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The Wild Borderlands of Science and Technology

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BY KELLY MOORE*

Michael D. Gordin. *The Pseudo-Science Wars: Immanuel Velikovsky and the Birth of the Modern Fringe*. Chicago: University of Chicago Press (2012). 304 pp., index. ISBN 978-0-226-30442-7. $29 (hardcover).

David Kaiser. *How the Hippies Saved Physics: Science, Counterculture and the Quantum Revival*. New York: W.W. Norton & Company (2011). xxviii + 372 pp., illus., index. ISBN 978-0-393-07636-3. $26.95 (hardcover).

Margaret Wertheim. *Physics on the Fringe: Smoke Rings, Circulons, and Alternative Theories of Everything*. New York: Walker Books/Bloomsbury Publishing Company (2011). 336 pp., illus., index. ISBN 978-0-8027-7872-2. $17.00 (paperback), $7.79 (ebook).

Today's scientific eccentrics and "wingnuts" might turn out to be tomorrow's geniuses—or become the sincere but quixotic failures whose work is only partially remembered by historians. Operating on the edges, in the wings, or at the cutting edges of science—depending on the ultimate fate of the work—they are usually treated as sidelines in the histories of the winners. Yet the rigid borders between outsiders and insiders are more porous than previously acknowledged, and indeed such fluidity ought to be taken seriously as a contributor to the development of scientific ideas and forms of public engagement with science and technology.

These three books take eccentrics and the scientifically marginalized seriously in their own right, as a class or type in what the historian Patrick McCray calls scientific "ecosystems."[1] Using controversies within, at the edges, and far

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1. Patrick McCray, *The Visioneers: How a Group of* Elite *Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future* (Princeton, NJ: Princeton University Press, 2012).

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outside the center of the physical sciences in the twentieth century, Wertheim, Kaiser, and Gordin raise questions about rigid philosophical distinctions between science and non-science, the visionary and the unrealistic. They home in, instead, on the dance between each of these poles, and their significance for science in public life. Traversing landscapes of imagination and invention from the woods of Washington State to the lecture halls of Princeton University, these books make a powerful case for treating the fringes of science as a serious historical subject.

Using the story of Jim Carter as her fulcrum, science journalist and curator Margaret Wertheim describes the theories, organization, and hopes of "outsider physicists" who have often unwillingly lived in very deep shadows of the mainstream. From Washington State, Carter is the inventor of a new, mechanical theory of the physical world, based on a ring-shaped unit that he calls the "circulon." Carter's ambition was not to add a footnote to other theories of matter, but to overthrow them: his theory includes a rejection of the conventional idea of gravity, replacing it with the idea that what appears to us to be an object dropping downward toward the earth is, in fact, the earth rising to meet the object. Unlike most outsider physicists, who long for the attention of mainstream physicists and for the chance to run experiments to test their propositions, Carter is content to pursue a more solitary path, of the sort that led him to mine for gold and dive for abalone. Werthheim's portrait of Carter is sympathetic rather than mocking, and she beautifully captures the very human desire to make sense of the universe, and the longing that some have to do so on their own terms alone.

Werthheim has for more than a decade collected the stories of outsiders and fringe scientists like Carter. A compulsively readable middle chapter is devoted to *The Budget of Paradoxes*, English mathematician Augustus De Morgan's collection (or "budget") of columns about "paradoxers"—those apart from the general opinion—that he wrote for the magazine *Athenaeum* in the middle of the nineteenth century.[2] DeMorgan collected and commented on all manner of fringe ideas, including those in science, history, physics, and theology. Wertheim has amassed a similar collection of fringe science ideas, but she has a major advantage over De Morgan in her efforts to collect and document. Fringe physicists now have their own associations, conferences, compendia, and web sites. Wertheim uses these materials not, as De Morgan did, to comment on their plausibility, but to raise questions about the purported

