ing many speeches and writing articles and books. In fact, he is a very prolific writer. These writings are not only political polemics but also semi-technical.

As mentioned earlier, it is difficult to cover all of Teller's activities. He is exceedingly proud of his work on peaceful uses of nuclear energy. He certainly is entitled to be proud of the program he developed to make nuclear reactors safer. He formed committees of people to analyze the plans of nuclear reactors. His activities eventually led to the setting up of nuclear-reactor safeguard committees and thereafter the Nuclear Regulatory Commission. Another effort to find peaceful applications of nuclear energy was the aforementioned Plowshare project at LLL. They studied using nuclear explosives to make harbors in remote areas like Alaska; they studied the use of explosives to break up rocks in the vicinity of oil wells; and they studied the possibility of facilitating the building of canals. Congress discontinued the program in the U.S. because of the fear of residual radioactivity. However, the Russians successfully carried out several projects.

Teller attacked people who advocated different technical models than those he believed in. He attacked Linus Pauling, Andrei Sakharov, radiologists, and the Physicians for Social Responsibility. These people believed in the linear model of the effects of nuclear radiation, which says there is no threshold. The other model believes in an effective level at which radiation is safe. The level is that of the natural radiation that is around us, specifically, the radiation in cosmic rays, natural radioactivity in the air, the radiation in rocks, walls, etc., and the natural radioactivity accumulated in a person's bones. Teller presents a rather clear advocacy of this latter model in the book.

The autobiography also covers his relationships with people at LLL and the terrible problems of the members of his family who were left behind in Europe. The book will be read with a great deal of interest by those in weapons laboratories, those in the field of arms control, and nuclear defense. He acknowledged the many individuals who helped him and carried out his projects at LLL. Those who are interested in complex people will find the book very interesting because Teller is an exceedingly complex person. The autobiography is that of a person who both wanted to be admired but who also wanted to be feared by those who disagreed with him. Teller is an amazing person as evidenced by the number and the variety of activities he was involved in.

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John Stachel, *Einstein from 'B' to 'Z'*. Boston/Basel/Berlin: Birkhäuser, 2002, xi + 556 pages. $ 69.95 (cloth).

This book is a collection of what the author deems his best articles and talks on Einstein. John Stachel is well known as the founding editor of the *Collected Papers of Albert Einstein*, a job that he carried out from 1976 until 1989, producing the first two volumes. Considering that Einstein is so widely admired, Stachel emphasizes the importance of elucidating a fair historical account, rather than becoming a "keeper of the flame" worshiping a "plaster saint." Not everything in the extant documentary evidence supports some of the pleasant myths associated with Einstein, and Stachel tells us that there have been instances when archived letters have suspiciously disappeared and hence might never be made public, had Stachel not made copies. Thus, two articles of the present book tell us about the nature of historical editing and the standards that Stachel upheld as Editor.

Most of the book concerns other subjects, including: biographical sketches of Einstein, articles on the history of special and general relativity, quantum theory, Einstein's relationships to other physicists (notably, Arthur Stanley Eddington, Leopold Infeld, and Satyendra Nath Bose), his relationship with his first wife, the development of Einstein's Jewish identity, and assessments of biographies by Abraham Pais, Albrecht Fölsing, and Louis Pyenson. Three of the papers on relativity were co-authored with Jürgen Renn, Leo Corry, Tilman Sauer, and Roberto Torretti.

The title might seem to suggest that *Einstein from 'B' to 'Z'* contains everything but the basics on Einstein. Stachel explains, however, that his book purports to do nothing of the sort, that the title is meant as a reminder that any account of Einstein's life and works remains tentative and incomplete. He comments that since the *Collected Papers*, to date, have dealt mainly with the first half of Einstein's life, biographies tend to be superficial and defective when discussing his later years as, for example, the otherwise excellent book by Fölsing. Stachel warns that accounts that connect extant evidence tightly and neatly are in danger of being upset by new evidence.

As with other accounts, the heroic aspect of Einstein surely shines through: the dedicated theorist who successfully labored for decades, often alone, to ascertain symmetries, and to simplify and unify the foundations of physics. Yet we also are told of lesser-known sides of his life and work. A recurring theme is the rectification of widespread myths. We are reminded that Einstein is often portrayed as an always-old impractical thinker, creator of perfect and permanent theories, regretful father of the atomic bomb, and bleeding-heart sufferer for all humanity, loved by everyone. Stachel carefully corrects such popular caricatures, quoting Einstein, for example, saying that, "It is a curious thing, to see how one appears from the perspective of others. It was my fate that my accomplishments had been overvalued beyond all bounds for incomprehensible reasons." Einstein emerges not as a success story frozen in time for us to admire, but as a lively critic of physical theories, including his own. He often characterized the axioms or fundamental concepts of physics as "free creations of the human mind." He didn't share the faith of quantum field theorists in special relativity. He was never satisfied with the quantum-mechanical explanation of the wave-particle duality, nor of fluctuation phenomena. He never accepted Niels Bohr's principle of complementarity, the philosophical placebo that still today is sometimes used to deter students from seeing contradictions between basic concepts of quantum mechanics.

Since his relativity theories were based on deductions from general principles, writers often portray Einstein as preferring theories of principle over constructive theories, but Stachel shows us that Einstein construed theories of the former kind as but preliminary to the search for the latter. He was unsatisfied with quantum mechanics partly because it posited electrons as seemingly independent structures rather than derived them. Likewise, he always was unsatisfied with special relativity because it posited clocks and measuring rods as seemingly independent structures rather than having them emerge as solutions of equations.

