Along the Double Strand, Echoes of Discontent

Rosalind Franklin: The Dark Lady of DNA

Brenda Maddox
HarperCollins, New York, 2001. $29.95 (380 pp.). ISBN 0-06-018407-8

Reviewed by Eugenie V. Mielczarek

In 1951, the race to publish the structure of DNA was heating up with the fanaticism apropos of an athletic contest. That race ended in 1953, when Rosalind Franklin's unpublished measurements of the crucial distances in the DNA molecule were provided without her knowledge to James Watson and Francis Crick, enabling them to build a model of DNA. Many scientists think Franklin deserved to share the Nobel Prize awarded to Watson, Crick, and Maurice Wilkins in 1962 for determining the structure of DNA. She had died four years earlier at the age of 37, and the prize is never awarded posthumously.

Brenda Maddox's *Rosalind Franklin: The Dark Lady of DNA* is a meticulous study of a brilliant scientist and a chronology of an epochal scientific adventure. Maddox is a science journalist, an editor for the *Economist*. No details of Franklin's personal or scientific life escaped her. Maddox interviewed scientists, talked with Franklin's relatives, and read her personal and scientific correspondence. Maddox is a prize-winning biographer; Franklin was a perfectionist. The biographer and her subject are well matched.

My introduction to Rosalind Franklin was through reading James Watson's *The Double Helix* (Atheneum, 1968). Watson's now infamous personal descriptions of her are a well-remembered chapter in scientific history. It is difficult to read any biography of Franklin dispassionately. The first biography of Franklin, *Rosalind Franklin and DNA* (W. W. Norton, 1975), was by her personal friend Anne Sayre. Maddox did not know Franklin, and wrote with a 44-year perspective. The success of Maddox's biography is that its extensive scholarly detail eases the reader into objectivity.

Maddox devotes four chapters to Franklin's childhood and formal education. From her family life, Franklin learned to trust her judgments, live modestly, and scorn self-indulgence. She understood her capabilities and was forthright about speaking up, an unexpected and perhaps unwelcome trait for a female scientist.

At the age of 21, Franklin started her research on crystalline materials in support of an important wartime project. Coal was used in gas masks during World War II, and Franklin investigated why some kinds of coal are more impervious than other kinds to gas and water. Because of her expertise on "holes in coal," in 1947 Jacques Mehring invited her to join the Laboratoire Central des Services Chimiques de l'Etat in Paris. In Mehring's lab, she latched onto x-ray crystallography and used it to study disordered carbon crystals. In chapters 5 and 6, Maddox describes Franklin in Paris as "a woman of the Left Bank"—happy, beautiful, successful, and valued by colleagues.

Franklin's success landed her at King's College, London, in 1951, with a fellowship to study proteins in solution and in dehydrated forms. Before leaving Paris, she carefully designed the apparatus she would need. Her major concern was to control the humidity and temperature of the samples. When she arrived at King's College, the focus of the project changed from protein solutions to biological fibers, particularly DNA. Control of humidity was a serious issue, because DNA fibers lengthen as they hydrate, and the motion blurs the photographs. Franklin was already familiar with such problems through her work with crystalline forms of coal.

Although scientifically fortuitous, the move to King's College carried the seeds of dissent. The lab director, John Turton Randall, informed Franklin by letter that only she, Ray Gosling (a graduate student), and an assistant would be working on her project. However, Randall was already studying DNA fibers with Maurice Wilkins. Randall and Wilkins needed Franklin's x-ray diffraction experience, but offered her only a three-year fellowship, with neither rank nor academic appointment. Understandably, the laboratory relations between Franklin and Wilkins were uncomfortable.

In nearby Cambridge, investigators at the Cavendish laboratory were also using x-ray diffraction to examine complex biological molecules. Also at Cambridge was Francis Crick, a PhD student, who was joined by James Watson in 1951. Watson and Crick undertook to find the structure of DNA by model building. Naturally, they needed measurements of DNA's crystalline parameters, but lacked the experimental technique and resources. In *Genes, Girls, and Gamow: After the Double Helix* (Knopf, 2002, p. 8), Watson explains: "I hoped to expand the attention of the unit to DNA . . . once I had learned x-ray diffraction techniques." Adding to that hurdle, Lawrence Bragg, head of the laboratory, told Watson and Crick to cease work on DNA because British scientific politics gave priority to Randall's group.

Meanwhile, Franklin labored intensely in a hostile atmosphere. (Even Watson, on p. 20 of *The Double Helix*, admitted that at King's, "the best home for a feminist was in another person's lab.") Her x-ray photographs and laborious calculations "suggested a helical structure . . . with the phosphate groups on the outside." She discovered the B (wet) form of DNA, and was the first to photograph it and to measure the spacing between the bases and the cylindrical repeat distance. She wanted to delay her final decision about the structure until she and Gosling were completely convinced by the data. However, without her or Gosling's knowledge, Wilkins showed Watson and Crick the crucial x-ray photograph of the B form and gave them the crystalline parameters she had laboriously calculated. The 25 April 1953 issue of *Nature* carried three papers on the subject: by Watson and Crick; by Wilkins, Alec Stokes, and Herbert Wilson; and by Franklin and Gosling.

Franklin continued her scientific career at Birkbeck College, where she

Eugenie Vorburger Mielczarek *is emeritus professor of physics at George Mason University. She has worked in materials science and biological physics and is coauthor of* Iron, Nature's Universal Element *(Rutgers U. Press, 2000).*

tackled the structure of the tobacco mosaic virus, a subject more challenging than DNA. In his 1982 Nobel lecture, Aaron Klug—her closest collaborator and friend—acknowledged her contribution to his own work on molecular structure.

