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The problem with pseudoscience

Pseudoscience is not the antithesis of professional science but thrives in science's shadow

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It is quite difficult to picture a pseudoscientist—really picture him or her over the course of a day, a year, or a whole career. What kind or research does he or she actually do, what differentiates him or her from a carpenter, or a historian, or a working scientist? In short, what do such people think they are up to?

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The answer might surprise you. When they find time after the obligation of supporting themselves, they read papers in specific areas, propose theories, gather data, write articles, and, maybe, publish them. What they imagine they are doing is, in a word, "science". They might be wrong about that—many of us hold incorrect judgments about the true nature of our activities—but surely it is a significant point for reflection that all individuals who have been called "pseudoscientists" have considered themselves to be "scientists", with no prefix.

What is pseudoscience?

"Pseudoscience" is a bad category for analysis. It exists entirely as a negative attribution that scientists and non-scientists hurl at others but never apply to themselves. Not only do they apply the term exclusively as a discrediting slur, they do so inconsistently. Over the past two-and-a-quarter centuries since the term popped into the Western European languages, a great number of disparate doctrines have been categorized as sharing a core quality—pseudoscientificity, if you will—when in fact they do not. It is based on this diversity that I refer to such beliefs and theories as "fringe" rather than as "pseudo": Their defining characteristic is the distance from the center of the mainstream scientific consensus in whichever direction, not some essential property they share.

Scholars have by and large tended to ignore fringe science as regrettable sideshows to the main narrative of the history of science, but there is a good deal to be learned by applying the same tools of analysis that have been used to understand mainstream science. This is not, I stress, to imply that there is no difference between hollow-Earth theories and geophysics; on the contrary, the differences are the point of the analysis. Focusing on the historical and conceptual relationship between the fringe and the core of the various sciences as that blurry border has fluctuated over the centuries provides powerful analytical leverage for understanding where contemporary anti-science movements come from and how mainstream scientists might address them.

> *"As soon as professionalization blossomed, tagging competing theories as pseudoscientific became an important tool for scientists to define what they understood science to be"*

The central claim of this essay is that the concept of "pseudoscience" was called into being as the shadow of *professional* science. Before science became a profession—with formalized training, credentialing, publishing venues, careers—the category of pseudoscience did not exist. As soon as professionalization blossomed, tagging competing theories as pseudoscientific became an important tool for scientists to define what they understood science to be. In fact, despite many decades of strenuous effort by philosophers and historians, a precise definition of "science" remains elusive. It should be noted however that the absence of such definitional clarity has not seriously inhibited the ability of scientists to deepen our understanding of nature tremendously.

What is science?

Of course, many people believe that an accurate test of whether something is properly scientific exists: philosopher Karl Popper's doctrine of "falsifiability", whereby "the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability" [1]. Popper unveiled this theory in a lecture in 1953, and since the 1980s—when it was cited as a demarcation criterion between creationism and biology in the US Supreme Court decision *McLean v. Arkansas Board of Education*—it has become enormously popular as a talking-point and in school curricula. Nonetheless, it fails both logically and empirically as an accurate standard for demarcating scientific claims from disreputable imposters [2]. First, we have no guidance about when this goal has been accurately achieved: Did our experiment falsify the relevant claim, or did we just perform the experiment poorly? More importantly, Popper's criterion does not segment doctrines the way we would expect. Many fringe doctrines (psychical research, Bigfoot theories, AIDS-HIV denial) make pinpoint falsifiable

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predictions exactly as Popper demands, and many mainstream sciences that analyze unrepeatable past events (cosmology, evolutionary biology, geology) do not. The difficulty comes with relying on a single bright line that focuses on semantic form alone. As philosophers have since pointed out, no single dimension of analysis suffices [3].

> *"... opposition to climate science or tobacco regulation in some cases deploys the explicit articulation of free-market fundamentalism as an ideological position"*

Approaching fringe doctrines from the point of view of their advocates—that is, as efforts to engage in science as they understand it—reveals how much these varied movements concentrate on hostility to or imitation of those very features that make science "professional". This strongly suggests that scientists might confront the fringe more effectively if they built from the profession outward, rather than attempting to lop off one Hydra's head after another from behind defensive walls.

Classification of fringe sciences

Any attempt to build a taxonomy of the many doctrines that have been labeled as "pseudoscientific" reveals the impossibility of an internally consistent single definition of fringe science. The following breakdown is therefore not meant to be comprehensive, and different people surely would group these or other ideas in various ways—the point is that it is impossible to come up with a *single* categorization that would include all of them.

