the virtuoso touch with which he plays it will rivet the attention of any reader with a lively curiosity.

Any one of these three short volumes can be read in one sitting. In fact, for anyone who can spare the required few hours, it might prove hard to put one down. The first book in the trilogy begins on a beach, the second on a mountain trail, and the third at a spectacular winter sunset.

Trefil makes no pretense of offering a comprehensive view of any area of science. His style is to latch on to a phenomenon, coyly suggest a hidden link to another that seems unrelated, and explain the connection persuasively. Then before the reader's interest can flag, he is off on another startling leap.

For example, watching the destruction of a sand castle by a rising tide serves as an entrée into the dynamics of the Earth–Moon system, and in one jump we are at the discovery of the outer planets, the fruits of a well-placed faith in the law of gravity. A pump burned out by a lightning strike leads to sound advice on lightning safety, to speculation about the origins of life and, via Benjamin Franklin's lightning rod, to some cogent observations on the links among science, technology and society.

Although most of the phenomena discussed are commonplace, the science they lead to is hardly naive. Such central mysteries (and fashionable topics) as spontaneous symmetry breaking and chaos get their due.

While this sort of random walk necessarily leaves most of the intervening landscape unexplored, it certainly conveys a vivid impression of the interconnectedness of things. Along the way, Trefil manages to make the scientific world view look like just the ticket for any sensitive human being with a zest for life. To achieve such an end a writer must meet the popular understanding on its own ground. Thus Trefil defends scientific skepticism concerning UFOs without ever lapsing into condescension.

Trefil harbors a particular sympathy for some of the unsung heroes of science. A traverse across a mountain glacier brings to mind Milutin Milankovitch, whose model of the ice ages based on long-term orbital effects has become more respectable in our lifetimes than it ever was in his own.

A popularizer of science should convey some sense of its limitations as well as its powers, and Trefil does not shirk this responsibility. A child on the beach with a few hours to kill can become quite expert in skipping stones. Simple hydrodynamics and the conservation of angular momentum explain the virtues of a flat trajectory and rapid spin. But exactly what happens at impact remains a bit of a mystery.

The public deserves to know how easily scientists can succumb to the lure of a bandwagon. Trefil relates the "polywater" fiasco of the 1970s, a particularly amusing and embarrassing example. I must, however, take exception to his classification of the recent and ongoing "nuclear winter" studies in the same category.

Anyone with the curiosity to pull these books off the shelf should have little difficulty understanding them. At the other extreme, a professional scientist could find them insightful as well as entertaining. These are truly books for every reader.

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The Hunting of the Quark: A True Story of Modern Physics

Michael Riordan
Touchstone (Simon and Schuster), New York, 1987. 399 pp.
$21.95 hc ISBN 0-671-50466-5; $9.95 pb ISBN 0-671-64884-5

Michael Riordan has taken the title of his book from Lewis Carroll's poem, "The Hunting of the Snark." In the last line of Carroll's poem we learn that the identity of the snark has been disguised. Similarly, according to current ideas, the quark is the first particle in the history of physics that cannot be observed directly by experimental physics: It remains confined to the interior of hadrons by the strong color force of quantum chromodynamics. This confinement has created major difficulties for experimenters trying to find the necessarily indirect evidence for the existence of quarks and has also resurrected ancient philosophical arguments about the nature of reality and the nature of scientific measurement.

Riordan tells of the gradual accumulation of experimental evidence and the sudden shifts in theoretical ideas that led to the current "standard model," in which the fundamental particles of matter are three generations of colored quarks matched by three generations of leptons, and in which the photon, the $W^{\pm}$ and Z^0 bosons and the eight colored gluons are the carriers of the electromagnetic, weak and strong forces, respectively. However, this book is not a general

