Books

Gell-Mann: An Impressive Biography of an Impressive Physicist

Strange Beauty: Murray Gell-Mann and the Revolution in Twentieth-Century Physics

George Johnson
Knopf, New York, 1999. 434 pp. $30.00 hc ISBN 0-679-43764-9

Reviewed by Silvan S. Schweber

Writing the biography of a living person is not an easy task, particularly when the person is as assertive and commanding a personality as Murray Gell-Mann. How can his biographer stay free of the ever-present shadow cast by this forceful individual? And, perhaps more important, how can a biographer master all of Gell-Mann's scientific works, put them in context, and assess their importance?

On the whole George Johnson, a science writer for *The New York Times*, has successfully met the challenge; *Strange Beauty*, his fine biography of Gell-Mann, written for the general literate public, is a stimulating, very readable account of Gell-Mann's life. Gell-Mann's scientific contributions are explained in a comprehensible and lucid manner—without equations.

Johnson has an impressive command of the history of high-energy physics during the 20th century, and he vividly details the background and context within which Gell-Mann's work was carried out. What sometimes does not come through, I found, is Gell-Mann's passion for doing physics. Part of the reason for this, I believe, is Johnson's insistence on probing Gell-Mann's psyche to understand (and explain) his self-absorption and his past—often, abrasive—interactions with others: Abraham Pais, Leon Lederman and Fred Zachariasen, for example.

At times, Johnson conveys the impression that particle physics is "the most competitive of sports" and that Gell-Mann was the best competitor on the field. There is certainly some truth in that, but it is important to understand why the theoretical high-energy community—composed of some of the most talented theorists—is willing to have its intellectual agenda set for extended periods by a single individual. It is also important to appreciate the intellectual and social qualities that enable individuals like Gell-Mann, Steven Weinberg, and, more recently, Edward Witten to set that agenda.

The picture of Gell-Mann that emerges from Johnson's account is that of a "genius" who, only fairly late in life, was willing to confront his inner demons. Gell-Mann was born in New York City's lower Manhattan. During the Depression, while he was still very young, his family moved to the Bronx, where housing was more affordable.

His father, a Jewish immigrant from Galicia, was an uptight autodidact with an obsession for linguistics. He was never successful in any of the business enterprises he started, and he became a distant and alienated member of the household. Murray's mother, "an obsessively cheerful, . . . restless woman," had her own neuroses, "loosing herself year by year in a dream world." It was Murray's older brother, Ben (named after Benedict Spinoza) who introduced Murray to the world of science and nurtured his curiosity and gifts.

At the Columbia Grammar School, to which Murray won a full scholarship, the "wonder boy" became known as the "walking encyclopedia." He graduated in 1944 at age fourteen and that fall went to Yale. At Yale, although not inspired by his physics teachers—Henri Margenau, Gregory Breit and Leigh Page—Gell-Mann was already showing his affinity for physics. (A very gifted Abner Shimony, who was a student at Yale at the same time, found the ease with which Gell-Mann mastered physics and mathematics personally discouraging.)

Yale transformed the young Gell-Mann from a somewhat shy, but clearly brilliant, poor Jewish boy from the Bronx into a young man at ease with the *Social Register* crowd. A severe case of writer's block, an affliction from which Gell-Mann has suffered for most of his life, prevented him from writing his senior thesis. His failure to do so was probably the reason that Margenau declined to write an "outstanding" letter of recommendation for him, and MIT was thus the only school to offer him a fellowship for his graduate studies.

Though somewhat disconcerted by this—Gell-Mann didn't consider MIT to be on a par with Princeton and Harvard—he did go there in the fall of 1949. MIT provided Gell-Mann with two mentors, Victor Weisskopf and Marvin Goldberger, whose influence proved consequential. Gell-Mann would later state that Weisskopf had convinced him of the importance of "prizing agreement with the evidence above mathematical sophistication," of always searching for simplicity, and of "avoiding cant and pomposity." Goldberger, who became Gell-Mann's lifelong friend, showed him what theoretical physics is like when honed by such masters as Enrico Fermi, Edward Teller, and Gregor Wentzel (with whom Goldberger had studied at Chicago): It is pragmatic, it is concerned with getting out numbers that can be tested experimentally, and it is practiced by a community that values accurate calculations.

For Gell-Mann's PhD thesis, Weisskopf gave him a problem in nuclear physics, which Gell-Mann finally wrote up in January of 1951.

Gell-Mann came into his own at the Institute for Advanced Study, where Weisskopf had gotten him a post-doctoral fellowship. In the early 1950s, under the leadership of J. Robert Oppenheimer, the Institute had become the finishing school for the best and brightest young theorists, and it was where the action in theoretical physics took place. Gell-Mann's first published paper, on the description of bound states in quantum field theory, was the first of several deeply influential papers he wrote with Francis Low. At the Institute, Gell-Mann's unusual abilities

SILVAN S. SCHWEBER *is professor of physics and Koret professor of the history of ideas at Brandeis University. His book,* In the Shadow of the Bomb, *has just been published by Princeton U. P. (See review, PHYSICS TODAY, July, page 55.)*

became manifest to the physics community at large, and an appointment at the University of Chicago ensued. Subsequently Gell-Mann received an invitation from Caltech, and he stayed there until his retirement in 1993. Johnson describes incisively Gell-Mann's collaborations at Caltech with Richard Feynman—and their rivalry.

