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EDITORIAL

Why scientists should study chess

KEITH D. PUTIRKA[1,*]

[1]Department of Earth and Environmental Sciences, California State University, 2576 E. San Ramon Avenue, Fresno, California 93740, U.S.A.

All true histories contain instruction; though, in some, the treasure may be hard to find, and when found, so trivial in quantity that the dry, shriveled kernel scarcely compensates for the trouble of cracking the nut.

—Anne Brontë

A Father's Day trip to Santa Anita inspired the thought of comparing publishing to pari-mutuel betting, but an unexpected turn provides instead the pleasure of introducing our new editors, Don Baker and Hongwu Xu, who join Letters Editor Ian Swainson at the helm of *American Mineralogist* (we'll get to Anne Brontë later). Don and Hongwu are excellent choices, serving more than ably as *American Mineralogist* Associate Editors. New policies may be in store, but one policy will remain: professional differences will not be conflated with personal grievances. Antonin Scalia was asked how he and Ruth Bader Ginsburg could be close friends. "I attack ideas. I don't attack people," he said, adding that "Some very good people have some very bad ideas." Good ideas will withstand the light of day, and I would happily entrust any manuscript of mine to the light of the new Editors. Policies notwithstanding, though, their tenure will see challenges.

I may be the last to teach "Mineralogy*"* in the state of California. Many Geology departments in both the Cal State and University of California systems have substituted "Mineralogy" with courses entitled "Earth Materials." In some cases, these courses are identical to Mineralogy, while in others, Petrology is combined. The course, in some departments, is not required for a major. How prevalent is the change? Enough to cause a California State Board that oversees Professional Geologist licensure to make the same substitution. If disappointing, the change is not shocking. At a conference a few years ago, Mike Dungan rhetorically asked: "When's the last time your department hired a crystallographer?" He could have asked the same about a "mineralogist." His implied message was that if petrologists are not tackling compelling problems of broad interest, "petrology" would not be far behind. It's not. Many departments do not have a petrologist, or mineralogist or a crystallographer, as readers of this journal would define these. And this happens, of course, because our colleagues believe that other disciplines attack more compelling problems. Can a discipline lose its direction? In *The Loss of Certainty*, by Morris Kline (1980), and *Lost in Mathematics: How Beauty Leads Physics Astray*, by Sabine Hossenfelder (2018), it would appear that the answer might be "yes." Kline's book is controversial, less because he rediscovers David Hume's uncertainty, but more because he then concludes that applied math has thus been undervalued. Hossenfelder's book is no less pointed, as she argues that a search for mathematical elegance holds back discovery of new physics. In any case, many universities no longer have a faculty member specializing in any of the three fields that comprise MSA's logo. What happens to *American Mineralogist* when no course is taught, and no faculty member self-identifies with any of these disciplines? It might not matter for scientific progress; there will always be a need to study rocks and minerals. Astronomy departments might hire petrologists to study exoplanets—and they will call them "planetary materials scientists," and they will teach classes titled "Thermodynamics of Planetary Objects." Biologists (who, unlike geologists, have never been self-conscious about their Greek-originated name) will hire mineralogists, and call them "bio-geochemists," and they will teach courses titled "Biomaterials." And so the work goes on, under a new name at a different place. And the nodes of our social network are shifted.

Nicholas Christakis (2010) says that social networks are "sustained" by "the spread of good and valuable things." Citations are one way to measure those things our community finds valuable, if not good. This is not unrelated to the increasing weight of the Journal Impact Factor (JIF) for hiring and promotion decisions. I've earlier made the argument that when judging journals, or scientists, a single-valued gauge is hardly a gauge at all (e.g., Putirka 2016)—the systems are complex. But the use of JIF is not just a signal of laziness, or overwork, on the parts of Deans and Personnel Committees—it also stems from the proliferation of pay-to-play journals that often fly under the banner of Open Access, but play no meaningful role in a social network. Some could be called "predatory," charging unsuspecting authors hidden and exorbitant fees (see https://oaspa.org/, which maintains resources and standards for ethical Open Access). But some have lax peer review standards that authors purposefully seek. As Gina Kolata explains in "Many Academics are Eager to Publish in Worthless Journals" (2017), there is a symbiotic relationship between despairing authors and pay-for-acceptance publishers. That relationship will endure so long as numbers of publications, rather than their quality or impact, are used in some quarters to decide hiring, tenure, and promotion.