Maddox brings out one fact not generally known: *The Double Helix* was originally scheduled to be published by Harvard University Press. The outcry from eminent scientists and from Franklin's family was so intense that Harvard's board of overseers asked the press to drop the book. Atheneum later published it.

Maddox's mastery of historical detail gives us a definitive portrait of this warm and brilliant scientist and represents the science in an accurate and approachable way.

True Genius: The Life and Science of John Bardeen, the Only Winner of Two Nobel Prizes in Physics

Lillian Hoddeson
and Vicki Daitch
Joseph Henry Press, Washington, DC, 2002. $27.95 (367 pp.). ISBN 0-309-08408-3

Although many outstanding scientists are known for their outgoing dynamic personalities, John Bardeen, one of the most creative scientists of the 20th century, was a modest and quiet man. Yet he received two Nobel prizes in physics—one for the transistor (which revolutionized computers and communications) and one for the theory of superconductivity (one of the fundamental theoretical advances in recent times). *True Genius* gives an insightful and warm account of the scientific and personal life of this remarkable man.

Bardeen was the son of the dean of the University of Wisconsin–Madison Medical School. An outstanding student, he skipped from third to seventh grade. He majored in electrical engineering at the University of Wisconsin–Madison, where he took John Van Vleck's course on quantum mechanics—the first of its kind in the US. He then joined the research laboratory of Gulf Oil Co in Pittsburgh, where he worked on electromagnetic prospecting. The authors follow his career to Princeton, where he did his PhD thesis on many-body effects on metal surfaces. After a postdoctoral fellowship at Harvard, Bardeen joined the faculty of the University of Minnesota. There, he began his interest in superconductivity. Following Fritz London's ideas, he was convinced that there was an energy gap in the electronic spectrum that led to the expulsion of magnetic field.

After World War II, Bardeen joined Bell Laboratories in Murray Hill, New Jersey, where he worked on developing a semiconducting triode to replace the vacuum tube device, particularly in switching circuits. In a series of experimental and theoretical advances, Bardeen and Walter Brattain found that by placing two fine contacts at close spacing on a surface below which was a holelike semiconductor, they could achieve a 100-fold triode gain. As documented in the book, William Shockley, who led the group, thought he should receive the major credit for the discovery, because of an earlier suggestion of his (which proved to be incorrect). Shockley later developed the junction transistor, and the group shared the 1955 Nobel Prize in Physics.

In 1950, Bardeen moved to the University of Illinois, Urbana–Champaign, where he was able to pursue his interests in basic research. He founded a semiconductor laboratory and a theory group. Returning to his old interest in superconductivity, he brought together Leon Cooper (a postdoc with field-theory training) and me (as a graduate student). To attack the problem, Cooper found that two electrons above a frozen Fermi sea bind for all coupling strengths, which shows that the normal state is unstable. I found the wavefunction of the many-pair problem from which Bardeen proved there was an energy gap. Over a two-week period we were able to show that many of the theory's predictions were in agreement with experiment, with unique effects of the pairing correlations being observed.

True Genius relates how Bardeen taught his students to decompose a complex problem into simple pieces that preserve the physics. He was highly successful in using simple mathematics to analyze complicated problems: Stating the grand formalism often gets in the way of fundamental simple effects.

The book contains a collection of wonderful stories of how genius and humility can be combined to produce remarkable results. Having made a hole-in-one on the golf course, Bardeen was asked which was better: a Nobel Prize or a hole-in-one. He replied that he guessed two Nobel prizes were better.

I recommend this book as a joyous read.

J. Robert Schrieffer
Florida State University
Tallahassee

Journey from the Center of the Sun

Jack B. Zirker
Princeton U. Press, Princeton, N.J., 2002. $29.95. (302 pp.). ISBN 0-691-05781-8

Journey from the Center of the Sun is written with the experience, perspective, and insight of one who has spent decades in solar physics. Its author, Jack Zirker, graduated in 1996 to astronomer emeritus with the National Solar Observatory at Sacramento Peak, New Mexico. During his career, he contributed to solar physics as observer, experimentalist, theorist, and observatory director. In his own words, "[I] wrote this book because I wanted to share some of my pleasure in the subject. . . . I wanted to try to explain how the Sun works, the physical principles that govern its behavior, the many things we have learned since Sputnik, and the long list of things we still don't understand to our satisfaction." In these objectives he has been abundantly successful.

Solar physics is challenging and provocative because so much observational detail is available and so much remains to be puzzled out. The nearness of the Sun, with its generous photon, particle, and magnetized plasma fluxes, enables discovery of physical details inaccessible from any other astrophysical source. As a magnetically variable star, the Sun yields extravagant observational phenomena that need to be understood and explained from first principles. As Zirker says, "the more information one has, the more complex the phenomenon seems to become." The very core of the Sun is observable in neutrinos; the interior down to about 0.1 of the solar radius is studied with exquisite precision by helioseismology. Above the photosphere layer (where radiation can escape), the real fun begins: One can observe radiation from gamma-ray to kilometer wavelengths. Outside the magnetosphere of Earth, in situ measurements directly probe the solar wind, solar cosmic rays (energetic charged particles from flares and interplanetary shocks), and magnetized clouds.

Zirker sets out to deal with it all, and does an admirable job. He fits the many pieces together in an eminently satisfying manner. The book is free of mathematics but replete with illuminating cartoon illustrations and minigraphs, which, with only a couple of exceptions, are well integrated into the text. The typography is attractive and readable, with plenty of room in the margin for notes. In this era of brilliantly colored