2. Augustus De Morgan, *A Budget of Paradoxes* (New York: Dover Publications, 1954).

differences between the role of the speculative and imaginative at the center and the far edges of physics. Her most provocative assertion is that the highly speculative and untestable exists at the very heart of the physics community, in the form of string theory (or in Werthheim's sense, string theories). For here at the wild frontier, there are all manner of weird ideas and unimaginables, such as twenty-six dimensions, that we have no way of testing or even fully mathematicizing. How and why is this sort of speculation lauded and praised, she asks, while the imaginaries of the non-credentialed fringe are often mocked? One easy answer is to argue that one group is credentialed, and the other composed of mere amateurs. That dividing line will not do, Wertheim argues, for in the past physics outsiders have offered new interpretations that have been taken up by the mainstream. Critical of the image of physics as a strictly cumulative and mathematical discipline with shared agreement on the basic features of the universe, she reminds readers of another less appreciated aspect of doing physics: the excitement and pleasure of being a co-author, with nature, of cosmologies that give meaning to human life. Imagination and the human desire to make sense of the world, Werthheim argues, is what joins physics insiders and outsiders; the increased isolation of physics from the grasp of non-physicists thus ought not to be understood as a badge of honor, but as a failure that can be addressed by opening up physics, and sciences more generally, to the popular imagination. And it is just this process that Gordin and Kaiser also take up in their studies.

Carter, Wertheim's central figure, has almost no contact with mainstream physicists or other cultural brokers, nor does he have a following among his peer outsider physicists or among any particular American subgroup. That places him in a very different social position than the one occupied by Immanuel Velikovsky, the author of the 1950 book *Worlds in Collision* and the subject of Michael D. Gordin's book. Velikovsky was a Jew born in the Belorussian city of Vitebsk, and later became a Zionist and a physician, trained in psychoanalysis.[3] In a meticulously documented and highly readable study of the origins, reception, and significance of *Worlds in Collision*, Gordin uses the public popularity of Velikovsky's claims, not their obscurity, to raise questions about the borders between pseudo-science and science.

"Pseudo-science" and many synonyms have been used by philosophers and scientists to characterize claims that use the language and style of science, and sometimes some of its well-established facts, to make assertions that are not scientific. But philosophers have not been able to single out criteria that clearly

3. Immanuel Velikovsky, *Worlds in Collision* (New York: MacMillan, 1950).

and unequivocally separate science from nonscience. Instead, there are a series of "wars" between scientists and pretenders to the throne, including those who challenge scientific realism. The "Science Wars" of the 1990s that took place between postmodernist cultural studies scholars and scientists over the criteria for judging scientific claims are but a recent example. In 1983, sociologist Thomas F. Gieryn called this sort of jousting "boundary work," or the activities that scientists undertake in policing the edges of their fields to keep interlopers out. More specifically, the science wars of the 1990s have profitably been analyzed by Gieryn and other analysts as another case of the policing of the edges of science and nonscience.[4]

Worlds in Collision is not an easy work to characterize. Velikovsky proposed that about 3,500 years ago, Venus was ejected from Jupiter. Venus traveled to the Earth as a comet, becoming entrapped in a gravitational and electromagnetic interaction, where it remained for decades. The earth's axis was thrown off, and its crust ruptured. Comets rained down, and all manner of calamities, from volcanoes to firestorms to plagues, afflicted humanity. Velikovsky did more than propose a novel astronomical event: he linked it to the collective memory of all humans. Disparate stories of these sorts of disasters and unusual geophysical events exist across most cultures. They are often thought of as independent myths. But Velikovsky argued that they were not only true, but coincided with the Venus event. Velikovsky's masterwork was thus a grand synthesis of independent myths of the human past whose commonality could be traced to an astronomical event theretofore unknown to scientists. It was, for Velikovsky, a great recovery of the collective unconscious. *Ages in Chaos*, Vol. I, followed, and this time he used the Venus event to revise the known history of Egypt around the time of Exodus.[5] Over the next several decades, Velikovsky produced many more historical works concerning events and stories from the Hebrew Bible, always using his interpretations of astronomical and geophysical events to buttress his claims.