Judgments of quality are not easy. Sometimes centuries are needed, as in the late re-assessment of Robert Hooke, who today, seems to be the better of Newton in all but mathematics. Newton would likely be dismayed at modern science. Hooke would be perfectly comfortable. Newton was a Bible literalist who likely stole the inverse square law and other ideas from Hooke (see *Restless Genius*, by Ellen Tan Drake 1996) to make his undoubtedly useful contributions to physics. Hooke, on the other hand, was a true polymath. He was an early evolutionist, skeptical of biblical estimates of a young Earth, presaged

*E-mail: kputirka@csufresno.edu

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Hutton's ideas of uniformitarianism, and probably directly influenced Hutton (Drake 1996). He apparently "surpassed" Steno's interpretations of fossils and strata (Drake 1996), and was perhaps the first true meteorologist (see Inwood 2002). Hooke also was the first proponent of polar wander and co-developed "Boyle's Law" (the foundation of physical chemistry). Inwood (2002) also notes that "it was Hooke as much as Wren" who helped rebuild London after the fire of 1666, while Drake (1996) argues that through his inventions and demonstrations, Hooke was the effective "creator of the Royal Society." As to Newton, Drake (1996) shows that he lied to his colleagues to diminish Hooke, and that "none of the thousands of instruments and models he [Hooke] constructed or the fossil specimens he collected survived Newton's presidency of the Royal Society" (Stone 2003). Newton might even have burned Hooke's portrait. We think of Newton as a great man; he probably wasn't even a good one.

We retain our heroic view of Newton because the myth simplifies what we feel we need to know about history. Luckily, most practical judgments do not require multiple hard-working historians or re-evaluation of myths. But as bogus journals proliferate, so will the importance of citations and JIF. A spate of hoax papers prompted an Op-Ed titled "Fake News Comes to Academia" (Melchoir 2018). Science journals are not targeted there, but readers perusing only the title may question whether "peer review" is still a safeguard against fraudulent studies in any discipline. Authors of good science have taken notice. At Fresno State, newer faculty members volunteer JIF values in their CVs, to differentiate their hard-earned efforts from cheap pabulum. Here's the challenge: while the JIF of *American Mineralogist* reached an all-time high in the 2018 report (see Fig. 1 and caption), that high JIF is *lower* than the JIF of every journal voluntarily cited by Fresno State faculty in the College of Science and Mathematics. What happens to *American Mineralogist* when citations of JIF are not voluntary?

Perhaps Artificial Intelligence (AI) can help. We no longer need humans to publish hoax articles in bogus journals; SCIgen (https://pdos.csail.mit.edu/archive/scigen/) generates fake text, charts, and citations; the author list is optional. Perhaps computers can do real science too. In "Chess, a Drosophila of Reasoning" (Science, Dec. 26, 2018), Gary Kasparov (2018) explains how the program AlphaZero, utilizing an AI-approach called "deep learning," mastered chess by playing against itself—for a few hours. AlphaZero is different from prior chess-playing programs in that it does not beat its opponents with pre-programmed strategies or by out-calculating optimal board positions. Instead, AlphaZero knows only the rules of the game and plays itself to discover its own strategies. Steven Strogatz (2018) argues that AlphaZero provides a "glimpse of an awesome new kind of intelligence." Could a future program, call it "AlphaScience," replace us? Even now, a marriage of Mars Rover inputs to SCIgen could fill journals with all the "data papers" we'd care to read. Why not unleash terrestrial rovers to do the same? No humans need apply. And where might AI-powered robots seek to publish? Perhaps at the Cornell University's website arXiv, where publication and downloads are free (robots have no income after all). This site has received some criticism in one corner of the mineralogic community

