model. In summary, this is an enjoyable book with enough good explanations and clear discussions to make it well worth reading both for the expert in modern high energy physics and for the general reader.

ALEXANDER FIRESTONE
Iowa State University

Einstein's Legacy: The Unity of Space and Time

Julian Schwinger
Scientific American Books (Freeman), New York, 1986. 250 pp. $32.95 hc

ISBN 0-7167-5011-2

Albert Einstein's legacy: Ask the typical layman what it was and you're likely to hear "$E = mc^2$," "everything is relative," "the atom bomb" or "the space–time continuum." If the layman has read anything about the renaissance of general relativity over the past 25 years, you might hear "black holes," "the Big Bang" or even "gravity waves."

But unless he or she has studied physics at the high school or college level (and remembers any of it), the average layman is unlikely to have any real understanding of the foundations of the concepts mentioned above. Nor is the layman likely to appreciate how Einstein and his work fit into the three-century-long continuum of physics, stretching roughly from Isaac Newton to the present. These gaps in the understanding of the nonphysicist are admirably filled by Julian Schwinger in *Einstein's Legacy*.

Schwinger, of course, is no stranger to relativistic physics, his Nobel Prize in 1965 (shared with Richard Feynman and Sin-itiro Tomonaga) for quantum electrodynamics being but one recognition of his many achievements during a 50-year career in physics. Nor is he a stranger to the popularization of science. In fact, this book started out as part of a BBC television series written in collaboration with astronomer George Abell. Unfortunately, the series never saw the light of prime-time television, at least in the United States.

The "legacy" of the title actually carries a double meaning. First is the legacy left by Einstein's scientific forebears: Newton, James Clerk Maxwell, Michael Faraday, G. F. B. Riemann and Ernst Mach, to name a few. The book includes numerous historical and biographical sketches of physicists and mathematicians of the 18th and 19th centuries. These not only illustrate the human side of science, an important ingredient in

writing for the lay reader, but they also help the reader to understand Einstein's place in physics at the turn of the 20th century and to comprehend the nature of the change in physics that he brought about.

The second legacy is the one stemming from Einstein, and here the subtitle of the book reveals that Schwinger is interested less in the popular buzzwords that I listed above than in the unity inherent in Einstein's theories of special and general relativity. Masterfully, with very clear arguments, he shows how the postulate of the constancy of the speed of light leads inexorably to the failure of simultaneity for separated clocks, and how applying the principle of equivalence to two spacecraft in free fall on opposite sides of the Earth leads almost as inexorably to the notion that space–time must be curved. He reviews the basic consequences and experimental tests of special and general relativity in clear and simple terms, and takes the reader right to the present frontiers of experimental relativity, with very pretty discussions of the Stanford gyroscope experiment and of gravitational waves.

My only major technical criticism lies with Schwinger's explanation of Einstein's doubling of the deflection of light over the Newtonian value. He uses the notion that the equivalence principle alone is sufficient to explain the doubling, by arguing that the gravitational-redshift effect on clocks has a symmetrical counterpart for rods. This idea, first popularized by Leonard Schiff, has since been thoroughly discredited. The effect of gravity on rods through space curvature is determined by the field equations of the theory, which are logically independent of the equivalence principle, as the existence of alternative metric theories of gravity (such as the Brans–Dicke theory) amply demonstrates. Apart from this flaw, Schwinger does a good job throughout the book of making the physics understandable without diluting it.

The question inevitably asked about a book like this is: What is its audience? The level lies somewhere between the purely descriptive nonmathematical approach taken by books such as my own *Was Einstein Right?—Putting General Relativity to the Test* (Basic Books, New York, 1986; reviewed in PHYSICS TODAY, May 1987, page 93) and the level of an elementary textbook such as Anthony French's *Special Relativity* (Norton, New York, 1968). There are equations, but the lay reader with a bit of a background in algebra can

handle them easily, while the reader without can stick to the clear exposition and historical sidelights; either will thoroughly enjoy this book. As is usually the case with Scientific American publications, the production values are high, the diagrams are clear and colorful and the photographs are numerous.

CLIFFORD M. WILL
Washington University

BOOK NOTES

Elementary Particles and the Laws of Physics: The 1986 Dirac Memorial Lectures

Richard P. Feynman and Steven Weinberg
Cambridge U. P., New York, 1987. 110 pp. $12.95 hc
ISBN 0-521-34000-4

Paul Adrien Maurice Dirac died in 1984. In honor of Dirac, St. John's College—Dirac's college at Cambridge—has endowed annual lectures at Cambridge University. The first two Dirac Lectures were Richard Feynman's "The Reason for Antiparticles" and Steven Weinberg's "Towards the Final Laws of Physics," both clearly inspired by Dirac's prediction of antimatter in 1930 and by his philosophy of physics: "Physical laws should have mathematical beauty." John C. Taylor has written a brief introduction.

—PER H. ANDERSEN

Letters to Solovine

Albert Einstein
Philosophical Library, New York, 1987. 159 pp. $9.95 pb
ISBN 0-8022-2526-8

Previously published in French translation, Albert Einstein's writings to Maurice Solovine over a 50-year period are now available in an English translation that includes facsimiles of handwritten and typed letters. From 1902 to 1906 Einstein, Solovine and Conrad Habicht met for wide-ranging informal intellectual discussions—what they dubbed the "Olympia Academy of Berne." Solovine writes in the introduction that "our meetings were sometimes highlighted by Einstein's playing some musical selection on his violin." They read and discussed physics, mathematics, literature and philosophy; Solovine notes that they found David Hume and John Stuart Mills especially stimulating. In later years Einstein looked back with evident fondness at this period, which included 1905, Einstein's *annus mirabilis*. From Princeton in 1953 Einstein wrote to Solovine: "To the immortal Olympia academy. In your short active existence you took a childish delight in all that was clear and reasonable. Your members created you to amuse themselves at the expense of your big sisters who were older and puffed up with pride. . . . To you I swear fidelity and devotion until my last learned breath!"

The letters touch on science, politics and matters of health; as one would expect, Einstein was always to the point in cutting through pomposity and cant. In a letter from 1946: "You write to me so politely—as if you had never herded pigs with me . . . when we were both still young." Several letters concern business details of the publication in French of Einstein's writings, which the Rumanian Solovine had translated. During the Korean War, Einstein wrote to Solovine about world government—and more mundane matters: "But if every effort fails and men end by destroying themselves, the universe will not shed a single tear for them. It would still be good, however, if the book could at least appear first and be placed on sale." In 1922, after his American lecture tour the previous year, Einstein wrote, "A firm approach is indispensable everywhere in America; otherwise one receives no pay and little esteem." From Florida in 1949 Einstein made light of his role as a living icon: "The exchange of letters with a South African schoolgirl which you refer to was a dismal failure. The main outcome was astonishment at the news that I had not been dead for 300 years (confusion with Newton)."

During his sister Maja's years-long lingering illness before her death in 1951, Einstein wrote: "Dear Solo, . . . Among the works that I have been reading to my sister in the evening are certain things from the philosophical writings of Aristotle. They were actually deceptive. If they had not been so obscure and so confusing, this kind of philosophy would not have held its own very long. But most men revere words that they cannot understand and consider a writer whom they can understand to be superficial." And in 1951: "Physicists have no understanding of logical and philosophical arguments." In a New Year's letter the same year Einstein wrote: "I have found no better expression than 'religious' for confidence in the rational nature of reality insofar as it is accessible to