Worlds in Collision was an immediate bestseller, and acquired cautious interest by some intellectuals, and even a handful of scientists, who were attracted to its bold claims. But even before its publication—importantly,

4. Thomas F. Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* 49 (1983): 781–95. Thomas F. Gieryn, "Epilogue: 'Science Wars' as Boundary Work," in *Cultural Boundaries of Science: Credibility on the Line* (Chicago: University of Chicago Press, 1999), 336–62.

5. Emmanuel Velikovsky, *Ages in Chaos: A Reconstruction of the History from the Exodus to King Akhnaton* (New York: Doubleday, 1952).

through a peer-review process—leading American scientists were quietly expressing concern about Velikovsky's ideas, notably the astronomer Harlow Shapley, who himself had been pushed toward cultural and political margins as a result of security investigations. Scientists' lack of enthusiasm for the book and their routine refusals to run experiments that would "test" Velikovsky's theories came with a price. *The Saturday Evening Post* mocked the "censorship" of Velikovsky's work, and in the 1970s, Velikovsky enthusiasts invented stories of systematic repression that buttressed their sense of the revolutionary nature of Velikovksy's claims. That scientists would give any attention to the book at all, however, cannot be understood without this critical piece of knowledge, argues Gordin: American scientists were keenly aware of how pseudo-science could be validated through nonscientific mechanisms. The Soviet validation of T. D. Lysenko's theory of genetics (and the National Socialist government's misuse of genetic theory) were well known, and at a time when U.S. scientists were sorting out how the outpouring of financial support from and political alignment with the government might affect their work, the idea that groups outside science might come to validate scientific claims was worrisome indeed.

Velikovsky's ideas attracted controversy in the decade or so after their first publication, but by the 1970s, a different kind of battle in this particular pseudo-science war had arisen. In this round, college students, mass media outlets, scientists, and other scholars with strong credentials took Velikovsky to be a visionary, a hero who challenged establishment views and whose outsider status were in sync with the era's freewheeling, exploratory, and populist views of knowledge and knowledge makers. Science was no longer on a pedestal by the early years of this decade—it had come to be associated with militarism, conformity, and a slavish insistence on rationality (as well as with war, environmental destruction, racism, and sexism). Its wobbling elite status left wide open the possibility that wildly novel approaches could fill the vacuum. It is worth noting, too, that the standard bearers of the philosophy of science were also under fire. As Gordin makes eminently clear, just as in the earlier period, the stakes were high if Velikovsky's views were to persuade too many scientists, or allow publics to shape the direction of science. Carl Sagan and Isaac Asimov, among others, came to the rescue, publicly and roundly denouncing the science behind Velikovsky's claims, even as he remained a figure of scholarly and popular interest among some humanities scholars and social dissidents. Velikovsky never stopped seeking support for his theories, but never received any confirmatory experimental test of his geophysical claims.

Echoing the work of scholars in other fields who are less sanguine about the capacity of philosophy to settle the debate about what counts as "real" science, Gordin concludes that it is not possible to keep the Velikovskys of the world cordoned off merely by denouncing them as "non-scientific." He agrees with other authors who have shown that there is an increasing variety of challengers to mainstream scientific claims, procedures, and authority, including those who collectively and deliberately sow doubt about the veracity of well-established knowledge for their own gain, such as climate denialists and those who purport that tobacco is not harmful, and practitioners and citizens who work with or are exposed to things that scientists study, such as beekeepers who are contributing to scientific theory and practice. The boundary work that takes place during each round of science wars, and the uptake and study of "border" knowledge, not abstracted theory, is what sets pseudo-science and science apart. Gordin's outstanding scholarship is a critical example of why, how, and with what intellectual consequences the edge-worlds of science are contested and policed.

