. They had agreed to have no children.

The final chapter, "Professor Emerita Darleane Christian Hoffman: Determination Wins," by Caroline F. V. Mason, presents one of the pioneer researchers of transuranium elements, the natural occurrence of plutonium, and the environmental impact of radionuclides. As an undergraduate, Darleane Christian (b 1926) worked on the 68-MeV synchrotron at Iowa State University. She received her Ph.D. in 1951 and married Dr. Marvin Hoffman and accompanied him to his new position at Los Alamos National Laboratory (LANL) where work was active in analyzing the residue of a 10.4 megaton H-bomb test ("Mike") in the Pacific. She was not offered a position immediately: "For three frustrating months I sat and waited while others were discovering einsteinium and fermium in the test debris." Today, with increasing frequency, it is the husband who is the "accompanying spouse." Dr. Rod Spence, head of the nuclear test group, met Darleane Hoffman at a reception and immediately hired her. Analyzing debris from the bomb test, she discovered plutonium-244, half-life 80 million years, and she imagined that it might be naturally-occurring at ultra-trace levels. From a mine in California, she found 20 million atoms (!) of this isotope in 85 kg of ore. In 1971 Hoffman discovered the symmetric nuclear splitting of some isotopes of fermium—results initially treated with skepticism. Following a one-year stay in Oslo, she commenced study of the environmental distribution of radioisotopes in nuclear waste. In 1979 Hoffman became Division Leader of the Isotope Nuclear Chemistry Division—the first woman to head a division at LANL. Her research focused on "one-atom-at-a-time" studies of short-lived rutherfordium, dubnium, seaborgium, and bohrium. In 1984 Hoffman moved to a tenured professorship at the University of California, Lawrence Berkeley Laboratory, as Glenn Seaborg was retiring. She became the first director of the Glenn T. Seaborg Institute for Transuranium Science. In 2017, her team created livermorium (Lv, 116) and oganesson (Og, 118). Among many honors are three major awards from the ACS Nuclear Chemistry (1983), Garvin-Olin Medal (1990) and the Priestley Medal (2000), the Society's highest award. In 1997 President Clinton honored Hoffman with the 1997 National Medal of Science. Clearly, Professor Emerita Hoffman has enjoyed an amazing career as scientist, administrator and, as the author specifically highlights, family member.

There are many threads woven throughout this book. These include the barriers faced by women scientists, enormous strength in adversity, the vital importance of good mentoring and a conducive environment, the number of brilliant women who worked without pay at various points in their careers, and the impact of World War II. The women presented herein include those who this reviewer feels were deserving of Nobel prizes and those who were "merely" extraordinary and deserving of more exposure to scientists and non-scientists alike.

Arthur Greenberg, Professor of Chemistry, University of New Hampshire; Art.Greenberg@unh.edu

---

African American Women Chemists in the Modern Era, Jeannette E. Brown, Oxford University Press, New York, 2018, viii + 290 pp, ISBN 978-0-19-061517-8, $35.

This book can be considered to be a sequel of sorts to a previous Jeannette Brown volume. Her first book, *African American Women Chemists*, was enthusiastically reviewed seven years ago in the *Bulletin* by Sibrina N. Collins (**Vol. 37**, No. 2, pp 106-107 (2012)). That particular book dealt with women chemists from civil war times to the civil rights era. Brown, an ACS Fellow, has been very active in programming symposia at ACS meetings with an emphasis on matters of diversity. Her graduate degree comes from the University of Minnesota, where she was a student of C. Frederick Koelsch, of Koelsch's radical fame. Brown has had a successful career in the pharmaceutical industry.

This new book tells the stories of twenty African American women chemists with accomplishments in industry, academia, and government service. In general, these biographical sketches come from Brown's oral history interviews carried out through the Chemical Heritage Foundation, now known as the Science History Institute. Almost all of these oral histories have been turned into third person narratives. However, two of the histories, those from Sondra Barber Akins and Sibrina N. Collins, are in the first person.

The book consists of an introduction, chapters about the principals described, a concluding section focused on the future, a listing of selected publications from the twenty chemists, and a bibliography of useful sources on women scientists. After the introductory Chapter 1, Chapter 2 deals with "Chemists Who Work in Industry," with subjects Dorothy Jean Wingfield Phillips, Charlynlavaughn Bradley, Sharon Janel Barnes, and Sherrie Pietranico-Cole. Chapter 3 treats "Chemists Who Work in Academia," with chemists Etta C. Gravely, Sondra Barber Akins, Saundra Yancy McGuire, Sharon L. Neal, and Mande Holford. "Chemists Who Are Leaders in Academia or Organizations" is the heading for Chapter 4, with examples Amanda Bryant-Friedrich, Gilda A. Barabino, Leyte Winfield, and La Trease E. Garrison. The classification for Chapter 5 is "Chemists Who Work for the National Labs or Other Federal Agencies," who are Patricia Carter Ives Sluby, Dianne Gates Anderson, Allison Ann Aldridge, LaTonya Mitchell-Holmes, and Novella Bridges. Chapter 6 is the first person narrative of just Sibrina N. Collins and is titled "Life After Tenure