Stachel traces in detail Einstein's struggles to formulate a broader theory to account for gravitation: his rejection of the fundamental role of the concept of inertial system, his rejection of the general validity of his principle of the constancy of the speed of light, the roles played by his analyses of a rigidly rotating disc and the hole argument, and finally, his renunciation of the requirement that all coordinates have physical significance. Yet, even in success, having formulated general relativity, we find Einstein unsatisfied. He complained that the theory left the problem of the structure of matter unexplained. Thus, when Cornelius Lanczos told him about his efforts to find successive approximations of his famous gravitational equations, Einstein commented: "But why should anybody be interested in getting exact solutions of such an ephemeral set of equations?" Lanczos reminisced that, "Although at the time it was a complete shock to me, later on I realized that it was a marvelous example of his complete lack of dogmatism, even in relation to his own intellectual work."

Writers often portray Einstein as having advocated field theory wholeheartedly as the key for solving fundamental problems and unifying the branches of physics; yet Stachel highlights evidence that Einstein even carried significant reservations about field theory and became increasingly pessimistic about it. Throughout the years, he was somewhat skeptical of the ultimate validity of the concept of space-time continuum so essential in his theories and approach. Stachel calls him "the Other Einstein," one who suspected that differential equations might not be of fundamental importance, that the continuum might be just an auxiliary construct. Einstein repeatedly deemed it "entirely possible" that physics cannot be based on the field concept, that is, on continuous structures. He meant that if a spatially limited physical system can have only a finite number of states, then the mathematics with which to properly describe it should be based on finite quantities, rather than the infinitely-many degrees of freedom assumed by continuum notions. Hence, he admitted the possibility of "a purely algebraic physics," and urged mathematicians to develop new methods not based on continuity.

That all these critical threads in Einstein's views emerge so clearly may stem from Stachel's roots as a theoretical physicist. Stachel warns against the "mythologizing urge" that leads even qualified historians to exaggerate the significance of often-scarce bits of documentary evidence. Accordingly, he gives

enough evidence to warrant most of his claims, for example, when arguing that Max Born's statistical interpretation of the wave function stemmed from Einstein's ideas on the physical significance of de Broglie waves. Yet we find that he too advances some conjectures on scanty grounds, for instance, that long before Bohr proposed his model of the atom, Einstein perhaps had already considered the idea of discrete energy states in which the atom does not radiate. But such claims are quite welcome, not just because of their plausibility, but especially because we find that Stachel, unlike historians who try to make much out of little, is careful to distinguish such claims as "conjectures" and "speculations," rather than intermix them indiscriminately as being equally as substantiated as other claims.

The book has some shortcomings worth mentioning. Its major defect is that it lacks an index, which is very unfortunate, especially because there is plenty of overlap among the subjects discussed, even among papers in different sections of the book. Another problem is that some of the material does not stand by itself, in particular, the classic article on "Einstein on the Theory of Relativity," taken from Volume 2 of the *Collected Papers*, lacks the bibliography to which its Notes refer. Overall, Stachel's papers have few flaws in matters of detail, for example, he repeatedly characterizes Einstein's friend, Michele Besso, as essentially a "sounding board" for Einstein's ideas, a description first used by Einstein but repudiated by Besso as downplaying his role in their discussions and collaborations. Nevertheless, *Einstein from 'B' to 'Z'* is a valuable resource for anyone seriously interested in the development of Einstein's works, his personal and professional relations, and perhaps even for practicing physicists looking for some suggestive insights from history.

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Per F. Dahl, *From Nuclear Transmutation to Nuclear Fission, 1932–1939*. Bristol and Philadelphia: Institute of Physics Publishing, 2002, xii + 304 pages. $ 75.00 (cloth).

This is primarily the story of the development of accelerator technology to produce charged particles of sufficient energy for nuclear transmutation. Although nuclear transmutation had been demonstrated considerably earlier using alpha particles from natural radioactive decay, experiments were limited by source strengths and because only alpha particles and (many fewer) secondary neutrons were available. The challenge was to produce projectiles of sufficient energy to surmount the Coulomb potential barrier hindering the approach of a charged particle to the positively-charged nucleus. One way to look at the challenge to the accelerator builders is to deduce the voltage required to accelerate a singly-charged proton or deuteron to the same energy relative to the Coulomb barrier as the typical alpha energy from radioactive decay. Since the alpha particle is doubly charged, this corresponds to a proton energy of about 4 MeV. Thus for an equivalent energy the proton must fall through an electrostatic potential of 4 million volts, a potential nearly two orders of magnitude larger than available when this story begins. For lighter target nuclei, somewhat less energy than given by this example will suffice. And as recounted by Dahl, it was later realized that quantum-mechanical barrier penetration meant one could use lower energies if one compensated for the reduced reaction rate by an increase in the number of accelerated ions.

This book describes the "race" among four laboratories to build sufficiently powerful accelerators for nuclear transmutation. In fact, the different laboratories were not all driven by the same clear-cut goal, but the name of the game, in any event, was getting to higher and higher energies. And getting to higher energy meant getting to higher voltage, except for the Wideröe or cyclotron technologies where one managed to use the same modest electrostatic potential repeatedly. Quite a few different technical approaches were tried, with some of the laboratories trying more than one approach. Several of the technologies developed are now known by the names of their developers, Cockcroft-Walton, Wideröe, and Van de Graaff.