The Reductionist Paradox

Subir Sarkar

In response to "[The Good Soldier](#)" (Vol. 5, No. 2).

To the editors:

David Berlinski has had a bad day. He has not enjoyed reading Brian Greene's *Until the End of Time*. Admittedly, at 428 pages it is hardly a light read, and Berlinski appears to have also ploughed through Greene's four other similarly hefty tomes written over the past two decades. This outburst may well have been a long time coming.

Berlinski does admire Greene for being "clever, chatty, accessible," but damns him and his entire enterprise with faint praise: "Greene is a sophisticated mathematician, and although there is no assurance that mathematical ideas will prove of relevance in analysis, common sense suggests that they could not hurt." His new book is easily dismissed: "*Until the End of Time* is an account of how the universe began and how it might end. Things began with a bang and they will end in a whimper." The rest of Berlinski's engaging, if rather sardonic, review focuses on what he clearly perceives as the shallowness of the epistemology in Greene's writing, with barbs fired at other contemporary science popularizers too.

He does have a point. Indeed, "what ought to be the case cannot be derived from what is the case." To hear yet again that we are all just "bags of particles" inexorably "governed by physical law," as Greene has written, is neither insightful nor inspiring.¹ It adds little to our understanding or appreciation of our place in the universe. The truth is of course that the laws of physics are simply *indifferent* to our existence. And Berlinski is right that Greene should be careful about invoking Charles Darwin, whose name occurs 47 times in the book. Darwin's theory of evolution does not follow from *any* "mathematically complete articulation of the fundamental microphysical processes."² It is just this sort of hard reductionism that makes philosophers of science very uncomfortable. There is nothing wrong with that per se. Similar standoffs occur in quantum foundations, for example, where not everyone can or does follow David Mermin's advice to simply "shut up and calculate."³ But in this particular context, Greene is indeed unconvincing.

Nevertheless, he *can* shut up and calculate, so I have a soft spot for him. Greene was a graduate student in the early 1980s in my research group at Oxford, shortly after the first superstring revolution had begun with the discovery of the cancellation of quantum anomalies in 10 dimensions. The head of our group was the distinguished particle phenomenologist Graham Ross, who had also been caught up in the excitement surrounding string theory as it swept through the physics world. Greene worked with Graham and two of his other students on the construction of a superstring-inspired Standard Model:

An analysis is presented of an $E_8 \otimes E_8$ superstring-inspired ten-dimensional supergravity model following from compactification on a particular Calabi-Yau manifold which gives rise to three generations. The multiplet structure and discrete symmetries after compactification are determined. It is shown that the model has flat directions which allow for breaking of the gauge group to the standard $SU(3) \otimes SU(2) \otimes U(1)$ model at a high scale. The resulting low-energy theory has a realistic spectrum and, remarkably, the discrete symmetries predict a reasonable structure for the Kobayashi-Maskawa mixing matrix. Without unnatural adjustments, proton decay is inhibited and neutrino masses consistent with experimental limits are obtained.⁴

Thirty-four years later, physicists are still waiting for a unique reduction of the superstring in ten dimensions to the Standard Model in our familiar four. The landscape of possible compactifications of the unseen additional six dimensions, which constitute the aforementioned Calabi-Yau manifold, has grown somewhat to around 10^{500} possibilities. Greene's latest paper in 2017—he has not published any since then—is more modest in scope, seeking only to address the "computational complexity of the landscape II—cosmological considerations."⁵ From attempting to construct a final unified quantum theory of all the forces including gravity, Greene is now down to discussing how to "associate global time in a multiverse with clock time on a supercomputer which simulates it."⁶ In the intervening years, he has done seminal work on mirror symmetries

which relate different Calabi–Yau manifolds in string theory and have also proved important in quantum field theory and indeed in pure mathematics. Berlinski may well scoff that “Rigor is just the party line,” but surely “a man’s reach should exceed his grasp. Or what’s a heaven for?”⁷ At the very least, he must acknowledge the thrill of the chase that Greene and many other theoretical physicists have been swept up in—the excitement that another epochal moment has come when we mere mortals may be privileged to make sense of the shadows dancing on the cave wall. And 34 years is surely too short a period in which to pass judgement. Berlinski is familiar with the history of science. I expect he will agree that string theory, and string theorists, need more time.