We can begin with *vestigial* doctrines. These are systems of thought that used to be considered sciences but that professional scientists have, over time, either gradually moved away from or actively excluded. The most well-known are astrology and alchemy, which during the Renaissance were largely synonymous with what would become by the end of the Enlightenment "astronomy" and "chemistry" (on alchemy, see [4]). The same can be said for eugenics, a term which preceded "genetics" and even "gene" and existed for decades as a superset, including many researchers we would now classify as geneticists, or the ether theories which dominated 19th-century physics and are still well represented in fringe publications.

Another group, for lack of a better term, are the *ideological* fringe sciences. Most prominently associated with Hitler's National Socialism or Stalin's Soviet Union, these doctrines, such as the anti-relativity, anti-quantum, and anti-Semitic *Deutsche Physik* or anti-Mendelian Michurinism trumpeted by Trofim Lysenko from the 1930s to the 1960s, are commonly considered distortions of rational thinking in the service of a political ideology. Other fringe doctrines, less obviously fraught, carry strong markers of political, religious, or racist identification and are intended by their advocates to harmonize natural science with ideology. By way of example, opposition to climate science or tobacco regulation in some cases deploys the explicit articulation of free-market fundamentalism as an ideological position.

A third of these overlapping groups is the *mentalist* fringe. Especially abundant, these doctrines focus on allegedly unrecognized or underappreciated powers of mind, and include a complex family tree that descends from late 18th-century Mesmerism to late 19th-century Spiritualism (table-rapping, séances, and so on), to the research in extrasensory perception (ESP) that has sporadically appeared in psychology journals since the 1930s. The complexity of the brain and the relative youth of neuroscience have provided ample space for unorthodox thinking and innovation—ranging from psychoanalysis to psychopharmaceuticals—which necessarily brings along vestigial and ideological fringes in their wake.

I conclude this partial taxonomy with those cases I call the *controversy* fringe. Perhaps more than any others, they illustrate how problematic determining any "essence" for the fringe is. The controversy fringe comprises cases in which potentially path-breaking work is published within the bounds of a science and is greeted with intense skepticism and debate, typically aired across the pages of professional journals. There are two ways this might play out: The controversy ends up vindicating the radical proposal and the science itself is restructured (as happened with relativity theory and quantum mechanics) or the claim is rejected and those who persist in defending it are relegated to the fringe (cold fusion, polywater, phlogiston).

As one sees from each case, the boundary between the mainstream and the fringe is relatively porous and there is a lot movement across it—although, to be sure, once a doctrine is thrust into the fringe, it is quite difficult for it to get out again. Some ideas, such as acupuncture or inheritance of acquired characteristics, do on occasion reappear in highly attenuated form, but this is rare. Typically, the long list of vestigial doctrines grows apace. The point is not only to demonstrate that the heterogeneity of the fringe defies simple classification and dismissal, but also to suggest that focusing on the *content* of the theories is not the most productive way to understand the durability of fringe science. The more appropriate vantage point is professionalization itself.

Worlds in collision

Various fringe doctrines share family resemblances, but each family member is often more distinct from counterparts in different families than from aspects of the specific mainstream scientific theories it critiques. Fringe ideas share in common that they are all, to greater or lesser degree, ostracized from the genteel company of professional science. A complicated but persistent engagement with science as a profession characterizes the most persistent and prominent fringe doctrines of the past half-century.

> *"Sometimes attempts to mobilize against perceived pseudosciences can backfire"*

Largely forgotten today, the furor that swirled around the cosmic catastrophist arguments of Immanuel Velikovsky (1895–1979) from 1950 until shortly after his death provides an excellent case study [5]. Born in Vitebsk (then in the Russian Empire, now in Belarus), Velikovsky moved peripatetically to Moscow, Berlin, Tel Aviv, and Vienna before sailing to New York City in 1939, just before the guns began firing in the Second World War. He originally intended to write a book to refute Sigmund Freud's final work, *Moses and Monotheism*, but ended up constructing a narrative that argued that the resemblances among ancient mythic traditions (Hebrew, Greek, Egyptian, Mesopotamian, Indic, Chinese) could be explained by an astronomical-geological cataclysm that

was witnessed by the entire globe and then transmuted into metaphorical legends. The hypothesized catastrophe violated most of the established tenets of astronomy, geology, and ancient history: the electromagnetic and gravitational capture of a comet by the Earth in near orbit, tilting the Earth's axis, raining fire from the heavens, spawning earthquakes, until decades later the comet settled as the planet Venus; that is, our nearest planetary neighbor was born in the full witnessing of the world's cultures about 1500 BCE. Velikovsky's monograph detailing this theory (Fig 1), *Worlds in Collision* (1950), became an immediate non-fiction bestseller for Macmillan Press, which happened to be the leading scientific publisher in the USA. Scientists, especially astronomers, responded immediately with hostile reviews, and a small subset proposed boycotting Macmillan Press, which would have crippled the profitability of the firm. A few weeks into its spectacular launch, responsibility for *Worlds in Collision* was transferred to Doubleday, a competing publisher without a significant science textbook division.

