1981, 1989) to *Weird Water and Fuzzy Logic* (Prometheus, 1996). Washington University physics professor Michael W. Friedlander gave us a new survey of cranks, crooks, and charlatans in *At the Fringes of Science* (Westview, 1996). Carl Sagan summarized his career-long concerns about pseudoscience and superstition in his lively 1996 book *The Demon-Haunted World* (Random House). There have also been some single-subject books on topics like cold fusion and polywater, and some multiauthor anthologies.

But in *Voodoo Science*, Robert Park has brought us a book that has a freshness and originality—and an importance and potential for influence—perhaps not seen since Gardner's first. Its focus is on recent episodes of fringe science that capture the imagination not just of the public but of Washington policymakers and the major news organizations. And he shows why scientists would do well to pay attention, why they should even devote some time to helping people in high places distinguish good from bogus science. Because over and over again, Park's examples show the inability of people—high and low—to make that distinction.

Park is perfectly situated for the task: He is professor of physics and former head of the physics and astronomy department at the University of Maryland, and he has become widely known through the acerbic, weekly "What's New" electronic newsletter he produces as director of the Washington office of the American Physical Society. From there he keeps watch on, among other things, the latest examples of people (some of them scientists) who—if they aren't just dead wrong and credulous—use and misuse science, or twist or exaggerate scientific findings to gain public funding or advance their own causes.

Park coined "voodoo science" as an umbrella term: It encompasses "pathological science" (Irving Langmuir's term [PHYSICS TODAY, October 1989, pages 36–48]), "in which scientists manage to fool themselves"; "junk science," in which people craft arguments and tortured theories "deliberately intended to befuddle jurists or lawmakers with little or no scientific background"; "pseudoscience," whose practitioners adopt the language and symbols of science when "there is no evidence at all"; and "fraudulent science," in which what may have begun as honest error evolves through "almost imperceptible steps from self-delusion to fraud."

Most of Park's cases are from the past dozen years. It's all here: Joseph Newman's "energy machine" and Dennis Lee's "free-energy" devices (its advocates downplay the term "perpetual motion machine"); "Vitamin O" (water packaged in vials and sold as "stabilized oxygen molecules" to increase energy and stamina and prevent disease); the Pons and Fleischmann cold fusion proposition; "magnet therapy" (or, as *ABC World News Tonight* in 1997 called it, "biomagnetic therapy"), now a multimillion dollar business; homeopathy's infinite dilutions and Jacque Benveniste's "remembering water" claims; the Podkletnov gravity shield (which NASA spent four years and more than $1 million attempting to validate); Deepak Chopra's "quantum healing" confusions; and the *l'avion renifleur*, or "sniffer plane," a secret device that was said to be spectacularly successful at detecting oil fields (the French government got so embroiled in this scheme it invested $200 million in it). When the device proved to be a hoax, the government covered it up, and when the cover-up was later revealed, quashed any plans of Valéry Giscard d'Estaing to again seek the presidency of France.

Two chapters on the exaggerated claims and fears of health effects of electromagnetic fields (promoted heavily by Paul Brodeur in his books and *New Yorker* articles), and the millions of dollars that have been spent to conduct a series of increasingly definitive studies to put those claims finally to rest, are sobering. Park also explores the case of the x-ray laser and the space station as examples of exaggerated claims on behalf of political and technological agendas.

All these cases bear an important lesson: It is dangerous to consider pathological science, junk science, pseudoscience, and fraudulent science so silly as to be unworthy of serious scientists' attention. Time after time Park shows federal agencies, congressional representatives, judges, and juries getting embroiled in voodoo science—without, of course, realizing at the time that is what it is. Policymakers' time and attention are diverted, taxpayers dollars are wasted, and the public's perception of science gets all out of whack. The public is the loser.

Park is an effective guide through this morass. He repeatedly draws on physical principles to explain clearly where a claim is wrong or impossible. He understands the politics and the dynamics of belief. He calls or visits proponents to see what makes them tick. He treats them with some compassion. He has participated directly in some of the investigations of "voodoo" propositions. He has served on evaluative scientific panels and attended sometimes bizarre public hearings. All this gives *Voodoo Science* first-person credibility and vividness. And Park is not only a clear-thinking scientist, he's a good storyteller. The book is a great read.

Park finds vexing the reluctance of scientists to confront voodoo science. Scientists are human and, Park emphasizes, they have no more intellect or virtue than anyone else. Time and time again, individual scientists have gotten caught up in self-delusion or worse. As Park says, "The scientific method transcends the flaws of individual scientists. Science is the only way we have of separating truth from ideology, or fraud, or mere foolishness." But it won't happen, Park maintains, unless scientists are willing to come forward and make it happen.