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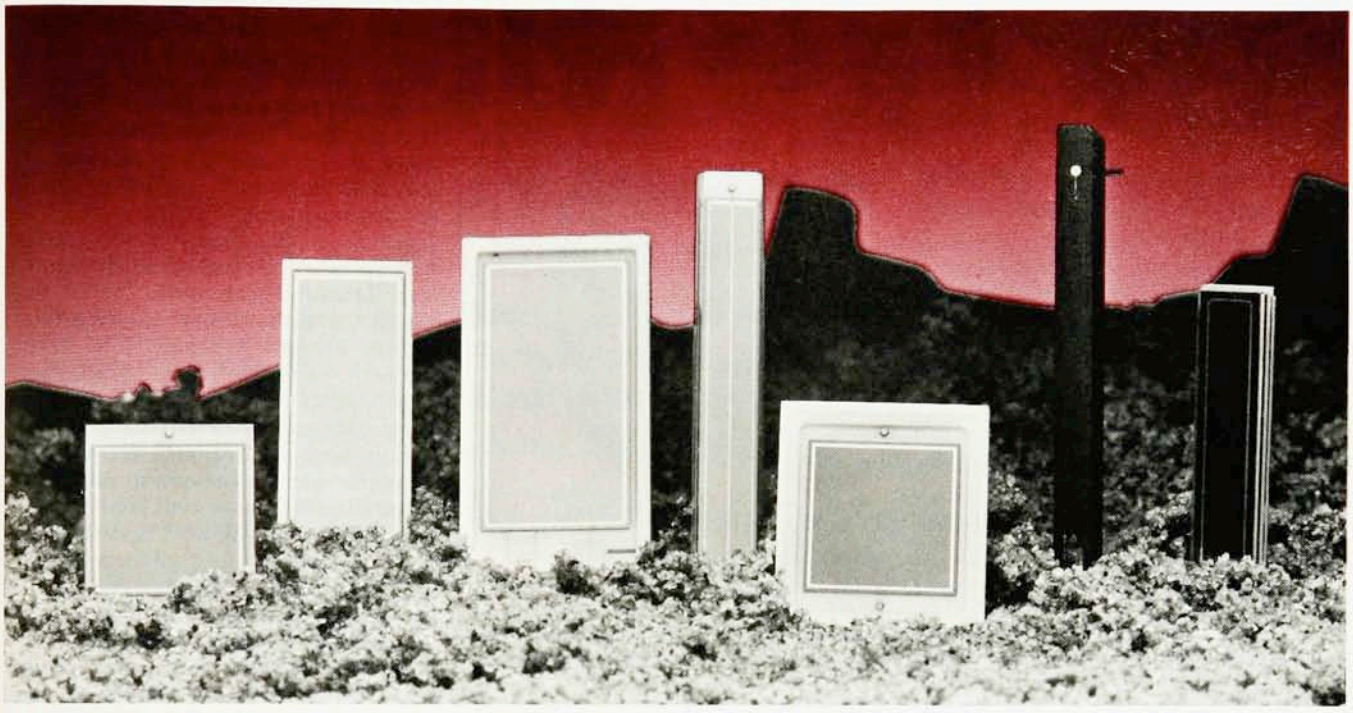

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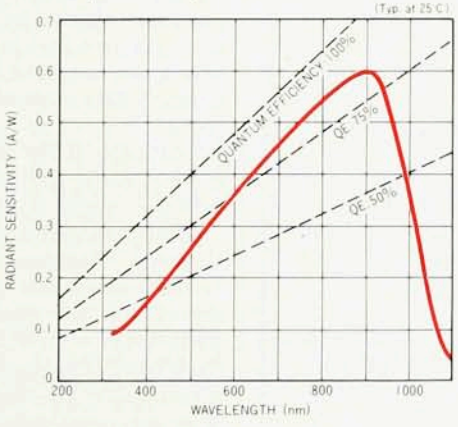

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history of the development of modern physics. The focus is narrowly on the quark; earlier theoretical and experimental developments are discussed only to give the general reader a sense of how radical a departure the quark concept was from previous ideas. Thus the canvas is much narrower than that of, say, Robert Crease and Charles Mann's *The Second Creation* (Macmillan, New York, 1986; reviewed in PHYSICS TODAY, November, page 92), which presented the development of the contemporary ideas of physics in a broad philosophical context and provided a much more complete intellectual history of some of the most important developments of the 20th century. Furthermore, *The Hunting of the Quark* concentrates heavily on developments at the Stanford Linear Accelerator Center, in which the author either played a role or was a close observer. (The deep inelastic electron–hadron scattering experiments at end station A receive particular emphasis.)

This book is not just an experimenter's memoir, but also attempts to be intellectual history. It is here that the book is weakest. Specifically, many of the intellectual arguments for the existence of quarks, which come directly from the SLAC deep inelastic electron–hadron scattering data, are probably not clear enough for the general reader. This is largely because much of the intellectual milieu has been neglected. Certainly, the great philosophical break with the past necessitated by the quark model, which is probably as important as the break necessitated by quantum mechanics, gets short shrift in this treatment. It isn't enough to assert the importance of the break; the general reader needs particular examples of how it changed our thinking.

There are many positive features of the book. Riordan navigates skillfully between Scylla and Charybdis in describing the nearly simultaneous discoveries of the J/ψ resonance at SLAC and Brookhaven and the subsequent battle for recognition. He also does an excellent job of describing events after the November revolution of 1975: the discoveries of particles with naked charm, the tau lepton and gluon jets, for example. But he says almost nothing about the fifth, or bottom, quark, which emerged with the discovery of the upsilon resonance at Fermilab, nor about the $W^{\pm}$ and Z^0 resonances discovered at CERN, both of which are essential to the standard model. This emphasis is consistent with Riordan's narrow focus on the discovery of the quark and not on the development of the entire standard

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.

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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