The "Velikovsky affair", as it came to be known, could have been about many things—not least about the conflict or harmony between science and religion,

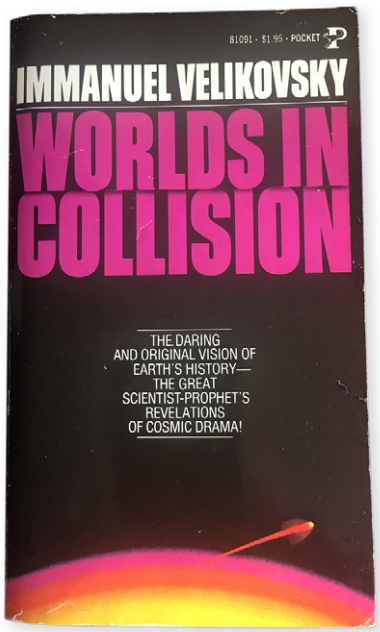

Figure 1. Cover of the 1977 Edition of "Worlds on Collision" by Immanuel Velikovsky published by Pocket Books.

given that he had attempted to reconcile the Hebrew Bible with the structure of the solar system. But the boycott and the immediate backlash from scientists, a consequence of their own perceived insecurity amid the massive interlinking of professional science and the national-security state at that very moment, oriented the narrative in a very specific direction. As the name of the controversy indicates, Velikovsky's story came to be understood by his defenders and by himself as a 20th-century reprise of the so-called Galileo Affair: an outsider facing persecution for speaking up for truth against the forces of a reactionary establishment. The appeal this gave Velikovsky was undeniable, and in the 1960s and 1970s his popularity among the student counterculture skyrocketed. He remained a headlining gadfly to public scientists like Carl Sagan and Harold Urey until he passed away in his home in Princeton, NJ, in November 1979.

There are two points to highlight in this brief account. The first is that *Worlds in Collision* seemed poised to be the season's publishing success and then fade away like many other such books, when the actions of professional scientists unintentionally endowed Velikovsky and his followers with a remarkably potent foundational story. Sometimes attempts to mobilize against perceived pseudosciences can backfire.

The second point might at first seem unrelated: In the second wave of countercultural enthusiasm for cosmic catastrophism, Velikovskians began establishing courses on college campuses and then journals of their own, the latter complete with peer review using referees selected from among their own ranks, footnotes, and complicated orbital calculations. In reaction to a scientific mainstream that they understood as suppressing their own heterodox point of view, Velikovskians assembled many features that resembled those of professional science—a counter-establishment, we might say. This significant feature can be found among many of the more dominant fringe doctrines in the sciences: Their advocates see themselves as fundamentally pursuing *science*, so they do all the things that scientists do, and that means publishing, teaching, and finding other doctrines on the fringe that they can denounce as pseudoscientific—the Velikovskians typically singled out creationism. This is intrinsically a *mimetic* process, and it is precisely the same path that any new discipline in the sciences—evolutionary psychology, neuroscience, cosmology—has had to pursue.

Both lessons from the Velikovsky episode emphasize the significance of the structures of professional science in thinking about the contemporary fringe. Certain doctrines, such as creationism and intelligent design, benefit from the enormous financial and organizational resources of American evangelical Christianity in order to build a parallel establishment with graduate programs and research institutes [6]. Others, like UFOlogy, define themselves in opposition to the professionals, arguing that the very hallmarks of professional astronomers' respectability are indications of their corruption by a military cover-up. Recently, historians have followed the ways in which what had originally been an advertising campaign developed for the tobacco industry—the marketing of denial and doubt—spread through a parallel professional network of think tanks and gray literature into a series of anti-regulatory doctrines dedicated to obscuring the mainstream professional consensus on acid rain, chlorofluorocarbons, ozone, and of course anthropogenic climate change [7,8].

The shadow of science

To return to the metaphor I advanced at the beginning of this essay, pseudoscience is science's shadow. Specifically, it is the shadow of professional science, and just as a shadow cannot exist without the object casting it, so does every object necessarily cast shadows. During the past two hundred years, demarcating what stands as legitimate, mainstream science from its less reputable counterparts on the fringe has been a central mechanism of how various disciplines have developed.

