

Review of Nancy Cartwright's *Nature, the Artful Modeler: Lectures on Laws, Science, How Nature Arranges the World and How We Can Arrange It Better*

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Nancy Cartwright's most recent monograph: *Nature, the Artful Modeler: Lectures on Laws, Science, How Nature Arranges the World and How We Can Arrange It Better* presents the state of the art in the philosophy of science literature. Here, we are presented with the most coherent form of Cartwright's views to date, combining building blocks she and other Cartwrightians have meticulously crafted throughout the last decades. We are thus presented with a book containing not only incredibly rich work on a diversity of topics spanning several decades, but also a number of novel ideas that will leave an impact on the philosophy of science in the decades to come.

The book is structured as follows: **Part 1** contains her three Carus Lectures at the American Philosophical Association. **Part 2** offers four additional essays that expand on her arguments in the Carus Lectures. As three of these have been published elsewhere, I will here only focus on the former.

Cartwright has two central goals in mind. Firstly, science does not only create or consist of 'knowledge-that' but also 'knowledge-how'. Science is not an abstract arm-chair activity but instead requires artful modeling/engineering, i.e. the active engagement and knowhow of practicing scientists.

Much of scientific knowledge is context-dependent and implicit in scientific labs and individual scientists. While this recognition does little to

undermine the severity of the replication crisis, it can be considered a substantial causal factor for why it is so hard for scientists to replicate experiments, even when they have full access to the data. Cartwright attributes the unwillingness among philosophers to take this sort of knowledge seriously back to Aristotle's unfortunate distinction between *techné* and *episteme*, i.e. between art, craft, or what we might call engineering and what is considered 'real' or 'genuine' knowledge/wisdom.

Unsurprisingly, the latter has occupied philosophers for centuries, being bound up with the conception of philosophy itself. Cartwright, however, takes this approach to science to be misguided. Her book presents a decidedly anti-Aristotelian alternative that seeks to replace this traditional view of philosophy of science. Contra Aristotle, Plato, and much of the history of philosophy, Cartwright wants to turn *techné* from an inferior representation of nature and reality into the "very best representations of Nature that are possible, human or otherwise" precisely "because this is just what Nature is like" (p. 4).

Cartwright intends this thesis neither as a pragmatic theory of truth nor as one about the limits of human minds, but as a claim about the nature of reality. As such her approach bears some similarities to Weisberg's position on necessary tradeoffs in modeling (see Weisberg 2013). Her 'artful modeler' thesis is twofold, applying to both humans and nature itself. The first component of the *artful modeler thesis* - i.e. that science progresses by building models rather than the discovery of laws - has already received widespread recognition. This is unsurprising, of course, since her previous work is largely responsible for the very creation of this subfield in philosophy of science.

Her main argument relies on an example from physics, as it is here that the 'dogmatism' about the discovery of fundamental principles is most persistent and tied with the equally metaphysical claim that physics studies the *fundamental level of reality* of which all other levels are composed. Discussing Robert Milikan's famous oil-drop experiments, Cartwright insists that there is no simple or straightforward path from theory to experiment, no way in which experiments could simply be 'read off' from the theory. Instead, modeling must be conceived as a craft requiring incredible ingenuity on the part of the scientist.

Cartwright's second goal is more ambitious and intended as an alternative to the supervenience view of nature. This latter view - now the dominant one in philosophy of science - postulates that the basic or fundamental Humean facts determine all the facts. For committed physicalists the physical facts fix all the facts. Higher level features, on the other hand, such as functional traits in biology, or the example of 'slipperiness' suggested by Cartwright, can be multiply realized and, hence, do not determine the arrangement at the lower level. Cartwright argues

that this talk of levels is wishful thinking, a dogma that committed empiricists need not take seriously.

Cartwright's alternative, echoing the title of her book, is to see nature itself as an 'artful modeler'. While I had quite a hard time coming to terms with the notion that nature is a modeler, Cartwright recognizes the dissatisfaction readers may have with her choice of words, elegantly arguing that it is in no way more problematic than the notion that nature is an 'enforcer' of laws or 'does' it by the book. I find it therefore, most useful to treat her *nature as an artful modeler* thesis as metaphor, that albeit hard to digest is simply meant to combat the metaphors of the received view in the philosophy of science. As Dennett (1991) points out, philosophical disputes often involve a *war of metaphors*. That we might be reluctant to switch allegiances and adopt new metaphors comes as no surprise here. After all, we have very much 'grown up' with the metaphors Cartwright attempts to eliminate.

Just as modelers exclude other factors - Cartwright calls this a *nothing-else-rider* - nature, or reality, is a chaotic patchwork which is sometimes ordered such that other factors are excluded which thus enable the activities of actual modelers to be successful. Empiricism, she argues, simply forces us to take scientific practice seriously. If it is artful modeling that explains the success of science, rather than the discovery of laws, then we should adopt a view of nature that corresponds to the role modeling plays in science.

Let me illustrate this idea with an example from a scientific field that is closer to my area of expertise. One of the major questions in biology is how multicellular organisms evolved from free-floating single cells (see Veit 2019). Groups of single cells, just like groups of cooperating humans, can be faced with a tragedy of the commons. If there is a public good, cheats will arise that reap the benefits of cooperation without contributing themselves. Rainey and Kerr (2010) argued that the focus on cooperation in the study of major transitions has been overemphasized. They hypothesized that cheating cells could serve the role of a proto germ-line enabling a life-cycle and hence giving natural selection something to act on. Evolutionary questions such as these have often been merely discussed by theoretical biologists; experimental evolution, however, offers the opportunity to use nature as an artful modeler in the sense Cartwright proposes. Hammerschmidt et al. (2014) aim to explore this hypothesis with a creative experiment that decidedly does not follow any book.

Using the *Pseudomonas fluorescens* wrinkly spreader system, they initially propagated 140 beakers with a *P. fluorescens* population. While the ancestral population of these single-cell prokaryotes floats individually within the broth, mutations quickly occur within them leading to a new phenotype that produces cell-cell glue. Under normal conditions these cells have a lower fitness than their

smooth counterparts. Due to the adhesive, daughter cells are unable to detach themselves from their parents, suffering the costs of glue-production and a life in close proximity. However, though non-buoyant, these groups are able to attach themselves at the wall of the beaker, taking over the interface between broth and air. This allows them to reap the benefits of access to oxygen by contributing to this public good, taking over the entire surface. Counter-intuitively, a cheat-embracing life-cycle (in which smooth cells served as propagules) achieved a higher fitness for the ‘group’ than a cheat-purging regime.

Nothing in this experiment could have followed from following the book. In the very same way as the experimental set-up required artful modeling, so did nature itself ‘arrange’ the right conditions for the first steps towards multicellularity. In the biological sciences, Cartwright’s conclusions will fall on warm and fertile ground, indeed, they offer a rich number of possible case studies that would support her *artful modeler thesis*. Modeling needs to be seen as akin to something like ‘plumbing’ (cf. Veit 2020) – fully embracing and appreciating the messy, context-sensitive, and artful nature of its craft.

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