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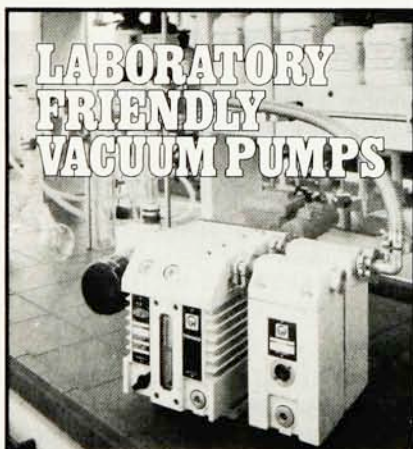
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cepts to many disciplines as distinct from changes in the concepts themselves (Cohen); belief in the lawfulness of vital and social phenomena and in the capacity of statistical methods to uncover this lawfulness (Bernard-Pierre Lécuyer and others); a shift from probability as dealing with *judgments* of an elite of reasonable men to the *behavior* of societies that include irrational members (Lorraine J. Daston); and belief in indeterministic statistical causation growing out of a holistic qualitative causation founded on the political-social ideal of *Gemeinschaft* (M. Norton Wise).

Among the social *causes* of the probabilistic revolution, according to the authors, were population growth and urbanization, leading to the emergence of mass phenomena best described statistically (Karl H. Metz), and the breaking of the connection between gambling and insurance in association with new middle-class attitudes favoring provision for one's family over provision for oneself (Daston).

Some readers will be surprised to find that physics is given only a minor role in this revolution. The thesis that nature possesses a certain amount of indeterminism independent of our own ignorance of it is discussed by Michael Heidelberger and Lorenz Krüger, but the importance of this thesis is explicitly downgraded by John Beatty, Nancy Cartwright, William Coleman, Gerd Gigerenzer and Mary S. Morgan. They argue on the contrary that the revolution was primarily a methodological shift to the attitude that probability must be used to measure and reason about reality, not to characterize its essence. Krüger's statement in volume 2 that "quantum physics has become one of the cornerstones of our present-day probabilism" is contradicted by most of the rest of the book.

A physicist might want to read these two volumes backwards. Start with the last section of volume 2, where, following Krüger's concise survey of the probabilistic revolution in physics, von Plato and Cartwright throw new light on familiar subjects: Albert Einstein's views on probability, the history of ergodic theory, Max Born's interpretation of the wavefunction, and the philosophical non-commitments of American quantum physicists. Then turn to the end of volume 1 for Wise's "How Do Sums Count?" an intriguing discussion of the connections among statistical physics, psychology and social theory. Brace yourself for some heavy but valuable analysis of the background of James Clerk Maxwell's philosophy

in Krüger's "The Slow Rise of Probabilism." Read or re-read the introductory essays by Kuhn, Cohen and Hacking on how it all fits together, and then decide whether you want to dip into the more specialized essays on the social and biological sciences that make up the bulk of the work.

As a contribution to intellectual history and a provocation to rethink many taken-for-granted assumptions, *The Probabilistic Revolution* is superb, and it will (with high probability) remain the authoritative source on the subject for many years. All the more unfortunate, then, that physics is given so little importance. Perhaps it is true, as Gigerenzer argues, that psychologists used probabilistic thinking to advance the role of determinism and objectivity, explicitly refusing to follow the lead of physics. Perhaps it is historically correct that physics and evolutionary biology are unrepresentative of the sciences in their use of probability as a theoretical tool, as Beatty and others assert in their introduction to volume 2. Even so, I would have thought the notoriety of Heisenberg's principle in modern culture would earn it a more prominent place in such an account. One can only conclude that the human compulsion to impose regularity on the world continues to suppress the evidence for fundamental chaos.

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A Scientist at the Seashore

James Trefil

Scribner's, New York, 1984.
208 pp. \$16.95 hc
ISBN 0-684-18235-1

Meditations at 10,000 Feet: A Scientist in the Mountains

James Trefil

Scribner's, New York, 1986.
236 pp. \$16.95 hc
ISBN 0-684-18627-6

Meditations at Sunset: A Scientist Looks at the Sky

James Trefil

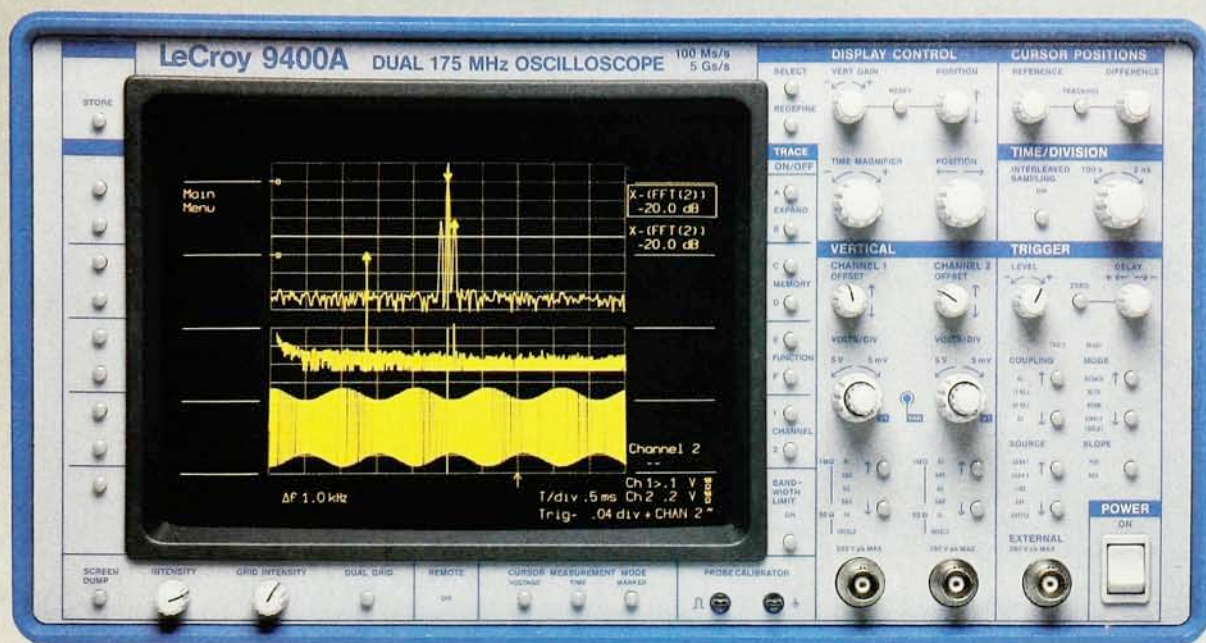
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the virtuoso touch with which he plays it will rivet the attention of any reader with a lively curiosity.

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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University of Wisconsin, Madison

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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