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Supersymmetry: Squarks, Photinos, and the Unveiling of the Ultimate Laws of Nature

Gordon Kane
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On page 116 of *Supersymmetry*, Gordon Kane classifies physicists according to their views on the form that Higgs physics (the physics of electroweak symmetry breaking) will take: He lists fundamentalists, who "believe there exists a fundamental particle, the Higgs boson, as in the simplest form of the theory"; atheists, who "believe there is no fundamental particle at all, but some as-yet unknown form of the interactions at higher energies will somehow play the role of Higgs physics"; and agnostics, "who are uncertain." I am one of Kane's atheists: I prefer the dynamical approach of John Bardeen, Leon Cooper, and John Schrieffer to what we call the Higgs mechanism over the elementary scalar approach of Lev Landau and Vitaly L. Ginzburg.

There are many things I do like about Kane's book, and some I don't.

First, what I like: *Supersymmetry* is clearly written. When Kane explains

a concept, like dark matter or the idea of superspace, he does it right. In two appendices, he makes clear how a Higgs field gets a vacuum expectation value—by artificially making its mass-squared negative—and how supersymmetry can make this *seem* less artificial—by making the mass of the top quark large. It is a pity, however, that Kane puts less effort into explaining particle spin, the *sine qua non* of supersymmetry. Also, Kane practically ignores the important "flavor" problem: the proliferation of identical quark and lepton species and their inexplicable pattern of masses and mixings.

Kane devotes chapter 3 to effective theories, the modern way to organize our descriptions of nature by the energy or distance scales to which the descriptions apply. This idea says that our models of nature can be expected to be valid only within a limited domain of energies, because our basic framework—relativistic quantum field theory—gives answers that are insensitive to physics at energies much higher than those we are studying. (The same idea works in condensed matter, as Michael Fisher, Leo Kadanoff, and Kenneth Wilson taught us.) Thus, biologists need know nothing about atomic nuclei, chemists and atomic physicists need know nothing about quarks, and so on. This notion is one of the greatest advances of 20th century physics. It puts us ahead of the 19th century giants who thought physics was complete. (It is surprising, therefore, that Kane seems to believe we can extrapolate our current knowledge 17 orders of magnitude to the Planck energy of 10^{19} GeV. On page 21: "Most particle theorists . . . think we have finally reached the end of the line." On page 45: "Most particle physicists currently expect that quarks, leptons, W and Z, and gluons will ultimately be understood as having string-like extension. . . .")

Kane's chapter 5 on experimental methods is also much needed in popular expositions. The question of how we get evidence of phenomena beyond the reach of our own senses "would be a good unifying theme for a history of scientific discovery," he says. Media presentations of science and the work of some scientist-writers often attribute advances to pure thought or to mystical manipulations by white-coated lab nerds. Kane makes clear that a well-defined process of observation has evolved, despite the limitations of our senses, to reach out to 10^{10} light years and in to 10^{-16} centimeters. He describes the mammoth particle detectors and what they "see"—photons, electrons, muons, hadrons, and missing energy—and how these elements are "seen." He stresses that all measurements have errors and that physics signals are beset by deceptive backgrounds no matter how precise the detector. Kane even tells about triggering and trigger budgets! These discussions of experimental methods and effective theories are wonderful. There ought to be a whole book on them at this level.

One thing I don't like about Kane's book is his argument, repeated so often that it seems elevated to a physical principle, that such-and-such is true because most particle physicists think or expect or believe it is true. I noted two examples above, but the book is peppered with them. No particle physicist I know denies the beauty and appeal of supersymmetry. The absence of unambiguous signals for physics beyond the standard model may be consistent with supersymmetry, but that is not evidence for it. What most theorists "currently" think is no more important than it was 100 years ago. What experiment reveals is what counts.

Finally, I cannot identify the audience for *Supersymmetry*. Kane doesn't say. It can't be beginning physics students, or even the interested public; Kane says too little about spin (and other basics) for them. Media science reporters and politicians would profit from this book, but it seems too long for their attention spans. About halfway through, I thought I had the answer: This book is meant for me! Alas, it is not funny enough. *Supersymmetry* hasn't a shred of humor or lightness, so that excludes us atheists.

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The Discovery of Anti-matter: The Autobiography of Carl David Anderson, the Youngest Man to Win the Nobel Prize

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Carl David Anderson (1905–91) received the Nobel Prize in 1936 for the discovery of the positron. In 1936, with Seth Neddermeyer, Anderson