J. D. Trout. *Wondrous Truths: The Improbable Triumph of Modern Science*. Oxford University Press 2016. 258 pp. $31.95 USD (Hardcover ISBN 9780199385072); $19.95 USD (Paperback ISBN 9780190878658).

If the history of philosophy of science, especially its last fifty years, were drawn in broad brush strokes, then two major approaches would supply the fundamental categories. One of them is realism. Though it has numerous variants, the underpinning idea is that science somehow relates to those things that are in the world independent of us. Whether that 'relates' is actually 'corresponds' or 'approximates' or 'correlates' need not concern us now; what matters is that realists are committed to the independent existence of something extra-human and claim that we have some sort of access to it. Defenders or sympathizers of the other major strand argue that regardless of whether there is an independent something, science does not aim at its real description, but seeks instrumentally valuable knowledge, constructing useful models for technical and social application, ordering bits of experience, and so on.

Realists are usually characterized by the following ideas: science is mainly a truth-seeking enterprise, dominated by rational standards and methods. Even though some actual scientists might violate those rules that were carved first by ancient minds and shaped into perfection by early modern scientists, scientific rationality still dictates rule following, and any deviation from that standard should be eliminated. Members of the other camp, however, argue for a different approach. They not merely accept, but also emphasize the role of contingency, social influence, political invasion, and other factors that seem non-rational or even irrational.

Even though some readings of classical figures (such as Kuhn) aim to harmonize the two approaches, realists and constructivists/instrumentalists/antirealists are treated as two sharply separated camps in philosophy of science textbooks. Trout's *Wondrous Truths: The Improbable Triumph of Modern Science* (in a beautifully edited edition) is a nice exception. It offers a grand vision of how to build bridges between these two standpoints.

The book consists of seven chapters. Trout covers some of the major categories and concepts in the philosophy of science, such as explanation, understanding, and inference to the best explanation. The author discusses the biological basis and psychological underpinning of what he calls the 'sense of understanding' (chapter 3): whenever we sense that something is closer to or coherent with our established beliefs and values, we are more likely to regard it as understandable. A certain form of psychological 'fluency' lurks around the concept of explanation as well. Bringing things closer to our field of interests and beliefs makes us fluent in new fields as well, prompting us to accept something as an explanation. Good explanations increase our understanding; the connection is provided by the capacity of our explanations to reach the world.

Trout makes clear in the Preface (ix), and indeed throughout the entire book, that he is a confirmed scientific realist. He constantly talks about the greater accuracy of scientific theories (23), the truth of theories (29), the correctness of decisions in the context of representing the world (33), how the 'world steps in and corrects' our theories (51), 'reliable guide[s] to truth' (74), discovering how the world is (123), 'merely being right' (166.) and so on. Which problems, however, need to be explored in connection with scientific realism? Above all, the problems of *explanation*, *understanding*, *progress* and *discovery*. Though we do not get a detailed theory of explanation, the author provides many clues about how we should see the matter. '[W]hat makes something a good explanation,' writes Trout, 'is a relatively simple affair: an accurate description of the underlying causes that bring about an effect' (115). An explanation is thus something that aims to bring to light the causes that

surround an event; if you are able to detect the real causes, then your explanation will be a good one. However, as Trout emphasizes, explanation and understanding do not always go hand in hand. There are things, such as our embeddedness in a concrete and contingent world (referred to by the author as 'Umwelt') and our cognitive and physical boundaries, that restrict our access to the world *as it is*. Thus, there are explanations that are good since they capture the causes and causal networks of events and still do 'not convey understanding' (139) since we are unable to understand them due to our limited capacities.

This robust distinction between 'truth' on one side and, for example, 'understandability' on the other is a major feature of the book. There are explanations that are good/true but cannot be understood ('[a] good explanation is an accurate one, whether there is a moment when we understand it. But by following its causal deliverances, we may push science along the right track, even without a sense of understanding' (151); and there are theories that are true, but rejected. Then there are theories that are accepted, that seem to work, but still are untrue. For Trout, explaining this is the challenge for realists (46).

In the eyes of Trout, modern science, together with democracy, 'must be counted as the greatest accomplishments of human civilization' (121). Trout also commits himself to the progress of science, although we do not get a clear picture of what progress consists of exactly—'scientific progress is a one-way ratchet' (204). We might plausibly claim, however, that progress involves a certain form of perfection, since 'our best theories are approximately true' (ibid.). How such progress can take place may seem mysterious, given the shortcomings, contingencies and drawbacks that beset scientific discoveries. Trout recognizes that scientists do not always follow the secured path of rationality or scientific rigour. Scientific discoveries are often contingent in the sense that they are the results of 'a hunch, a religious epiphany, a dream, an accident of nature, a peculiarity of a warring culture, a chance meeting, a biological condition, a geographic boundary, and so on' (164). There are many things (spatiotemporal location, financial situation, social relations, vocabulary, experimental equipment, etc.) that have to be set up in the right way in order for scientific work to succeed, but lucky hunches and other accidental and occasionally mystical events may still play a role. (There is an elementary taxonomy of types of contingencies on pages 125-131 and another list of limitation on pages 142-146.)

'[M]ost of the history of science was a false climb' (51), a misconceived enterprise, a knotty line of contingent events that led eventually to the right theories. How is that possible? Trout's answer is almost shamefully direct and simple: the new theories that gave rise to the so-called scientific revolution were simply true: they uncovered the causal structure of the world more successfully than their alternatives. Science did not progress simply because we got more sophisticated equipment, methods, tools and concepts (as Trout frequently reminds us, the celebrated experimental method was used in Asian and Arabian science centuries before it kicked the doors of Western European academies, see 188. ff.), but because finally we got something right. 'The fact that a contingent discovery could move science forward is a testament to the traction of an unconceptualized, unobservable, mind-independent reality' (141), says Trout. He adds that we can explain the theoretical and cognitive significance of contingencies and lucky hunches in the history of science 'if the world is the kind of thing that can push back' (149).

The most interesting chapter (and the most surprising from a realist standpoint) is the sixth, where Trout discusses 'Newton's hunch.' In textbooks, Newton is still too often represented as the knight of the modern experimental method of natural science, who broke with the pseudo-scientific practice of alchemy and thus established from scratch the modern sciences of physics and chemistry. Trout argues that certain features of then-current theories—like corpuscular theory—made possible

the hunches and surprising ideas in Newton that led to the new physics. The author debunks certain myths of textbook-Newton and textbook-Newtonianism (186-189), and thus emphasizes the importance of contingent and non-rational factors in scientific practice.

If Newton's (and actually Boyle's) theoretical hunch were not (or at least not only) a product of deliberate scientific reasoning and a result of painstaking experiments, then why did the resulting theories dominate the scientific community and seduce individual scientists for hundreds of years? '[I]t was roughly accurate enough that it persisted, even flourished, under diverse tests,' writes Trout (185). He continues: 'When a theoretical hunch stands magnificently against the pushes of history, psychology, and culture, there are few other explanations for its triumph but improbable coincidence or fortunate truth. The best explanation for how a hypothesis overcomes psychologically idiosyncratic fluency, culturally parochial commitment, and political ideology is that the guess is accurate' (185). Whether or not this explanation increases our fluency, gives us satisfaction or leaves us with the feeling of disturbance, is a further question of basic commitments.

Although a book with such a comprehensive vision cannot be reduced to a one-dimensional equation, Trout's monograph seems to suggest that scientific progress = contingent and lucky hunches of people at the right place + capturing actually and finally the right causal networks (whatever they may be). Fluent, isn't it?

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