

ics that will be difficult for many, I think. Certain essays, such as Alan Guth's and Paul Steinhardt's "The Inflationary Universe," are adapted from articles that appeared in *Scientific American*, and hence will induce a sense of *déjà vu* in some readers. Most, however, appear for the first time in this book (or at least I haven't seen them elsewhere).

There are some unexpected moments of high literary drama. For example, in his essay on quantum field theories Howard Georgi recounts the experience of realizing, while sitting in a reclining chair in his living room one evening in 1973, that all of the problems that had been encountered in extending the electroweak unification to what is known as the grand unified theory could be solved in the context of the group SU(5). Although he recounts this tale in the standard dry prose one expects of academics, one can read between the lines a sense of the excitement that comes but rarely in the life of a physicist: a moment when everything falls into place and you just know that you have the right answer, even though it might take you months or even years to prove it. Accounts of such insights come even more rarely to those who read what physicists usually write.

I would like to close my specific remarks about *The New Physics* by discussing one of my pet peeves. In his comments on chaos, Davies gives the usual discussion of the great surprise physicists experienced when they discovered that a system can be determinate and yet "unpredictable." I have no problem with a phrase like this in a book that's intended, as this one is, for working scientists and people highly literate in the sciences. As physicists you and I know that when Davies talks about a system's being "unpredictable" in the chaotic sense, what he really means is that it is extremely sensitive to initial conditions. Given the inescapable uncertainties that accompany any physical measurement, the future of the system is, for all practical purposes, unpredictable. We also know that if the initial state is defined with mathematical precision, the system is perfectly predictable—indeed, most of our knowledge of chaotic systems comes from the study of computer models that do predict precise future states.

But though this distinction between "unpredictable in practice" and "unpredictable in principle" is obvious to us, it is confusing to people who are not familiar with physics. May I suggest that when we physicists communicate the deep and profound in-

sights the chaos theorists have given us, we stress that deterministic systems are unpredictable for all practical purposes, rather than just saying that they are unpredictable? To fail to do so is to set up immense problems for ourselves in the future. I don't want to see another *Tao of Physics* hit the bookstands because of our failure to be precise on this point—do you?

I recommend *The New Physics* highly to physicists. It gives a complete picture of modern research, rendered by the people doing it. I intend to put my copy on the shelf in my library that holds the small number of volumes to which I find myself constantly referring because of their breadth of information and clarity of exposition. Over the years, I expect the volume to become an old friend, and it will become yours too, I suspect, if you buy it.

What Mad Pursuit: A Personal View of Scientific Discovery

Francis Crick

Basic Books, New York, 1988.

182 pp. \$16.95 hc

ISBN 0-465-09137-7

Francis Crick is known for his occasionally acerbic wit and his breezy manner, which has been interpreted on occasion as arrogant or frivolous. This reputation did not lead one to anticipate this graceful, pleasantly modest, serious autobiography, written for the Alfred P. Sloan Foundation series that seeks to promote public understanding of science. In my small experience with Crick, I have always perceived science as totally central to his being, as it is to any great scientist. His autobiography can be read as a manual (or in his case a record) of how to change the world through science. He brings in enough personal detail to give one a sense of a life fully lived, but the focus is on the science.

Crick tells us how at age 30, after a somewhat undistinguished undergraduate degree in physics, a start on obviously boring research and a stint of building and designing mines during the war, he found his vocation by means of the "gossip test": "What do I most enjoy gossiping about?" Crick's answer: how to determine the chemical basis of life.

He seems to have set out his basic program by about 1948–49, after intensive reading and some biophysical research experience. Four years later, still an overage graduate student in the Medical Research Council unit

at the Cavendish Laboratory, Crick, with James Watson, proposed the double helix for the structure of the genetic material DNA—the first of the several breakthroughs associated with Crick that did, in fact, change the world. One is reminded of Einstein's years in the patent office, forming underlying viewpoints that led to the extraordinary burst of creativity that created modern physics. Crick is not Einstein—for one thing, most of Crick's achievements were collaborative—but one can argue that the 13 years that followed the revelation of DNA's structure had at least as much effect on the world as Einstein's great decade, both in a practical and in an intellectual sense: Biology became firmly rooted in chemistry and physics, and much of the mystery was removed from evolution. Crick's penetrating, critical intelligence illuminated the whole of that remarkable "classic" period of molecular biology, and in his book he runs us through several of the discoveries of that era as they happened.

Crick places the greatest emphasis on matters of scientific style, intellectual—even philosophical—content, and personal and psychological attitude. Do not be afraid of making mistakes, he says: No single idea, no matter how brilliant, is going to solve a hard problem; persistence is all; evolution seldom chooses the elegant solution. He stresses that "professionals know that they have to produce theory after theory before they hit the jackpot." But, he also stumps for another very important type of professionalism: knowing *all* the relevant facts, ideas, constraints. In his case this meant knowing the biological evidence, the stereochemistry, the way nature usually works and so on. To my mind, the greatest weakness of young scientists in *any* field is a reluctance to go outside their narrow professional specialty for evidence and ideas. Crick emphasizes these rules as pertaining to biological research, but I think he underestimates the complexity of some of nature's other manifestations. Mathematical elegance is sometimes useful in physics, for instance, but much less often than he seems to think, relative to a knowledge of empirical fact. I can hardly imagine a field of natural science where his advice would be irrelevant, and I would strongly recommend this book to young theorists in any discipline.