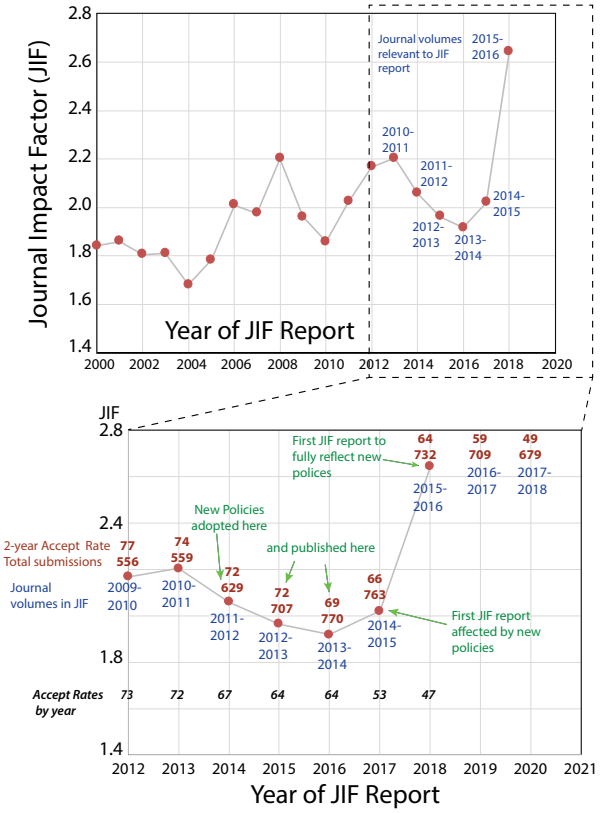

FIGURE 1. Recent history of Journal Impact Factor (JIF) reports for *American Mineralogist*. Blue lettering in the top and bottom panels shows the journal volumes relevant to the JIF report. In the bottom panel, the red lettering shows the combined two-year acceptance rate and total submissions relevant to each JIF report. Black font shows acceptance rates by year. For example, in 2014, our acceptance rate was 67% (black font for 2014), but the reported JIF in 2014, of 2.059, was for papers published in 2011–2012 (and provides their average citation rate in 2013). In 2011–20112, our two-year accept rate was 72% for 629 submissions (red font for 2014). The JIF would not "see" the 67% accept rate of 2014 until 2017 (since most papers submitted in 2014 were published in 2015; the 2017 JIF gives citation rates in 2016, for papers published in 2014–2015). For 2019–2020, we know the operative submission and acceptance rates, but must await the JIF reports. (Color online.)

because some arXiv posts are garbage. But no journal survives that critique. And what does it matter? We all fish at the same lake; some hike to freshwater inlets while others cast their lines from parking lot asphalt. Our use of journals has always been like this. Some astronomers already read arXiv exclusively, though they cite published versions when available. What happens when arXiv is listed in the Web of Science?

Years ago, my father introduced me to modeling. He took me to Hollywood Park. The tantalizing prospect was that, with the right model (everyone had the same data: *The Daily Racing Form*), we could leave the track more flush than when we arrived. Among other boyhood heroes of mine, such as Don Sutton, Rory Gallagher, John Muir, and Ed Zern, was Bobby Fischer, who had his own, rather powerful, model. In his "Game of the Century" (Fischer vs. Byrne 1956), the 13-year old Fischer

played a highly non-obvious but masterful and winning move against a U.S. Open Chess Champion, Donald Byrne. A future AlphaZero might similarly explore non-obvious but correct, or at least useful, solutions to scientific problems—and the occurrences might not be once-in-a-century, but daily. Hospital patients will be thankful, and "data collectors" may be out of a job. But curiosity-based science should still flourish. As Strogatz (2018) explains, AI cannot explain its answers; in scientific terms, AI might not be able to provide a translatable model. AI also does not discover goals. At least some kinds of judgments will thus necessarily remain human endeavors. Here's an impossible task for AI: Should Bob Dylan have won a Nobel Prize in Literature? Neil Peart is vastly less influential, but readers of their respective lyrics and memoirs will know that Peart is immeasurably more literate and has a lot more to say (my kids can ignore Bob Dylan all they like; I'd love for them to listen to "War Paint"; they prefer *Hamilton*). It's just a short step from literature to ask: Was Hooke a better scientist than Newton? Would the vast resources devoted to particle physics be better directed towards exploring Venus? Should we abandon our narrow focus on finding life on Mars, and instead venture to understand those forces have left Mars so obviously and comparatively barren? Should I box the trifecta? (Yes, *always* box the trifecta).

The *New York Times* columnist, Russell Baker said that a "newspaperman" is "someone with nothing on his mind and the power to express it." AI is kind of like that. Scientists keep their jobs in an AI-powered world if they can do better than Baker's "newspaperman"—and we can if we meet the challenge of Anne Brontë's opening lines of *Agnes Grey*.

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