Much of the book is devoted to a comprehensive and perceptive account of Gell-Mann's important and varied contributions to particle physics, both as an innovator and as a critic: strangeness, K_0-K_0 regeneration, renormalization group methods, dispersion relations, the σ model, the eightfold way, current algebra, quarks, quantum chromodynamics—work done by himself and with collaborators. One of the very valuable features of the book is Johnson's even-handed and fair exposition of George Sudarshan and Robert Marshak's (earlier) formulation of the V-A hypothesis in the weak interactions, of Yuval Ne'eman's independent framing of the SU(3) classification scheme and the eightfold way, and of George Zweig's independent invention of the quark model. Johnson has also carefully recorded Gell-Mann's views regarding the reality of quarks, from his first suggestion of the model to his later reinterpretations of his initial views.

Strange Beauty gives a sympathetic description of Gell-Mann's personal life—of his courtship of Margaret Dow, his first wife, and of their marriage and travels. Johnson does not shy away from discussing the price paid by Gell-Mann's children for his success. Similarly, his marriage with Marcia Southwick, whom he married some ten years after Margaret died, is forthrightly and sensitively described. Johnson also relates Gell-Mann's passion for birdwatching, for linguistics, for collecting primitive art, and for one-up-manship. But other aspects of Gell-Mann's life—his involvement with Los Alamos, with the Rand Corporation, with the Institute for Defense Analysis (IDA) as a "Jasonite," and more generally with the military-industrial complex, are probed less thoroughly. Johnson's concluding chapters deal with Gell-Mann's affiliation with the Santa Fe Institute, his involvement with the description of complex systems, and the writing of *The Quark and the Jaguar* (Freeman, 1994).

All in all, *Strange Beauty* is an elegant biography of one of the outstanding theorists of the twentieth century.

Thermal Physics

Ralph Baierlein
Cambridge U. P., New York, 1999. 442 pp. $95.00 hc ($42.95 pb) ISBN 0-521-59082-5 hc (0-521-65838-1 pb)

An Introduction to Thermal Physics

Daniel V. Schroeder
Addison-Wesley, San Francisco, 2000. 422 pp. $44.00 hc ISBN 0-201-38027-7

The teaching of undergraduate thermal and statistical physics has been dominated for the past twenty-five years in the United States by two textbooks: *Fundamentals of Statistical and Thermal Physics* by Frederick Reif (McGraw-Hill, 1965) and *Thermal Physics* (Second Edition) by Charles Kittel and Herbert Kroemer (Freeman, 1980). However, during this period there have been many developments that are not reflected in these and other texts. Fortunately, two recently published texts, Ralph Baierlein's *Thermal Physics* and Daniel V. Schroeder's *An Introduction to Thermal Physics*, at least partially address the need for up-to-date material in this important field.

Thermal physics is a difficult subject to teach, partly because of the subtleness of its concepts, the lack of an organizing mathematical statement analogous to Newton's equation of motion in mechanics, and the paucity of models, other than the ideal gas, that can be solved by simple techniques. As a result, few physics undergraduates appreciate the arguments of classical thermodynamics in the context of heat engines, and many find statistical mechanics to be a grab bag of tricks that can be applied only to relatively uninteresting problems. By contrast, research in statistical physics is a rapidly growing area with many diverse applications.

One of the major decisions that instructors have to face when teaching a one-semester course in thermal physics is the relative weight to give to thermodynamics and statistical mechanics. A good argument can be made for adopting the approach taken by Reif and by Kittel and Kroemer, which is to introduce heat and thermodynamics using the students' knowledge of the atomic structure of matter rather than from a macroscopic point of view. However, the limitation of this approach is that students will probably not appreciate the reasoning of classical thermodynamics.

Both Baierlein and Schroeder have faced these challenges by discussing new developments, by stressing conceptual understanding, and by motivating the second law of thermodynamics by considering the multiplicity of a macrostate.

Baierlein's text emphasizes the development of statistical mechanics and is organized around the themes of entropy and the second law of thermodynamics, the canonical probability distribution, the partition function, and the chemical potential. Critical phenomena in the context of mean-field theory and the renormalization group for the one-dimensional Ising model are the major recent developments that are discussed. There are also many interesting tidbits, such as discussions of recent experiments on Bose–Einstein condensation, entropy and evolution, the history of the third law of thermodynamics, and negative temperatures. However, Baierlein uses the ideal gas model too exclusively, and I would have preferred more discussion by him of other models and applications. His emphasis on noninteracting systems makes it difficult for students to attain a sense of how statistical physics can be used in general.

Schroeder's text also combines the macroscopic and microscopic approaches but takes a more balanced approach. Part I introduces the first and second laws, using both microscopic and macroscopic viewpoints, but Part II includes chapters on engines and refrigerators and on free energy and chemical thermodynamics. Part III discusses further applications of statistical mechanics. In general, Schroeder's text has more applications, problems, and references to the literature. For example, the text includes a table of thermodynamic free-energy data, and the student is asked to use these data to discuss such problems as the phase transition between diamond and graphite and the power provided by a lead–acid cell. Schroeder's arguments are generally less sophisticated than Baierlein's, but they would be easier to follow for most undergraduate students. It is also refreshing that Schroeder suggests problems that require the use of a computer (or a programmable calculator) to do some numerical calculations. These problems enable the instructor to assign questions more complex than those that can be answered in terms of simple analytical formulae. Schroeder also has included a chapter on weakly interacting gases and the Ising model, and he discusses Monte Carlo simulations in the context of the latter. However, his treatment of the virial expansion is unnecessarily abstruse.

Schroeder is co-author with Michael E. Peskin of *An Introduction to Quantum Field Theory* (Addison-Wesley,