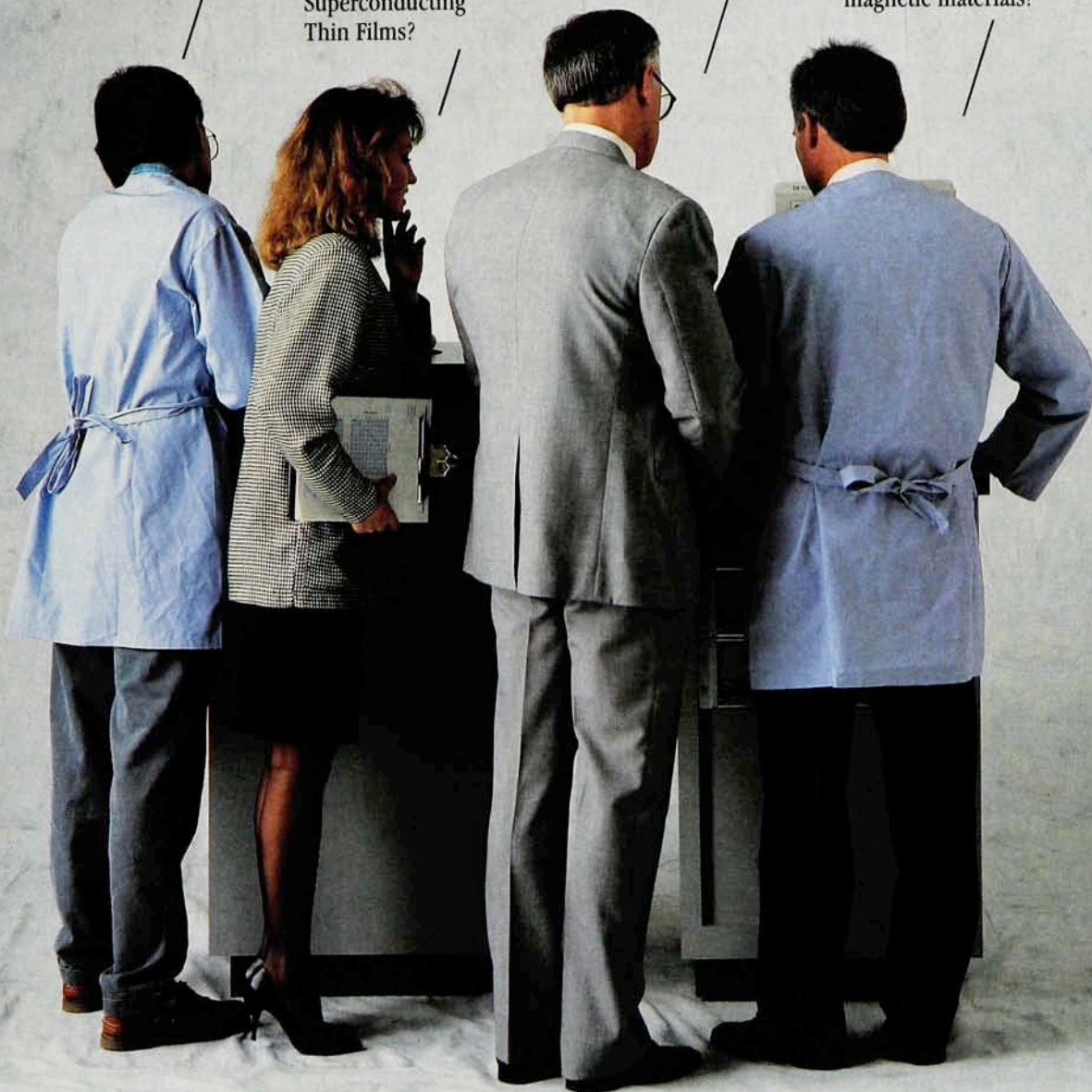
Do not be misled into thinking the book has no fun in it. There is, for example, the chapter in which he reviews books and movies based on the story of the discovery of the

Can it be used for
resistivity and Hall
Effect Measurements?

Can it measure
the moment of
Superconducting
Thin Films?

Is this instrument reliable
enough to run 24 hours
a day?

Will it measure
susceptibilities of very
magnetic materials?



LOOKING FOR ANSWERS TO TOUGH QUESTIONS?

double helix rather than retelling the real story himself, and the chapter called "How to Live with a Golden Helix," which contains the following charming passage: "Finally one should perhaps ask... am I glad that it happened as it did? I can only answer that I enjoyed every moment of it, the downs as well as the ups.... But to convey my own feelings, I cannot do better than quote from a brilliant and perceptive lecture I heard years ago in Cambridge by the painter John Minton in which he said of his own artistic creations, 'The important thing is to be there when the picture is painted.'"

