Einstein

'Subtle Is the Lord . . .' The Science and the Life of Albert Einstein. ABRAHAM PAIS. Clarendon (Oxford University Press), New York, 1982. xvi, 552 pp. $25.

The literature on Einstein is enormous. Yet up to now someone trying to find out what Einstein actually did during his creative scientific lifetime (1900–1955) faced a choice between reading one or more popularizations of limited scope (and often even more limited depth) and trying to read and digest the almost 300 scientific papers he produced. Now at last one can enthusiastically recommend a third course: read this book. Here is a coherent account of almost everything of scientific significance that Einstein did, along with a great deal of needed historical background information and an eminent physicist's perspective on the significance of Einstein's achievements. This is not done through dry abstracts of the papers but with style and wit, by a man who knew Einstein during his last decade—if not well, perhaps as well as one could know a man like Einstein. Pais does not hesitate to leaven his text with personal reminiscences and opinions, even the occasional refreshing admission that there are questions about Einstein's oeuvre that he cannot answer.

The book, moreover, is not merely an account of Einstein's scientific work but also includes a biography. Sometimes put into separate sections and sometimes mixed with the account of Einstein's scientific activities, and taking up perhaps a fifth of the book in all, the biographical material constitutes the most accurate account of Einstein's life yet written. Only someone who has consulted the existing biographies in an effort to establish a simple date can appreciate this achievement.

My recommendation of the book must be tempered by the statement that it cannot be fully understood except by someone trained as a physicist. Perhaps it is sufficient to note that the section of the book headed The Quantum Theory has already appeared in almost identical form in *Reviews of Modern Physics*, where it by no means seemed out of place. The introductory outline-summary of the book (pp. 5–51) provides a capsule account of Einstein's work that demonstrates that Pais could and should do the needed job of *haute vulgarisation* of his own book. Meanwhile, I urge everyone interested to read as much of this book as he or she can in order to learn something about the real Einstein.

After the introductory survey, Pais organizes his account of Einstein's scientific activities around five topics: Statistical Physics (pp. 55–107); Relativity, The Special Theory (pp. 111–174); Relativity, the General Theory (pp. 177–296); The Later Journey (on unified field theory, pp. 299–354); and The Quantum Theory (pp. 357–469). Within each section, the account is basically chronological. This method works quite well in the first four sections, since Einstein's progression from topic to topic was also roughly chronological. But it calls for extensive back-tracking in the section on quantum theory, which returns to 1905 and requires a good deal of cross-reference to the section on statistical physics. I fear this may cause some readers to lose sight of the threads that bound together all of Einstein's interests—statistical, relativistic, and quantum—in his *annus mirabilis* 1905, although Pais is well aware of the connections. The book concludes with Journey's End (an account of Einstein's last decade, pp. 473–479) and four valuable appendixes: accounts of Einstein's collaborators, his Nobel prize, and his Nobel prize proposals for others and an accurate chronology. I cannot overemphasize the care that went into producing what seems a smooth and effortless narrative, studded with dates and facts hitherto unavailable in any biography. In this effort Pais was fortunate to have the full cooperation of the late Helen Dukas, who had worked since 1928 as Einstein's secretary and presided over the Einstein Archive after his death.

Pais presents the most convincing account of Einstein's complex personality I have read, based upon personal contacts as well as documentary material. The only issue on which I would seriously disagree is his effort to play down or even deny the rebellious element in Einstein's personality. Einstein described himself as "inwardly rebellious" as a student (letter to Walter Leich, 19 April 1950), and the rebelliousness certainly persisted for some time. Erik Erikson's paper on the young Einstein (in G. Holton and Y. Elkana, Eds., *Albert Einstein: Historical and Cultural Perspectives*, Princeton University Press, 1982) integrates this "defiant" element into the picture of Einstein's personality.

In general the translations of the many quotations from Einstein and others are excellent, although Pais notes the difficulties of finding the *mot juste* in rendering Einstein into English. I rather like Erikson's translation of the epigram from which the book draws its title: "Raffiniert ist der Herrgott aber boshaft ist er nicht": "The dear lord may be tricky but he is not mean."

The discussion of Einstein's political and social views is very brief indeed. His views on pacifism, internationalism, and Zionism are accurately summarized and his generally left-wing political orientation is noted, all without the prejudice and condescension that mark Ronald Clark's more extensive account. I assume it is only a concern for brevity that accounts for the absence of any reference to Einstein's socialist views in his later years or to his very interesting ideas on education.

Pais, unlike some other biographers, pays Einstein the compliment of taking all of his work and views seriously. He is not afraid to disagree with Einstein on quite fundamental matters, such as the interpretation of quantum mechanics; but he makes it clear that Einstein's views were not perverse or quixotic but were based on an alternative vision of the future development of physics that addressed itself to issues unresolved to this day. He also dispels the myth of Einstein the childlike *naïf* in his discussions of Einstein's social views.

Pais has utilized the work of Holton, Klein, Hirosige, McCormmach, and many other eminent Einstein scholars and historians of science, but the serious study of Einstein's life and work is still at too early a stage for anything approaching a definitive account to be written. New documents keep turning up and may be expected to do so for some time. I could cite several instances where factual details given in the book already stand in need of modification.