Berlinski is on the money when he takes Greene to task for saying that he does not believe in free will. No one can deny that, as Berlinski nicely puts it, “If free will does not exist, then arguments about free will are, of course, rather like arguments among billiard balls about which pocket they might join.” Greene may well lament that

you and I are nothing but constellations of particles whose behavior is fully governed by physical law. Our choices are the result of our particles coursing one way or another through our brains. Our actions are the result of our particles moving this way or that through our bodies. And all particle motion—whether in a brain, a body, or a baseball—is controlled by physics and so is fully dictated by mathematical decree.⁸

But Berlinski will have none of it! There is nothing modern about this argument, as he emphasizes. Indeed, “human life is annotated in other terms and by other words: agency and intention, desire and belief, love and hopeless longing—*sunt lacrimae rerum et mentem mortalia tangunt*.” But there is no need to quote Virgil either because this very point has been well made by Greene himself. Not perhaps in what he has written, but in what he says.

Reading is hard work, and writing even harder. We aspire toward deep truths but often end up making sweeping generalizations which bear little resemblance to the complex emergent realities that we actually experience. To really understand where Greene is coming from, may I suggest that Berlinski listen to his recent appearance on BBC Radio 3 as a guest of Michael Berkeley.⁹ His “Private Passions” are Johann Sebastian Bach, Johannes Brahms, Ludwig van Beethoven, and Philip Glass, with whom he has in fact collaborated. Music is not merely “a vibrating air molecule slamming into your ear drum—which is what you are responding to,” but “a celebration of being alive ... and a recognition of how hard life can be.” Greene talks about how as a student at Oxford he was inspired to start learning the piano simply so he could play Brahms’s sublime *Rhapsody in G Minor*:

I went to a concert ... and I had never heard music like that in my life ... the brooding intensity of *that* piece just grabbed hold of me and I said to myself I have got to learn how to play that piece ... because then life would be better ... and that started me on a journey to try to do that.

He talks movingly about his father Alan Greene, a traveling musician who had dropped out from school, lived a hard life, and died before he could see his son become a professor of physics at age 30. He told his son that he had become a musician “to keep away the loneliness.” We hear the moving allegretto from Beethoven’s Symphony No. 7 in A Major, which his father had loved. This is followed by a favorite piece of Albert Einstein, Bach’s Chaconne in D Minor from the Partita No. 2, which was played in *Light Falls*, the theatrical work about Einstein that Greene scripted. We hear the original score by Jeff Beal too and then Bach’s classic Goldberg Variations No. 25. And then an amazing composition by Philip Glass, *Icarus at the Edge of Time*, depicting Greene’s reimagined eponymous hero traveling in a spaceship to the event horizon of a black hole where time slows down to a crawl. We also hear haunting cello music composed by Alan Greene. “When you think about the universe, you can think about it in a purely cognitive way—or you can *feel* it,” says Greene. And indeed, in 30 minutes, perhaps more is revealed about his feelings about the nature of existence, free will, life, the universe, and everything, than one might gather from reading all his books.

In the end, Greene is one of us—a card-carrying professional scientist. He insists: “Like a life without music, art or literature, a life without science is bereft of something that gives experience a rich and otherwise inaccessible dimension.”¹⁰ Amen to that!

We can all agree with Berlinski too when he says: “Inference is the source of influence, and beyond inference, there is nothing.”

Happy reading, folks!

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1. Brian Greene, *Until the End of Time: Mind, Matter, and Our Search for Meaning in an Evolving Universe* (New York: Penguin Random House, 2020), 237 and 127.
2. Greene, *Until the End of Time*, 118.
3. E.g., David Mermin, “[Could Feynman Have Said This?](#)” *Physics Today* 57, no. 5 (2004): 10–11, doi:10.1063/1.1768652.

4. Brian Greene et al., "[A Superstring-Inspired Standard Model](#)," *Physics Letters B* 180 (1986): 69–76, doi:10.1016/0370-2693(86)90137-1. See also Brian Greene et al., "[A Three-Generation Superstring Model: \(I\). Compactification and Discrete Symmetries](#)," *Nuclear Physics B* 278 (1986): 667–93, doi:10.1016/0550-3213(86)90057-X; and Brian Greene et al., "[A Three-Generation Superstring Model: \(II\). Symmetry Breaking and the Low-Energy Theory](#)," *Nuclear Physics B* 292 (1987): 606–52, doi:10.1016/0550-3213(87)90662-6. According to the iNSPIRE database, these papers have together been cited 842 times.
5. Frederik Denef et al., "[Computational Complexity of the Landscape II—Cosmological Considerations](#)," *Annals of Physics* 392 (2018): 93–127, doi:10.1016/j.aop.2018.03.013.
6. Denef et al., "[Computational Complexity of the Landscape II](#)."
7. Robert Browning, "Andrea del Sarto" (1855).
8. Greene, *Until the End of Time*, 147.
9. [Brian Greene in conversation with Michael Berkeley](#), "Private Passions," *BBC Radio 3*, May 24, 2020.
10. Brian Greene, "[Put a Little Science in Your Life](#)," *New York Times*, June 1, 2008.

Published on September 28, 2020

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