Every time you have a core, you necessarily have a fringe—it might be a source of ideas the core considers misguided or even dangerous, but it is also a place from which exciting new perspectives might emerge. Although contemporary fringe groups in physics are frequently hostile to Albert Einstein's relativity theory, they also love the idea of an innovator coming from a patent office outside the academy [9]. Carl Sagan, one of the leading figures in public attempts to both address and extirpate the fringe in the 1970s (ESP, UFOs, Velikovsky), put his hopes in improved scientific literacy. Raising the level of science education around the globe is a laudable goal that I

wholeheartedly support, but we should not imagine that this will remove the fringe. It will change the *content* of what people object to—less flat Earth, although perhaps more alternative theories of heredity—but the desire to participate in science from outside the professional ranks will persist.

> *"The more attractive science is, the more people with unorthodox ideas want to model themselves upon it, and the greater the public appetite for doctrines with the appearance of science"*

This is easier to see by extending the shadow metaphor a little: The brighter the light, the sharper the shadow. There have been periodic upticks in the visibility of various fringe doctrines, and right now we live in one of those moments (AIDS-HIV skepticism, anti-GMO movements, and so on); the 1970s (ESP, von Däniken), the early 1950s (UFOs, Lysenkoism), the 1870s (spiritualism), and the 1820s (phrenology) were other such prominent hotspots. These are, paradoxically, not moments when the prestige of science was low, but when it was *high*. The more attractive science is, the more people with unorthodox ideas want to model themselves upon it, and the greater the public appetite for doctrines with the appearance of science. In an age of anti-vaccination mobilization and organized hostility to GMOs, this point might seem absurd. But pay attention to how the claims are made. Studies in prestigious journals are cited—even if those articles have since been retracted—chemical ingredients invoked, parallel experts are brought out. This is how debate happens in public science, and people whom the mainstream considers far out on the fringe see themselves as engaged in the same project in form, albeit different in content. This observation is not to belittle advocates of fringe doctrines—as, for example, does Richard Feynman [10]—but rather to illuminate how the mainstream position might more fruitfully address the fringe's claims.

Addressing the fringe

Since the cultural significance of science changes constantly, so do the salient points that the fringe emphasizes, but a few complaints have remained rather persistent: abstruse jargon, excessive mathematization, and an impression that science is cliquish and resists engagement with outsiders. These points all stress the high barriers to entry in contemporary science, marks of the extensive training that has characterized professionalization of inquiry into the natural world. This suggests that reflexive doubling down on professional qualifications ("Trust me because I am a credentialed scientist") is simply pouring oil on the flames. On the other hand, explanation of why those professional barriers are built the way they are ("Climate is a very complicated phenomenon, and mathematical approximations give us a hope of understanding it, and that takes training") might go some way to meeting the critics. Communities of professional scientists also need to publicly discuss and address—with full honesty—crises of confidence within the their subfields, such as contemporary replication debacles or revelations of fraud, lest failure to do so foster even more suspicion of professionals. Many of the recent changes in publishing practices in the sciences, such as obligatory conflict-of-interest statements or making data open access, are examples of practices that address critiques leveled by certain advocates of fringe doctrines—a positive unintended consequence of remedies implemented for other reasons.

One could also wish for professional scientists to speak more directly to the public not about the content of their work, but the form: How are laboratories organized, why is the division of labor so specialized, why is mathematization so important and how does one acquire the skills, what is the process of training from undergraduate to postdoc actually like? Demystifying those aspects of science that are stamps of its being *professional*, rather than reiterating oversimplified versions of revisable knowledge claims, would at the very least educate neutral parties more about the daily practices of science, and provide a point of collaboration between the sciences and those social scientists—anthropologists, historians, and sociologists—who have made great strides in elucidating precisely these features of scientists' work. What these practices will not do is eliminate the fringe entirely, because the fringe is ineradicable.

Understanding the scientific fringe as a necessary shadow of the professional scientific consensus not only emphasizes the intimate connection between the sciences and those doctrines variously labeled pseudosciences, it also refocuses our attention on the causes of the phenomenon. When someone makes shadow puppets on the wall, our eyes are naturally drawn to the striking, cleanly outlined shapes of rabbits and ducks, but that is not where the action is. Similarly, I suggest the pseudosciences are not real in themselves; they are defined by external projection. The important thing to watch is not the shadow, but the hand. It not only is the source of the shadows; it is also the more fascinating and complex phenomenon of the two. The fringe not only shadows the core, it is continuous with it, and the most effective way to deal with attacks from the latter is to ensure that the former is in good working order.

Conflict of interest

The author declares that he has no conflict of interest.

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