Far-fetched theories, of course, also exist among scientists and engineers in established fields. But unlike "outsider" or "fringe" science, which is undertaken by people with neither credentials in the field to which they want to contribute, nor the capacity to mount convincing material or mathematical demonstrations of the veracity of their claims, credentialed and accomplished scientists also pose wild ideas and applications, drawing on eclectic sources and using unconventional techniques. They are of a different breed than Thomas Kuhn's "normal scientists," those archetypical cautious and unimaginative foot soldiers who solve the myriad small problems in the daily work of science.

In David Kaiser's lively history of origins and contributions of the Fundamental Fysiks Group to quantum physics, it was the group's imaginative, playful, no-holds-barred, all-comers-welcome approach that led them to new conceptualizations of the nature and dynamics of quanta. In Kaiser's view, their work led to the formulation of fundamental ideas in information science. Formed by under- and un-employed physicists in the twilight of the age of Big Physics, group members were involved in the networks of gurus, poets, and entrepreneurs who were increasingly defining Bay Area culture through experimental psychologies, drug-taking, and all manner of efforts at mind-blowing experiences and futurisms that were based on scientific and quasi-scientific ideas, Eastern religions, and American libertarianism. As Kaiser demonstrates, group members "shifted easily from weapons laboratories to communes, universities to ashrams" (xxiii). One of Kaiser's key themes is the importance of philosophical and speculative thinking in making scientific breakthroughs, and he favorably compares the Fundamental Fysics Group's style of work with that of Niels Bohr, Werner Heisenberg and Erwin Schrödinger, whose foundational work on quantum physics was the Fundamental Fysiks Group's starting point. Moreover, Kaiser asserts, spending time on the philosophical problem of demarcating science and nonscience leaves us with little way of understanding the processes by which they may influence each other, and a thin understanding of how knowledge is actually produced. Less explicit but nonetheless important in Kaiser's argument is that nonscientists are both audiences for and catalysts of new ideas in the sciences. Although Kaiser does not provide the smoking gun that demonstrates that physics was "saved" by hippies, or make a convincing case that without the hippies, quantum theory would not have progressed as it did, he does make a compelling case for treating extra-scientific ideas, people, and events as generators of scientific excitement and curiosity. This theme complements Gordin's mapping of student enthusiasm for a set of events and ideas that had no foundation in physics or geology, and Wertheim's emphasis on nonscientists' desire to be part of the creation of cosmologies.

The Fundamental Fysiks Group was formed in Berkeley, California, in 1975, by Elizabeth Rauscher, Fred Alan Wolf, and Jack Sarfatti. Wolf and Sarfatti were faculty members from San Diego State University looking for something more exciting than military applications of physics, and both were already participating in countercultural life. Rauscher was a newly minted PhD who had growing interests in the physics and philosophy of the mind. For all three, unanswered questions in quantum physics offered a puzzle that was not amenable to the "shut up and calculate" problem-solving so characteristic of post-War physics, and a way of exploring the nature of perception, time, and the mind. Along with John Clausen, Saul-Paul Sirag, Fritjof Capra (*The Tao of Physics*), Gary Zukav (*The Dancing Wu Li Masters*), and Nick Herbert (*Quantum Reality: Beyond the New Physics*), this core group sought to understand the problem of non-locality: How it could be that the measurement of one particle instantly affected another particle, no matter how distant?[6] The particles were in some way instantly entangled; the problem was to understand how that could be.

6. Fritjof Capra, *The Tao of Physics: An Exploration of the Parallels Between Modern Physics and Eastern Mysticism* (Boulder, CO: Shambhala Publications, 1975); Gary Zukav, *The Dancing Wu Li Masters: An Overview of Modern Physics* (New York: William Morrow and Company, 1979); Nick Herbert, *Quantum Reality: Beyond the New Physics* (New York: Anchor Books, 1985).

