Particle physics, art, and politics, with one eye on the past

Steven Weinberg: Third Thoughts. Cambridge, MA: The Belknap Press of Harvard University Press, 2018, 240pp, $25.95

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Steven Weinberg is best known for his discovery of the electroweak theory—unifying electromagnetism with the weak nuclear force (the force that allows a proton in a radioactive nucleus to become a neutron, or vice-versa), and utilising the mechanism of spontaneous symmetry breaking which predicted the existence of a Higgs boson. But, to philosophers, of course, Weinberg is just as well-known both for his dim view of philosophy, as well as his philosophical views on reductionism and the search for simple, fundamental laws of nature at extremely high energy scales. These philosophical views were spotlighted in Weinberg's congressional testimony in support of funding the Superconducting Super Collider (SSC): a particle accelerator that was under construction in Texas when in 1993, the US Congress cancelled the project. The SSC, designed for a maximum energy of 40 TeV, would have been three times as powerful as the Large Hadron Collider (LHC) in Geneva, and would have discovered the predicted Higgs boson a decade earlier than the European accelerator ultimately did.

Weinberg's reductionist philosophy, and his heartbreak for the termination of the SSC have not wavered, as evidenced in *Third Thoughts*: Weinberg's third collection of essays for a general audience. This collection comprises 25 short (ranging in length from two pages to fifteen), engaging pieces that Weinberg has written over the past ten years for a variety of occasions, and on an

assortment of topics. Most of these essays have previously been published, e.g., in books, newspapers, or other periodicals (most notably the *New York Review of Books*), and a short preface has been added to each essay outlining its origin and history up to the present publication. The collection is really a mixed bag, and one revealing of what Weinberg's life has been like over this period: opening with a lecture on the history and utility of astronomy, originally delivered on the deck of a barque cruising the Aegean Sea, and concluding with an after-dinner talk given after Weinberg received an honorary degree from Rockefeller University—in this, he reminisces on his time living in New York, and affectionately describes his current hometown of Austin, Texas.
The bulk of the essays concern subjects that are now familiar from Weinberg (science history, particle physics, the multiverse hypothesis, science funding, manned space flight, the SSC), but there are some new topics for polemics, including tax rates, climate change, and a diagnosis of the current climate of scepticism towards science shown by the public.

A criticism is the age of some of the papers: although several are historical, many are themselves now history, having been written, for instance, before the discovery of the Higgs boson, and before NASA's termination of its program of manned space missions. Another criticism is that the essays (as perhaps to be expected from this format) are not of great philosophical sophistication, although a number of topics discussed are of considerable philosophical interest (including, e.g., the role and status of symmetries in physics, the multiverse hypothesis in inflationary cosmology and string theory, anthropic reasoning, the question of how to define an "elementary particle", and the interpretation of quantum mechanics in response to the measurement problem).

There are three pieces that are particularly controversial, two of these (essays 8 and 9) focus on Weinberg's belief in writing a whig history of science, i.e., history with "one eye on the present". Science progresses towards an increasingly correct description of the world, and this, Weinberg maintains, gives the historian of science licence to judge previous episodes in the light of present knowledge (rather than by the contemporary standards of the figures involved). Throughout the collection, Weinberg enjoys not just identifying which historical theories were right and which were wrong, but also explaining why. Philosophers are wrong in developing theories without reference to quantitative observations. Some theories (even modern ones) are wrong because they ask the wrong type of questions. False theories persist due to a lack of testability or practical utility, which prevent them from being demonstrated false in their time. A colourful cast of past philosopher-scientists cameo throughout the book, particularly ancient and Hellenistic Greeks—Hipparchus, for example, was right in his estimate of the time scale of the precession of the axis of the Earth; Plato and Aristotle were wrong to dismiss the importance of experiments; Aristotle was wrong with his theory of motion; and Democritus was right with his atomic hypothesis, but for the wrong reasons.

The utility of science is a recurring theme in the collection: science is useful because it can be tested, and its utility, in turn, contributes to its success and advancement—because science is useful for practical matters, more hinges upon its theories being correct, and the more it attracts government funding (and the more useful a project is to science, the more it is worthy of funding: manned space missions, Weinberg maintains, are not useful to science, but the SSC would have been). This marks a point of tension for Weinberg, who wants to tout as the primary utility of particle physics its ability to reveal the simple, fundamental principles of nature to which all other scientific theories ultimately reduce. But, aware that this is not a practical benefit, he resorts to comparing particle physics to war: undertaking it necessitates technological advancements (e.g., in building accelerators), and also may result in unforeseen technological benefits further down the line.

Another recurring theme is the "art" of scientific discovery. Scientists do not know in advance the right questions to ask: these may only become clear right before they are answered. Yet, theoretical physicists have a secret weapon—there are *constraints* that guide them in picking out the correct theories. These constraints include, e.g., symmetry principles, the generalised correspondence principle (that the new theory [approximately] reproduce the successful results of older, established theories in the relevant domains), causality (that future events do not influence past ones), unitarity (that probabilities sum to 1), as well as more technical notions like renormalisability. While mentions of these crop up throughout the book, they reach their fullest exploration in essay 24: the most controversial piece in the collection. Weinberg explains that this essay had not been previously published "because everyone who read it disagreed with it" (vii).

The contention of essay 24 is that art, like science, also benefits from working within particular constraints. There is much to debate in this piece even apart from its main contention (e.g., the suggestion that one of the constraints on successful art is its preserving the successes of the past), but worth mentioning here is Weinberg's assertion that a correct theory of physics can be detected as one that is felt *inevitable*: such a theory not only satisfies the particular constraints imposed, but gives the impression that it is the *only* theory that could satisfy those constraints. This attitude is reflected in Weinberg's frustration with the standard model of particle physics, and with string theory: too many arbitrary parameters. Weinberg explains (in other essays in this collection) that it is the appearance of these arbitrary features that drive particle physicists like himself to search for a deeper, more fundamental theory beyond the standard model. This, however, has not been forthcoming.

Weinberg states that, generally, he only agrees to review a book if he thinks it will give him "a chance to sound off on some issue that interests [him]" (83). Who am I to deny myself the same opportunity? Philosophy may not be testable, but it is nevertheless useful in the quest to understand the natural world. To adopt Weinberg's controversial thesis from essay 24, we might say that philosophy, like art and science, is most often successful when it respects certain constraints—in the case of philosophy, some of these key constraints are provided by our best current scientific theories. This success is not accidental, the way Weinberg paints the success of Democritus' atomic hypothesis, but comes from its being constrained by empirically confirmed theories.

Of greater use to science is philosophy that challenges the constraints that physics imposes upon itself. These constraints are precious: in conjunction with experiment and observation, they guide and arbitrate the development and acceptance of physical theories. They are relied on when novel experimental data is scant or difficult to interpret, providing a glimpse into the fundamental workings of nature, and they can in fact be more reliable than experiment and observation in some cases, as Weinberg nicely explains (196 – 197). For these reasons, it is crucial that the constraints being used in the construction and assessment of any particular theory are appropriate, and well-justified philosophically. The fact that theoretical physics is still stuck trying to find a theory beyond the standard model that satisfies the particular constraints being employed may suggest that the constraints themselves require re-evaluation. Such questions are the right ones for philosophy.