

In Search of Mechanisms, by Carl F. Craver and Lindley Darden, 2013, The University of Chicago Press.

The voluminous writing on mechanisms of the past decade or two has focused on explanation and causation. At its center have been such questions as: what is mechanistic explanation? Is it distinct from, and can it supplant, law-based explanations? Can mechanisms ground an account of causation? Is all explanation and/or causation mechanistic? Is biology, or other sciences of complex systems, inherently or especially mechanistic?

But the current mechanistic school of thought grew out of thinking about scientific discovery to an extent that matches, and perhaps even surpasses, its engagement with causal explanation (Bechtel & Richardson, 1993; Darden, 1991, 2006; Schaffner, 1993). In their recent book, Carl F. Craver and Lindley Darden return to this wellspring of the mechanistic philosophy, offering a broad-ranging survey of the ways in which mechanisms are uncovered, represented and confirmed. They do so in a relatively short and highly accessible text, rich in historical examples and lean on philosophical polemics -- a text that is explicitly intended for the biologist as well as the philosopher, and that should be of interest to both..

Those who are well-versed in the literature on mechanisms, and in Craver and Darden's work in particular, will be broadly familiar with the central themes of this volume. The authors draw extensively on their previous writing and on others in the mechanist camp. This is true for many of the abstract philosophical claims they make, and for some of the case studies and examples as well. Similarly, those who seek a restatement of their outlook, in light of nearly 15 years of intense discussion, or a detailed response to various ongoing debates concerning the new mechanistic philosophy, are likely to be disappointed. Craver and Darden place a premium on synthesis rather than innovation and on articulating a positive agenda, rather than defending themselves against criticism.

The long shadow of logical positivism

Even today, writing about scientific discovery still occurs, at least in part, against the backdrop of Hans Reichenbach's famous distinction between the context of discovery and the context of justification. Indeed, one way of reading "In Search of Mechanisms" is as an extended argument against Reichenbach's contention that "epistemology cannot be concerned with [discovery] but only with [justification]" (1938, 382). It is an argument by illustration: starting from the assumption that biologists are in the business of elucidating the mechanisms of life, Craver and Darden articulate strategies of discovery and description that are fit for that task. That is: starting from a view about what justifies scientific theories (roughly, that they adequately describe underlying components and their interactions) they arrive at a view about how such theories can be discovered (roughly, via strategies for identifying components and patterns of organization, and for testing whether their interactions give rise to the target phenomenon).

One upshot of a resistance to the Reichenbachian conception is the potential for linking the philosophy of science quite closely to concrete aspects of its practice – especially to past episodes of discovery. This link is key to “In Search of Mechanisms”. Craver and Darden discuss classical historical episodes, such as Harvey’s discovery of the function of the heart, or Loewi’s proof that neuromuscular synapses operate chemically, through a variety of more recent cases drawn from molecular genetics, cellular neurophysiology, evolutionary theory, marine ecology and other areas. They utilize such examples to illustrate how real-world processes of discovery are shaped by their desired product – mechanistic explanations.

Is an argument against Reichenbach’s distinction still needed in 2014? I think the answer is ‘yes’. Although fewer philosophers now explicitly endorse the distinction, or the focus on logic in which it was embedded, it still greatly influences the landscape of contemporary philosophy of science – including the ways in which central questions are conceived and the types of answers that tend to be put forward. However, Craver and Darden’s book has value independently of Reichenbach and the history of the field. The connections they describe between mechanisms and discovery are interesting and significant in their own right.

Overview of content

Craver and Darden set out (in Chapter 2) by providing a characterization of the notion of mechanism, and its guiding role in science. Here they stay very close to earlier material, including their well-known “entities and activities” formulation (Machamer, Darden & Craver, 2000). Whether this formulation covers, for instance, the mechanism of evolution by natural selection or the processes studied by populational sciences more generally, is something that has been disputed (Milstein and Skipper, 2005). They seem here to take a pretty expansive view of what mechanisms are. Regarding its application to natural selection as a terminological choice, or at any rate as an uninteresting matter, they suggest that “a perhaps more fruitful topic is the evolution of mechanisms themselves” (p. 28). In this spirit they discuss natural selection as a mechanism at various points in the book. In one way this is a perfectly reasonable attitude, but as I remark below, it tends to weaken the overall “bite” of the mechanistic picture, in general and as it applies to discovery too.

Chapter 3 discusses models (or schemas) of mechanisms, and distinguishes several dimensions along which they may vary: completeness, specificity, plausibility and scope. In reverse order: Scope concerns the range of (actual) phenomena to which a model applies, while plausibility pertains to how well-supported the model’s claims are. Completeness and specificity are similar, in that both concern the amount of detail the model contains. But an incomplete model is one for which the knowledge needed for filling in missing detail is lacking, at least in part. An abstract (i.e. non-specific) model is born of choice, and its amount of detail varies considerably with

context – depending on the explanatory and/or predictive aims, representational tools and related questions.

