Adjusting the Scientific Canon to Accommodate Chandrasekhar

A Quest for Perspectives: Selected Works of S. Chandrasekhar (With Commentary)

Edited by Kameshwar C. Wali
Vols. 1 and 2. Imperial College Press, London (Distributed by World Scientific, New York), 2001. $150 set, $88 paper set, (1428 pp.). ISBN 1-86094-201-6 set, ISBN 1-86094-208-3 paper set

Reviewed by William H. Press

Subrahmanyan Chandrasekhar, never addressed in life as other than "Chandrasekhar" (by students) or "Chandra" (by all others), died in 1995. We are now in that twilight that follows the departure, whether through death or inactivity, of any productive figure in science, during which the scientific canon readjusts itself to a new structural equilibrium. In ordinary cases, the dominant adjustment is a loss of attribution, as the particular discoveries of the individual—freed of the discoverer's collegial presence—are absorbed into collective scientific lore.

For a few towering figures in any scientific field, however, the process is not one of absorption, but of canonization. For which specific achievements shall the individual be forever known? And, which true or apocryphal anecdotes about the individual shall be permanently stored in that distributed organic data store of carbon-based scientist lifeforms—transferred from professor to graduate-student brain in the laboratory or over lunch?

At a minimum, Chandra's immortality is guaranteed by his books, physically powerful and mathematically gorgeous monographs that appeared about once a decade for more than 50 years, each on a different subject in astrophysics, most of them not merely explicating but defining a subfield. Almost all are still in print, and most of them (if we believe the Amazon.com database) sell more copies today than do the typical winners of the nonfiction Pulitzer Prize over the same period of time. For example, *Hydrodynamic and Hydromagnetic Stability* (Clarendon, 1961) sells about the same as Norman Mailer's *Armies of the Night* (1969 Pulitzer); *Radiative Transfer* (Clarendon, 1950), *Introduction to the Study of Stellar Structure* (U. Chicago Press, 1939), and *Mathematical Theory of Black Holes* (Oxford U. Press, 1983) each outsells Theodore H. White's *The Making of the President* (1962 Pulitzer). And so on. Incidentally, *Chandra: A Biography of S. Chandrasekhar* (U. Chicago Press, 1991) by Kameshwar C. Wali (editor of the present volumes) also sells today in numbers comparable to these.

William H. Press, *an astrophysicist, is deputy director for science and technology at Los Alamos National Laboratory. He was formerly professor of astronomy and physics at Harvard University.*

The two fat volumes of *A Quest for Perspectives*, selected papers spanning Chandra's whole career, with useful commentary by Wali (a physicist at Syracuse University), are thoughtful contributions to the canonization process: They memorialize facets of Chandra's career that are different from his magisterial books. The needs of archivists and historians are already well served by the series of Chandra's *Selected* [but fairly complete] *Papers* published by the University of Chicago Press between 1989 and 1996. Wali's choices in these two volumes are a more selective and more interesting subset, picked as much to give a sense of the man as of the science.

Chandra's earliest scientific period includes his collision with E. A. Milne and unwarranted and undeserved public humiliation by Arthur Eddington over the issue of the existence of an upper mass limit for white dwarf stars (which, vindicating Chandra and vanquishing Eddington, soon became known as the Chandrasekhar Mass). Wali gives us, along with Chandra's key papers—including those that Chandra for a time suppressed rather than reengage his tormentors—a bit of the published Eddington–Milne discussion.

Chandra's celebrated *Reviews of Modern Physics* article "Stochastic Problems in Physics and Astronomy" (1943) is included; this alone is worth the price of the volume, since Nelson Wax's *Selected Papers on Noise and Stochastic Processes* (Dover, 1954), which included it and was a mainstay for generations of graduate students in physics, is currently out of print.

Fascinating also are the two 1953 papers by Chandra and Enrico Fermi, the writing of which Chandra later remembered as one of the most exciting experiences of his scientific career. The names are alphabetical in both papers, but each paper reminds one of the famous horse-and-rabbit stew (one horse, one rabbit). Fermi is the horse in the first, shorter paper, but is the rabbit in the second, longer one. What a delicious contrast it is!

More than 300 pages at the end of the second volume are devoted to Chandra's miscellaneous writings. Here, Chandra's humanity emerges most clearly in multiple aspects: puckish humor; unswerving belief in the emergence of scientific talent from the third world; deep thought about the nature of creativity, truth, and beauty—and the courage to speak about such matters in absolutist terms.

At the end of a 1994 essay titled "On Reading Newton's *Principia* at Age Past Eighty," Chandra wrote, "I am convinced that one's knowledge of the Physical Sciences is incomplete without a study of the *Principia* in the same way that one's knowledge of Literature is incomplete without a study of Shakespeare." No one perusing this collection can help adding, "or the study of Astrophysical Sciences without a study of Chandrasekhar." Such is the readjustment of the scientific canon to equilibrium in a post-Chandra century.

Electricity and Magnetism in Biological Systems

D. T. Edmonds
Oxford U. Press, New York, 2001. $75.00, $40.00 paper (286 pp.). ISBN 0-19-850680-5, ISBN 0-19-850679-1 paper

In the introduction to *Electricity and Magnetism in Biological Systems*, Donald T. Edmonds comments that "all biological function must eventually be understood in terms of electromagnetic forces." He writes later, "It is the aim of the first ten chapters of this book to describe electromagnetic theory in a manner that makes it more accessible to students of medicine, biology, biochemistry, and chemistry than the formal mathematical approach of physics books." That first group of ten chapters makes up part I, The Basic Theory, which represents about 60% of the book. Six to ten problems are appended to the end of each chapter, usually with one worked out in detail.

