The Genius of Physics: A Portrait Gallery FREE

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'Bram' Pais and the Physicists Who Occupied His Time

On the day (31 July 2000) that this review of Bram Pais's book was written, the *New York Times* reported his death three days earlier in Copenhagen. My review is dedicated to the memory of this outstanding historian and physicist. *S. S.*

The Genius of Physics: A Portrait Gallery

Abraham Pais
Oxford U.P., New York, 2000. 368 pp. $30.00 hc ISBN 0-19-850614-7

Reviewed by Silvan S. Schweber

During the last 20 years of his life, after a distinguished career as a theoretical physicist, Abraham "Bram" Pais became an enormously productive and influential historian of physics. His biographies of Albert Einstein—*Subtle is the Lord* (Oxford U. P., 1982)—and of Neils Bohr—*Niels Bohr's Times* (Oxford U. P., 1991)—set standards that will be difficult to meet.

In all his historical writings there is a distinctive voice that comes through: forthright, incisive, and insightful, echoing the way he spoke in person. That same voice animates *The Genius of Physics*, a collection of essays describing some of the eminent physicists whom he knew and with whom he interacted. In alphabetical order they are: Bohr, Max Born, Paul Dirac, Einstein, Mitchell Feigenbaum, Res Jost, Oskar Klein, Hendrik Kramers, Tsung Dao Lee, John von Neumann, Wolfgang Pauli, Isidor I. Rabi, Robert Serber, George Uhlenbeck, Victor Weisskopf, Eugene Wigner, and Chen Ning Yang. All of them are theorists (with the possible exception of Rabi), all of them are offscale, and all of them are men. Except for Feigenbaum, all are of Pais's generation or older.

Pais called the book a portrait gallery. Some portraits are but sketches: for example, the ones of Einstein (a translation of a 2000-word entry in a Danish encyclopedia), of Weisskopf, and of Lee and Yang. Others are more extensive, particularly the one of Pauli. They all attempt to meld the personality and the work of the person described. And in all cases, irrespective of the length of the portrait, we are offered gripping accounts of their lives and of their personal traits along with penetrating analyses of their work. Each portrait is complemented by one or more photographs that capture some essential trait of the person: a pained older Born, an enigmatic Kramers, a triumphant Lee and Yang.

Some of the essays reflect their provenance. Thus those of Bohr, Born, Dirac, Klein, Kramers, and Uhlenbeck are extended versions of invited addresses given on formal occasions, such as the centenary of the person's birth. Others are more personal, as are the ones of Pauli and Wigner. All are gems. I know of no better source with which to introduce students of physics and the literate public to some of the great theorists of the 20th century.

Several of the essays stand out: the one on Bohr, in which Pais attempts to distill into 20 or so pages what had previously taken him two lengthy books; the one on Kramers, his teacher, mentor, and father figure; the one on Pauli; and his heartfelt, moving portrait of his "best friend" and collaborator, Res Jost.

The book's title, *The Genius of Physics*, is of course ambiguous. Does it refer to the discipline and its amazing advances during the 20th century—relativity, quantum theory, chaos theory—or does it refer to the offscale individuals depicted in the book, who were responsible for some of these advances? To the reader who wishes to focus on the gallery of remarkable physicists, the portraits offer rich insights to the varied aspects of individual creativity. Pais does not hide the more mundane aspects of the enterprise: the rivalries, the foibles of the various individuals, and the cost to their personal lives that commitment such as theirs exacts. He is willing to talk forthrightly about the rifts between Jost and Pauli, and between Kramers and Bohr; they are dead. But he does not do so in the case of Lee and Yang, even though he says he feels he knows what was responsible for their break.

In his essay on Kramers, Pais quotes Kramers's entry into his diary when, upon graduating from the Gymnasium at age 17, he decided to study physics: "A man of science must sacrifice his individuality for his field." All the men Pais describes

In His Own Words

The scientist knows that it is in his enlightened self-interest to protect the past as much as is feasible, whether he be a Lavoisier breaking with phlogiston, an Einstein breaking with the aether, or a Max Born breaking with classical causality.

The . . . tensions between the progressive and the conservative are never more in evidence than during a revolutionary period in science, by which I mean a period during which (i) it becomes clear that some parts of past science have to go and (ii) it is not yet clear which parts of the older edifice are to be reintegrated in a wider new frame. (p. 32)

I regard chaos theory as one of the great revolutions in twentieth-century physics, along with relativity and quantum mechanics. No two of these are alike, of course. . . . One physicist has put it well: "Relativity eliminates the Newtonian illusion of absolute space and time; quantum theory eliminates the Newtonian dream of controllable measurement process; and chaos eliminates the Laplacian fantasy of deterministic predictability." (p. 102)

Every little bit helps, said the mouse, and pissed in the sea. —A Hungarian proverb, (p. 191)

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struggled to maintain their individuality in the face of the demands of their field. What Pais's accounts make clear is that individual creativity requires continued interactions with colleagues (whether by extensive correspondence as in the case of Pauli and Heisenberg, or by intensive association with the brightest young people in the field, as in the case of Bohr), and that cutting one's self off from the mainstream of inquiries and inquirers is at one's peril. This was so for Einstein, when he embarked on his quest for a unified theory, and for Dirac, when he became dissatisfied with the conventional quantum electrodynamics. The book is thus also a portrait of a community—the elite community of the world's best theorists.