Even on the basis of the existing documentation, general agreement does not exist among Einstein scholars on such fundamental questions as the development of the special and general theories of relativity. It is not surprising, therefore, that some of Pais's views are open to question. I find it puzzling, for example (to use a favorite phrase of his), that he builds his account of the special theory around the Michelson-Morley experiment, devoting the first 8½ pages of this account (pp. 111ff) to it, only to

come to the conclusion that it played a minor role in Einstein's thinking, yet says next to nothing about stellar aberrations or the Fizeau experiment, even though he characterizes Einstein's statement that these two results were sufficient for him as "*the most crucial statement Einstein ever made on the origins of the special theory of relativity*" (p. 117, his italics). More exasperating than puzzling is Pais's repetition of the old chestnut that the explanation of the "twin paradox" requires the general theory of relativity—especially since he misattributes this claim to Einstein (p. 145). I think his discussion of the two postulates of the special theory is also somewhat off the mark, largely owing to neglect of evidence that Einstein seriously considered an emission theory of light before adopting the second postulate.

Pais's discussion of the development of the general theory—in particular of the three-year delay between Einstein's adoption of the metric tensor in late 1912 and his discovery of the correct field equations in late 1915—is a careful reworking of what I may call the received version, filled in with many new details based on a careful reading of the relevant papers and correspondence in the Einstein Archive. This version attributes the delay (insofar as it was not due to external circumstances) to Einstein's failure to grasp certain elementary mathematical features of generally covariant equations. Unfortunately, Pais does not seem to have studied Einstein's notebooks from that period, also preserved in the Archive. One of these makes the received version simply untenable, as John Norton will soon show in a forthcoming paper. A number of minor features of Pais's account of the general theory and Einstein's ensuing quest for a unified field theory are slightly awkward, perhaps understandably given that he himself has not worked extensively in this area. In addition, he never explains why Einstein was so taken with the mathematical concept of displacement field or affine connection, on which he based most of his efforts at constructing a unified field theory after 1925. Einstein put it succinctly in 1954: "The essence of the general theory of relativity is to go beyond the inertial system . . . it [is] the displacement field which allows one to be freed from the obstacle of the inertial system." (The important letter to Besso in which this statement appears is translated in full in A. P. French, Ed., *Einstein: A Centenary Volume*, Harvard University Press, 1979, pp. 267–269.)

For me, the sections on statistical physics and quantum theory are the most successful in the book. Not only does Pais give an excellent presentation of Einstein's contributions to the development of quantum theory, he explains why Einstein felt that it never became a fundamental theory in his sense, even after the development of quantum mechanics. He makes clear the relationship between Einstein's critique of quantum mechanics and his search for a unified field theory: the non-singular solutions to the unified field equations were somehow finally to provide a fundamental explanation of the quantum riddle. His negative evaluation (p. 456) of the paper by Einstein, Rosen, and Podolsky, however, totally neglects the current discussion of nonseparability in quantum mechanics. There are some smaller weak points. For example, I do not feel the account of Einstein's work on "Gespensterfelder" and its influence on Born is adequate, nor does Pais explore the role of Einstein's challenge to reproduce his blackbody fluctuation formula on Jordan's work on the quantum theory of fields.

Other fascinating topics on which Pais expresses novel views that I don't have space to discuss include the reason for Einstein's fame (pp. 311–312), the interpretation of the concept of scientific revolution (pp. 29–30), and the concept of going beyond "the edge of history" in the analysis of individual creative acts (pp. 163–164).

This book is both unique and indispensable for any serious Einstein scholar, not least for its extensive documentation. May it serve not only as a source of profound insight and pleasure to many readers but as a further spur to the current renaissance of Einstein studies.

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Algology

The Biology of Seaweeds. CHRISTOPHER S. LOBBAN and MICHAEL J. WYNNE, Eds. University of California Press, Berkeley, 1981. xii, 786 pp., illus. $85. Botanical Monographs, vol. 17.

The Ecology of Algae. F. E. ROUND. Cambridge University Press, New York, 1981. viii, 654 pp., illus. $130.

The diversity of the algae is legendary. They consist of at least ten different phyla. Morphologically they range from single-celled organisms resembling bacteria to massive structures with complex anatomical and morphological differentiation. They are found in many different kinds of habitats, ranging from rocks in the Antarctic deserts through oligotrophic waters of open oceans to hot springs. Their physiological diversity extends to the most fundamental biochemical processes. The difficulties such diversity presents are often emphasized by apologetic authors, editors, and reviewers. Lines of demarcation that allow one to identify subject areas of manageable proportions must be drawn, but they frequently appear arbitrary and artificial. Two approaches are generally adopted; the one is to isolate a group (or groups) of the algae and consider all aspects of their biology, and the other is to identify one aspect of the biology and consider the entire range of algal types. The volumes reviewed here provide examples of these two approaches.

The editors of *The Biology of Seaweeds* wished to produce a book that "would deal with all three major divisions of marine macrophytes" and asked the contributors "to exclude material on freshwater algae and phytoplankton, as well as benthic marine diatoms and blue-green algae." In *The Ecology of Algae*, by contrast, Round set out to make "a first attempt to present a unified account of algal ecology without the artificial division into freshwater and marine communities."

The two volumes also present another opportunity for comparison, the one being a collection of contributions by different authors and the other a single-author book of possible appeal to students. The former genre offers the opportunity for expert treatment of particular subjects and comprehensiveness of coverage. The accompanying dangers include unevenness of presentation and lack of synthesis and integration. The latter allows for an integrated (albeit personal) approach but might suffer from superficiality and over-generalization. *The Biology of Seaweeds* has avoided most of the dangers of collective volumes, and the deficiencies of Round's treatment of his subject have little to do with superficiality.

The *Biology of Seaweeds* is a worthy addition to the series Botanical Monographs, which includes substantial contributions in many fields of study. The book is a work of scholarship that has much to offer to many people of diverse interests. It presents information that will delight and edify, and it contains myriad implicit (and sometimes explicit) suggestions for further work.

The editors have divided the subject into four broad sections: Structure and