While the exposition was clear, I judged that this part of the book was "more accessible" only to the extent that it was less ambitious than the electrodynamics texts I have used in teaching advanced undergraduate physics majors. For the most part, the material was treated conventionally, except that no use was made of vector algebra and vector operators. However, the discussion of conductivity, which emphasized ion currents, random-walk processes, and Fick's first law, was an unconventional exception, especially useful for biologists.

In his part II, Applications, about 25% of the book, Edmonds addresses six biological topics in which the introductory physics supposedly plays an important role; chapters 11 through 16 cover, respectively, ions in aqueous solution, the Debye Layer, ions in narrow pores, a magnetic animal compass, ion/ion coport or counterport, and theory of pulsed nuclear magnetic resonance. No problems are appended to these chapters, but references are listed. The book ends with three appendices, on mathematics, on the Boltzmann distribution, and on thermodynamics and the chemical potential. Each is followed by a few pages of hints for solutions and numerical answers to the problems.

Here, I find a disconnect between parts I and II. While part I is a textbook for beginning students, part II seems more a set of somewhat didactic special-topic essays requiring much more sophistication on the part of the student than does the conventional physics of part I. Moreover, the selection of subjects seems to reflect more the author's special interests than matters central to biophysics. While Edmonds devotes a chapter to coport and counterport ion transfer across cell membranes, emphasizing his own important contributions, he mentions voltage-gated ion channels in only one offhand sentence. Surely this aspect of membrane ion transfer is directly electrical and is central to much biology! Conversely, while animal navigation is great fun, and a special interest of mine as well as of Edmonds's, matters like the cable-like signal transmission properties of axons, dendrites, and the like, which are not mentioned, are certainly much more important. Indeed, that discussion of animal navigation is far enough in advance of what we know with certainty that I found it possible to disagree with elements of his essay. And while the discussion of the flow-through ion channels, which touches on Edmonds's recent researches, is elegant, I was disturbed that the Goldman-Hodgkin-Katz description was not even mentioned. Even if Edmonds believes that this half-century-old description is simplistic, it is still central to most discussions of channel flow, and any student should know something of it.

In summary, this text seems like two separate books not happily wed. Part I is a rather conventional electrodynamics text that might be considered for US biology students after their standard elementary physics course. While the exposition of the chosen topics, including Maxwell's equations in their integral form, was clearly presented, I am one of those who would prefer to introduce such students to vectors (described only in a mathematical appendix) and to the notation of vector operators (not mentioned anywhere). I argue that students sophisticated enough to appreciate the biological topics in part II should be comfortable at least with the qualitative meanings of the operators *div*, *grad,* and *curl* that they will meet in research papers.

Part II is a brief, 75-page set of six idiosyncratically chosen essays on a few topics of special interest to Edmonds. (Ten of the forty-six references listed in Part II were to Edmonds's papers.) I enjoyed these essays and learned something myself, but I see no place for this section in the education of undergraduate students in American colleges and universities.

Robert K. Adair
Yale University
New Haven, Connecticut

Nuclear Reactor Physics

Weston M. Stacey
Wiley, New York, 2001. $125.00 (707 pp.). ISBN 0-471-39127-1

Being a nuclear reactor physicist is very difficult. It is not merely the social opprobrium connected with the practice of the craft. (I write in California, where mere rumor that a microcurie of reactor-produced technetium is passing through town, a wisp remaining from the diagnosis of some poor soul's ailing heart, is sufficient to bring the environment mujahedeen into the streets for antinuclear jihad.) It is the essence of the subject, as well; a self-respecting reactor physicist should understand everything going on in the reactor core—and be aware of what is happening in its environs, too.

The discipline demands competence in nuclear physics, with emphasis on fission physics and neutron-induced reactions, and an understanding of the interaction of every variety of radiation with matter, from radiation damage to core material to "Is it safe to eat an irradiated strawberry?" Also required is an appreciation of the interaction of thermal neutrons with liquid and solid moderating materials—on so small a scale that the neutron "field" or distribution is described by the mathematics of neutron (and photon) transport theory, a branch of nonequilibrium statistical mechanics. At another level, the reactor is a macroscopic object and its macroscopic behavior is described—overall—by challenging nonlinear equations that describe subtle feedback mechanisms—often complicated by stochastic sources. Finally, since one tries to answer questions as well as possible, the reactor physicist attempts to master the latest and best numerical schemes for solving the complex equations one encounters.

Much of this material is treated in *Nuclear Reactor Physics*, by Weston Stacey. The book is 700 pages long, packed densely with text and equations and rich charts and tables and graphs. It is encyclopedic; the prose is clear, its style is relentless. One finds, along with the expected displays of cross-sections and coordinate systems, figures titled "Predicted frequency of fatality due to accidents from a number of technologies" and "Risk factor for LWR spent fuel without recycle." The book treats—in addition to the conventional material—topics like the R-matrix representation of neutron cross-sections, fuel processing and recycling, transverse integrated nodal integral transport theory models (TINITMo), and what happened at Chernobyl and at Three Mile Island.

The author's command of this diverse material is awesome. But the book has a point of view, an "attitude," which I think of as the MIT tilt: One's efforts should be directed towards the solution of "real" (rather than "academic") problems; one's goal is to build a machine, not to waltz in the complex