The Genius of Physics is a fascinating book, a tribute to the field, to its outstanding practitioners, and to its author. Pais captured better than any one else the vitality and the accomplishments of elementary-particle and high-energy physics, and he was able to convey better than anyone else what it meant to be part of that exhilarating enterprise during the 20th century. His wide erudition, his perspicacious insights, and the clarity of his exposition will be missed.

Rare Earth: Why Complex Life Is Uncommon in the Universe

Peter D. Ward and Donald Brownlee
Copernicus (Springer-Verlag), New York, 2000. 336 pp. $27.50 hc
ISBN 0-387-98701-0

The origin of animal life on earth was a remarkable evolutionary achievement, the apparent result of an endless array of environmental accidents. The key question, however, is whether this array represents a unique path, or even a rare one. Put another way, How many lucky accidents must occur before complex life can form?

Peter D. Ward, a geologist, and Douglas Brownlee, an astronomer, both at the University of Washington, have attempted to address this question in *Rare Earth*. In the process, they have written a thought-provoking and authoritative introduction to the issues and accidents that have affected the evolution of life on Earth and on other worlds. I believe they fall short, however, of their ultimate goal: to demonstrate that complex life is extremely rare in the Universe.

Carl Sagan argued almost 30 years ago that there may be many millions of intelligent species in the galaxy, and this claim provides a straw man for Ward and Brownlee's argument. But it has been some time since Sagan's early, wildly optimistic estimates have been adopted by most scientists, even those still actively pursuing extraterrestrial life. Nevertheless, this book may force a very useful and sober popular reconsideration of the all-too-prevalent notion that intelligent aliens are all around us.

Ward and Brownlee summarize clearly the developments over the past few decades that reveal the complexity of the evolution of advanced life forms on earth. However, demonstrating the complexity of a process is different from demonstrating that the end result is rare. If anything, Ward and Brownlee show clearly how much remains to be learned in the area that NASA has named astrobiology—a combination of geology, paleontology, astronomy, and biology that pertains to understanding the evolution of life and its signatures.

I was particularly interested in seeing this book after I heard about it, having just written a book that required me to explore several issues associated with the evolution and demise of terrestrial and extraterrestrial life forms. What I had found striking about the progress of life from single-celled prokaryotes (cells without nuclei) to multicelled, complex animals, is the important role of environmental catastrophes in the process. It is not at all clear that such catastrophes inhibit progress. Indeed, I expect that catastrophes may have been necessary, a notion that Ward and Brownlee also address. If catastrophes are indeed necessary, it is difficult to argue that such events might not similarly have driven evolution on other planets.

Overall, I enjoyed the book. It provides a great collection of diverse information brought together in one place and is very up-to-date. It includes such new ideas as "snowball earth"—the idea that the entire surface of the earth froze over and thawed several times during the past several billion years.

Nevertheless, I think the weakest aspect of the book is its description and defense of the rare-Earth hypothesis itself. The authors have not made completely clear, for example, precisely what the rare-Earth hypothesis is, beyond some qualitative notion that complex animal life is rare and vulnerable. If "rare" means far rarer than in Sagan's view, it is not particularly surprising. Or does "rare" really mean we are unique? What tests can establish or refute rareness? Several other poorly defined concepts, such as "Astrobiology Revolution" and "Principle of Mediocrity," are also introduced and capitalized, as if to imply some special scientific significance—which remained unclear to me.

In the end, the question of assigning a probability to the appearance of complex life with a sample of one (Earth) is fraught with difficulties. Frank Drake's famous equation (relating the occurrence of intelligent civilizations to a product of independent probabilities, such as the probability of finding a stable Sun-like star, times the probability of having a planet in a zone around it that could accommodate liquid water, and so on) was undeniably useful in opening the debate. Ward and Brownlee's book provides important new fodder. Nonetheless, the statistics of rare events are notoriously difficult to analyze.

It is undeniable that the specific route that led to modern terrestrial life-forms is remarkably complex and probably has a small absolute probability. But the same can be said for the series of events that led me to my computer this evening. We are probably not yet well equipped, in our knowledge of the relevant variables, to perform a proper maximum-likelihood analysis of the occurrence of life in the universe.

The book could have benefited from tighter editing. Certain ideas are repeated almost verbatim in different chapters, and various biological notions are discussed several times before they are finally defined. There are numerous graphs that physicists will appreciate but that are not likely to clarify the discussions for lay readers. Finally, a few embarrassing typos survived, most notably the statement in the penultimate chapter that the stars in our galaxy number in the hundreds of millions, rather than hundreds of billions.

These quibbles aside, Ward and Brownlee carry the reader through an otherwise well laid-out and comprehensive progression that rises through the specific rungs on the evolutionary ladder and discusses the environmental cofactors that governed this progression. I also like their exploration of the current controversy associated with various key ideas in these fields.

The next generation of research is likely to bring us far closer to quantitative analysis of the probability that