On this basis, the discussion moves on (in chapter 4) to the characterization of phenomena, i.e. to a discussion of the kinds of information and experimentation that are needed before a to-be-mechanistically-explained phenomenon is “ready” for explanation. To have a good sense of what kind of explanation would be satisfactory, they argue, one does best to have a good grip on what triggers and inhibits the phenomenon, as well as other experimentally-derived information such as its modulating conditions and how it behaves under unusual (“non-standard”) conditions. Here, Craver and Darden understand the notion of a phenomenon very broadly – it can be a recurring pattern or a one-off event; it can be a proper (selected-effect) function or not; it can be very local and narrowly circumscribed or highly general. They also provide a useful discussion of ways in which a phenomenon may get mischaracterized, forestalling its explanation.

Chapters 5-7 are closely related, and constitute the heart of the book. In it, Craver and Darden flesh out the search for mechanisms per se: they discuss strategies for constructing mechanistic models (such as localization, backward/forward chaining and modular subassembly); methods and tests for evaluating whether a mechanistic model, once constructed, is adequate (given the criteria outlined earlier in the book); and – via an extended discussion of Harvey’s discovery of the circulation of the blood – ways in which information about one part or aspect of a mechanism constrains further theorizing about it. It is hard to give a quick summary of this portion of the book, as it is very rich and engages with a lot of science. It details specific discovery strategies and illustrates them convincingly. Anyone who wants to understand the mechanistic program in depth would benefit from paying close attention to these chapters. That said, here as elsewhere, much of the material is drawn from the authors’ earlier work, such as Darden’s 2006 book “Reasoning in Biological Discoveries” – which contains several articles written jointly with Craver – and of other authors in the mechanistic camp (especially Bechtel and Richardson, 1993). Although the ideas are here synthesized and brought together in an illuminating way, few of the specific claims will be new to those who keep a close eye on the philosophy of mechanisms.

The final portion of the book – Chapters 8-11 – discusses the “solidification”, so to speak, of mechanistic knowledge. This consists of experiments for testing whether a constructed mechanism schema is adequate, strategies for revising deficient schemas, and, finally the integration of mechanistic knowledge across different disciplines, summarizing the “mosaic” vision that is expressed more fully in Darden’s work on interfiled integration (Darden, 2006) and in the closing chapter of (Craver, 2007). In this vision, scientific unity is achieved via mutual constraining efforts, by different fields, in the exploration of focal mechanisms.

A penultimate chapter (the final chapter is primarily a summary) discusses “the pragmatic value of knowing how something works”. The central points here are incontestable – to know how something works, i.e. to know the underlying mechanism, allows one to predict and/or control its

behavior, a highly valuable sort of knowledge. But it is doubtful whether this merits a full chapter's worth of discussion (most of which is indeed occupied by a description of cases of mechanistic knowledge based control). However, this chapter does achieve a kind of closure, reminding the reader that the mechanistic outlook is a pragmatic, practice-oriented philosophy. Throughout the book claims of a normative character are made, implicitly and explicitly – claims about how science ought to be done. But such claims are based on a close attention to actual scientific work, aiming to distill the factors underlying its successes and failures.

Concluding remarks

One question that has accompanied the mechanistic view from its outset concerns scope. On the one hand, as remarked earlier, Craver and Darden (and others, too) understand the central categories – first and foremost, ‘mechanism’ itself – very broadly. They also tend to contrast their view with highly general views about science, such as those of the logical empiricists. This suggests that thinking in terms of mechanisms is meant to give us a total view about science – or at least about explanation and discovery. On the other hand, the mechanists often overtly restrict their claims, presenting them as applying primarily in biology (Cf. the subtitle of “In Search of Mechanisms” – “Discoveries across the Life Sciences”). Furthermore, many of the claims they make seem to pertain to a certain class of causal systems – internally heterogeneous, decomposable systems, i.e. ones in which parts play different roles and understanding requires “looking under the hood”. It is unclear how, for instance, strategies of discovery in the spirit of localization or forward/backward chaining apply beyond this class, to processes such as evolution by natural selection or to aggregative, statistical phenomena outside the life sciences. The ambiguity regarding scope is not unique to this book. But it is not resolved in it either. It would be an interesting exercise to figure out if the claims made by Darden and Craver require modification, and if so how, when applied outside the areas of the life sciences to which they devote their attention.

Overall, Craver and Darden offer a wide-ranging and engaging synthesis of the conceptual and methodological foundations of mechanism discovery in biology. For aficionados of Mechanism, there is not a whole lot of novel material here, but the synthetic scope of the book is impressive. Moreover, the topics it addresses – discovery and its connection to justification – are important and still fairly peripheral within philosophy of science. If received as seriously as it ought to be, this book can propel its subject matter into the center of philosophical discussions of biology and of science more generally.

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