The group's explorations led them to explore psychokinesis, time travel, extra-sensory perception, and Jungian psychology by way of explorations with members of the Stanford Research Institute's studies of ESP, Werner Erhard's Erhard Seminars Training (EST) sessions, and FFG members' workshops at the Esalen Institute. At Esalen their courses competed with those on Primal Scream Therapy, Jungian Analysis, and Wilhelm Reich's theory of orgone energy. But they were also very much part of physics networks that served as interlocutors for the group's hypotheses about the dynamics of quanta. They included some of the most prominent names in the field, including the Nobel-Prize winner John Wheeler, Richard Feynman, and Victor Weisskopf. The worlds of popular culture and physics overlapped in 1976, at the first annual workshop on Physics and Consciousness at Esalen, and ideas from the group were spread to popular and scientific audiences through a publishing service run by Ira Einhorn of Philadelphia. But by the early 1980s, mainstream physicists were urging FFG members to cease their engagements with far-out phenomena such as ESP and to disengage from sponsors like Erhard.

The pathway from speculation to mainstream acceptance was indirect, at best. Throughout the life of the FFG, members had contact with prominent mainstream physicists. Some were intrigued, others peevish, and still others cautiously interested. But in a more traditionally scientific fashion, the gradual understanding and acceptance of non-locality and entanglement occurred as other scientists engaged and refuted some of the ideas and experiments that the Fundamental Fysics Group put forth. Experiments by group members and others, particularly Alain Aspect, GianCarlo Ghirardi, Nick Herbert, Tullio Weber, Henry Stapp, Wojciech Zurek, and Bill Wooters, were critical, and Kaiser makes clear that philosophical discussions were central to many of the advances, and so too was the circulation of ideas through Einhorn's publication service.

Kaiser's work parallels other nontraditional histories of science that look at how the California counterculture inspired and embraced speculative, imaginative, and often utopian visions of how science could be harnessed. Patrick McCray's *The Visioneers*, Fred Turner's *From Counterculture to Cyberculture*, and Christopher Turner's *Adventures in the Orgasmatron* offer evidence of coproduction of scientific ideas and cultural ideas, with overlapping casts of characters.[7] Certainly they describe activities that were a lot more fun than

7. McCray, *Visioneers* (ref. 1); Fred Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago: University of

similar mixings of the cultural and scientific by biologists during the same period who used Marxist and feminist theory to rethink the role of biological environments, sexism, and racism in conceptions of populations, reproduction, and morphologies. Taken together, new scholarship on the intersection of science and popular culture makes a compelling case that popular culture is not merely a reflection of scientific and technological developments but can be a source of them, too.

The borders between science and non-science, and between the "insiders" and "outsiders," are not nearly as neat and rigid as might be supposed or even hoped for. Especially between 1940 and the mid-1960s, American science and engineering were often shrouded in secrecy, increasingly highly mathematical, and organized around massive projects or around the relatively inaccessible interiors of the body and mind. These projects and approaches were outside the intellectual grasp of most people. They did not, however, dampen the longings of ordinary people to participate in making knowledge that matters in the stories of our past and the creation of our future. Nor did they reduce the critical role of the speculative and imaginary in scientists' own thinking and work. Higher levels of education, the Internet, technologies such as 3-D printing, and an entrepreneurial culture allow more people to participate in debates about science and technology and, at times, to make critical commentary and contributions. Conversely, scientists are ever less walled off from engagement with outsiders, entrepreneurs, the arts and popular culture, doubters, and critics. Although this may be cause for lament for some scientists, these three authors make clear that such engagement is Janus-faced, for it can also provide inspiration to scientists and encourage the very human interest in knowing who we are, where we came from, and what we might become.

Chicago Press, 2008); Christopher Turner, *Adventures in the Orgasmatron: How the Sexual Revolution Came to America* (New York: Farrar, Straus and Giroux, 2011).