

Understanding mechanistic research

Carl F. Craver and Lindley Darden: In search of mechanisms—discoveries across the life sciences. Chicago: The University of Chicago Press, 2013, xxii+228pp, \$25.00 PB

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The professionalization of science is a recent phenomenon. Before the mid-1800s, investigations of the natural world were largely performed by those hobbyists who had the leisure time to do so. Things are very different today. Open one of the over twenty thousand scientific journals currently in circulation, and you would be hard pressed to decipher the technical prose, much less the methodological and conceptual strategies being employed. This is changing, however. People are not only taking greater interest in how science works, but choosing to actively participate in the process, whether this involves discovering new protein configurations (Foldit), identifying and categorizing cancer cells from tissue samples (Cell slider), or analyzing the vocalizations of canids (the Canid Howl Project).

Why start a review on what might seem like an academic book in contemporary philosophy of biology with a discussion of citizen science? Craver and Darden's book, *In Search of Mechanisms*, is positioned to have an impact in precisely such an area. Biologists and medical researchers invest an enormous amount of time and resources into discovering mechanisms, from determining how an ecosystem undergoes eutrophication to the genetics of cystic fibrosis. Of course, this is not news to either the scientist or the philosopher. Indeed, Craver and Darden have played a key role in shifting the attention of philosophers to mechanisms over the last decade. The literature on mechanisms in philosophy of science is now vast and for good reason: If we want to understand how the majority of biological research is done today, we have to understand how scientists reason about mechanisms. Unlike past work, however, Craver and Darden's central aim in this book is not to contribute to the philosophical literature (although they do this too), but rather to share the findings of recent years with a broader audience.

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The audience for this book is anyone who would benefit from understanding the strategies by which researchers discover mechanisms. This includes scientists, students of science, and citizen scientists. Craver and Darden describe successful strategies for discovering mechanisms, as well as how to approach common problems and puzzles. This is a methods and reasoning handbook for the scientific researcher. The audience also includes philosophers and historians. Craver and Darden provide a resource for understanding the complex and varied episodes that one encounters in science and how to fit them in a broader descriptive and normative framework. More generally, this book would appeal to anyone who has wondered how something works and the best strategies for figuring that out.

Given the broad utility of Craver and Darden's book, it is surprising that it falls within a genre that is virtually nonexistent in contemporary academia. The book has the clarity and instructiveness of a textbook: It avoids specialist jargon and disciplinary controversies in order to serve as a field guide for the non-specialist. However, unlike a scientific textbook, it draws on years of philosophical and historical work in order to provide an account of biological research that is not limited to a particular field or point of view. Craver and Darden do this intentionally, recognizing the value of cross-disciplinary work and wanting to provide a meta-level perspective from which one can engage in such work.

Moving to the main content of the book: How does one go about discovering mechanisms? After introducing the book's aims in Chapter 1, Craver and Darden provide an account of mechanisms (Chapter 2) and the various means that researchers use for describing them (Chapter 3). A mechanism is an organized collection of entities and activities responsible for a phenomenon (i.e., the thing that a mechanism does or produces). The phenomenon of protein synthesis, for example, is produced by the reading (activity) of DNA by RNA polymerase (entities) within the nucleus (organization), among many other things. The tools that researchers use for describing mechanisms range from visual diagrams to mathematical models, and these descriptions vary in their grain and scope depending on the goals of research. Craver and Darden go on to describe the processes by which mechanisms are discovered. These can be categorized into three general stages: characterizing the phenomenon for which a mechanism is being sought, proposing mechanisms capable of producing that phenomenon, and evaluating and revising those mechanisms until there is agreement on the actual process in effect. It is in these chapters that the rich content of the discovery process is introduced. Chapter 4 describes the way in which a phenomenon can be picked out and its role in shaping the discovery process. Chapters 5 and 6 introduce strategies for developing models of mechanisms and criteria for evaluating them. Chapters 7 and 8 describe how one can improve one's model through the tinkering of real-world mechanisms and how the results of these interventions constrain the possible entities, activities, and organization under consideration. Chapter 9 introduces anomalies commonly encountered in research and strategies for resolving them.

The book closes with a discussion of how mechanistic reasoning facilitates the integration of research across a wide range of disciplines and the value of understanding such research. For Craver and Darden, the world is immensely complex and different fields provide different perspectives on this world. However,

there are various strategies that researchers can employ in order to integrate findings that differ in their focus and vocabulary. Such strategies are the focus of Chapter 10. Lastly, Chapter 11 illustrates the great power that mechanistic knowledge gives us in the form of new ways of predicting and controlling the world. Knowledge of mechanisms comes hand in hand with knowledge of how to manipulate those mechanisms with predictable results. This practical knowledge serves as a foundation for humanitarian and conservation projects like those found in medicine and wildlife restoration, but it also brings with it the weighty responsibility of determining and avoiding the many harmful ends for which such knowledge might be employed.

In Search of Mechanisms provides a unique and accessible contribution to both studies of science and science itself. Like scientists' knowledge of mechanisms, our knowledge of science is constantly being updated; this is by no means the final or only account of biological research. Nevertheless, Craver and Darden do not linger on existing disagreements and controversies, focusing instead on developing a toolkit of research strategies that can be understood and applied by the scientist and non-scientist alike. The fact that this book belongs in a genre of literature unfamiliar to most may lead some to criticize it for not being what it does not aim to be. My hope is that instead its utility will be recognized and inspire other philosophers to communicate their findings to a broader audience. Such recognition has already come in the form of Craver and Darden's book being chosen as one of the top 25 Outstanding Academic Titles of 2014. The time is right for this gap in the literature to be filled and this book provides an excellent start.