And this: "There was in the early fifties a small, somewhat exclusive biophysics club at Cambridge, called the Hardy Club.... The list of those early members now has an illustrious ring... but in those days we were all fairly young.... Jim was asked to give an evening talk to this select gathering. The speaker was customarily given dinner first at Peterhouse. The food there was always good but the speaker was also plied with sherry before dinner, wine with it, and, if he was so rash as to accept them, drinks after dinner as well. I have seen more than one speaker struggling to find his way into his topic through a haze of alcohol. Jim was no exception. In spite of it all he managed to give a fairly adequate description... but when he came to sum up he was quite overcome and at a loss for words. He gazed at the model, slightly bleary-eyed. All he could manage to say was 'It's so beautiful, you see, so beautiful!' But then, of course, it was."

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Nuclear Fear: A History of Images

Spencer R. Weart
Harvard U. P., Cambridge,
Mass., 1988. 535 pp.
\$29.50 hc ISBN 0-674-62835-7

Nuclear Fear is a superb account of the images that have dominated the atomic age. Spencer Weart traces such images as mushroom clouds, mysterious rays, desolate postwar worlds and "white cities" of the future from their often obscure origins in the past. Weart examines the symbols that scientists, publicists and ordinary citizens have used to describe the brave new world nuclear fission helped create. In a landmark study, he helps us understand the power of those symbols in our own lives.

Weart is admirably suited to his

task. He received a doctorate in astrophysics and worked on a solar space telescope at Caltech before turning to the study of history. He is now director of the Center for History of Physics at AIP. Bridging the humanities and sciences, his prose is as easy to read on the experiments of Ernest Rutherford as it is on the dream interpretations of Carl Jung. (See Weart's article in *PHYSICS TODAY*, June 1988, page 28.)

Nuclear Fear is based on prodigious research. Weart has worked on his project for the past 15 years, and his efforts show. He delves into books, films, songs and other art forms. Even Spider-Man and the mighty Hulk—the Marvel Comics creations of Stan Lee—appear in Weart's account. He analyzes *On the Beach*, the gloomy novel about the end of the world by Nevil Shute; he assesses the black humor of Stanley Kubrick's extraordinary film *Dr. Strangelove*; and he touches on many more such items of popular culture. Throughout his book, Weart is able to summarize such diverse sources in a few sentences or paragraphs and to explain persuasively how they fit into the larger pattern of our response to nuclear issues.

Weart argues that "modern thinking about nuclear energy employs imagery that can be traced back to a time long before the discovery of radioactivity." Decades before the successful experiments with nuclear fission, people speculated about the concept he calls "transmutation—the passage through destruction to rebirth." He observes how the Hiroshima bomb simply defined more clearly the hopeful and frightening images that already existed. By the early 1960s, with the development of bigger and better bombs, fears came to outweigh hopes. But then, weary from war scares and anxious to ignore the ever-present threat, people turned away from bombs and focused instead on nuclear reactors. In the 1980s the real fears of weapons surfaced again as arsenals grew larger and the likelihood of a nuclear holocaust appeared greater than ever before.

As he traces these cycles, Weart shows how images from the distant past can merge and how they can become entangled with emotions. He speculates about how they help determine events. "The effects of imagery," he writes, "were strongest where they joined with the laws of physics," for myth then had the force of hardware to back it up.

Weart has broken new ground in *Nuclear Fear*. Drawing on the findings of psychology, sociology and an-

thropology, as well as physics and history, he has crafted a lucid and compelling account of our conscious—and unconscious—efforts to understand our nuclear world.

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The QCD Vacuum, Hadrons and the Superdense Matter

E. V. Shuryak
World Scientific, Singapore
(Teaneck, N. J.), 1988. 401 pp.
\$78.00 hc ISBN 9971-978-32-6;
\$36.00 pb ISBN 9971-978-33-4

Much progress has been made in the understanding of quantum chromodynamics during the past 15 years. The discovery of asymptotic freedom has led to the development of detailed predictions about many properties of high-energy collisions. The successful comparison of these perturbative predictions with experiment underlies the near-universal acceptance of QCD as the correct theory of strong interactions.

Understanding the low-energy, or nonperturbative, dynamics of QCD has been much more difficult. However, a variety of approaches ranging from semiclassical analysis of instanton effects to numerical simulations of lattice discretizations have provided qualitative (or semiquantitative) understanding of several fundamental nonperturbative properties. Among these are the confinement of quarks into mesons and baryons, spontaneous breaking of chiral symmetry, and the transition to a quark-gluon plasma at high temperature.

Edouard Shuryak's book attempts to convey the fruit of 15 years' study of nonperturbative QCD and to serve as a guide to both past and present work. It is neither a textbook nor a research monograph; as the preface states, it is better described as "one hundred lectures on modern strong-interaction physics." The first quarter of the book is devoted to the vacuum structure of QCD. It begins with brief expositions on topics such as the meaning of color confinement and chiral symmetry breaking, topological classification of gauge fields, and numerical simulations of statistical systems. Instantons and their effects are then covered in some detail, beginning with the semiclassical treatment of a dilute gas of instantons and ending with models of interacting-instanton "liquids."

The second quarter of the book