New Perspectives on Reductionism in Biology

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Marie I. Kaiser, ***Reductive Explanation in the Biological Sciences***. Cham: Springer (2015), xi+277 pp., $129.00 (cloth).

Reductive explanations are psychologically seductive; when given two explanations, people prefer the one that refers to lower-level components or processes to account for the phenomena under consideration even when information about these lower levels is irrelevant (Hopkins, Weisberg, and Taylor 2016). Maybe individuals assume that a reductive explanation is what a scientific explanation should look like (e.g., neuroscience should explain psychology) or presume that information about lower-level components or processes is more explanatory (e.g., molecular detail explains better than anatomical detail). Philosophers have been analyzing reduction for more than half a century (Hüttemann and Love 2016), but neither of these possibilities is a consensus view (even if psychologically applicable). Instead, there is widespread agreement that the landscape of reductionism is complicated, especially in biology (Brigandt and Love 2017). Increasing scrutiny of actual practices within biology and other sciences has often provoked the questions (paraphrasing Alasdair MacIntyre): Whose explanation? Which reductionism? Marie Kaiser's book—*Reductive Explanation in the Biological Sciences*—is a decisive intervention into these discussions, offering a wealth of helpful distinctions and new analyses with a healthy focus on scientific practices of explanation.

Perhaps the most incisive contribution in Kaiser's book is its discussion of metaphilosophical questions (chaps. 1 and 2). Before evaluating different pro-

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posals, she concentrates on standards for what constitutes a good account of reductive explanation. Since biologists use reductive explanations (and methods) regularly (although not exclusively) in practice, philosophers need a set of standards for identifying exemplars, assessing their characteristics, and deciding on their merits. The result is a map of where different accounts of reductive explanation can be located on the basis of whether specific criteria of adequacy are applicable and whether they are satisfied.

The first of these criteria is descriptive adequacy: an account of reductive explanation should capture actual cases (successful or not) in contemporary biological research. This is a project about reduction *in practice*, not reduction *in principle*. It moves from the scrutiny of concrete practices to generalizations, rather than testing general claims against examples from biology. Kaiser situates this criterion broadly within a naturalistic approach to philosophical analysis (i.e., akin to scientific theories, one must at least "save the phenomena"). However, she is sensitive to the complexity of what counts as data in these cases; what scientists say and do can come apart and therefore both must be analyzed. While resisting a normative orientation that uses criteria such as accounting for intuitions or metaphysical suitability, Kaiser also eschews a purely descriptive orientation. Philosophical analyses of reductive explanation should involve normative dimensions that assist in the selection, interpretation, and evaluation of sometimes conflicting scientific practices. For Kaiser, paradigmatic and important explanatory practices should be analyzed to make their implicit assumptions explicit, and divergent practices must be reconciled into a unified perspective (either across sciences or in terms of wide applicability).

In this metaphilosophical terrain, the justification for these norms looms large. What counts as paradigmatic or important? What are the presumed standards of unity? Kaiser takes coherence considerations that yield generality to be part and parcel of a philosophical account. Why? What if different biological approaches successfully offer reductive explanations that are mutually inconsistent? Could the inconsistency be pertinent to their success and captured as such via the descriptive adequacy criterion? Kaiser's second criterion of adequacy offers a partial answer by attempting to balance specificity and generality methodologically: "an account of reduction in biology is adequate only if it captures the *diversity* of the cases of reduction that are present in contemporary biology, but is nevertheless *coherent* and as *universal* as possible" [25]). It is unclear why an account of reduction could not be adequate in capturing some but not all of the diversity. We can readily admit the philosophical aim of seeking to understand how things "hang together," but the discovery that they do not is an achievement in its own right.

Additionally, why favor "as universal as possible"? Kaiser misreads an earlier discussion of mine in support of her view (Love 2008). I agree that overly general and abstract philosophical accounts of science often lose contact with

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actual scientific practice. However, I do not concur that "the more particular or non-universal . . . a philosophical account is the greater is the danger that it is not philosophically interesting or even loses its status as being 'philosophical' at all" (26). A more particular or nonuniversal account might be significant because it accurately captures what is going on in an area of science or reveals unexpected features of the reasoning. If one worries about whether this is "philosophical," then it is probably time to step back and ask why. The desire for analyses that are as universal as possible is (in part) a contingent characteristic of twentieth-century professionalized philosophy (Doyle 2014), something Wittgenstein labeled "our craving for generality" (1965, 17).

Kaiser is aware that pluralist philosophers of science will take umbrage here. She is happy to be pluralist in the minimal sense that "different elements in different scientific fields" require accounts that often turn out to be nonuniversal in character. Her line in the sand is when the same element within a single scientific field receives different (adequate) philosophical analyses: "it remains just too unclear why and under which conditions the incoherency (or even inconsistency) between different philosophical accounts of the same subject is a proper multiplicity that should be sustained and does not represent a deficiency in philosophical knowledge that needs to be eliminated" (27). While I agree that specifying these conditions is necessary, I am skeptical about the assumptions involved in what counts as a "deficiency in philosophical knowledge." However, the more urgent concern for Kaiser is how one could be a pluralist in this minimal sense in light of her standards: "philosophers must develop theories that are coherent and general" (25). This takes on heightened importance because the final two criteria of adequacy—"norm-normativity" (specifying how reductions relate to epistemic and social norms) and potential usefulness (to scientific practice or broader society)—could constrain accounts of reductive explanation significantly. For example, having a criterion on accounts of reductive explanation that involves realizing social norms might narrow their generality.

Chapter 3 will be familiar ground for many philosophers. Kaiser astutely reviews the standard terrain in discussions of reduction to draw four lessons: (1) understand what reduction is (both the relation itself and its purported relata) before taking a stand for or against it; (2) if oriented around scientific practice, epistemology (inclusive of methodology) takes priority over ontology; (3) specify the notion of reduction in view (ontological, theory, explanatory, methodological); and (4) let Nagel's model of theory reduction rest in peace. Not all of these are original, and some are contentious (Sarkar 2015). The third lesson gives Kaiser the opportunity to justify her choice of analyzing explanations rather than methods or theories (although not convincingly, in my estimation). Yet what is illuminating here are the navigational tools. In characterizing what a reduction is, one can ask whether it is in practice or in principle eliminative or retentive. What is the scope? What is the locus? Is

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there more than one "fundamental" level in view for a reductive explanation? These could help to prevent unproductive debates cast as "reductionism versus anti-reductionism." However, Kaiser thinks ontological issues must not be neglected. For example, we should be more aware of the divergence between philosophers of biology and philosophers of mind on what is in view ontologically (token physicalism vs. type physicalism, respectively).

Chapter 4 is stage setting for Kaiser in the form of canvassing two broad approaches to explanatory reduction. One relates a higher-level explanation to a lower-level explanation (Rosenberg 2006); the other relates parts and wholes within an individual explanation (Sarkar 1998; Hüttemann and Love 2011). This clarifies her own approach as a version of relating parts and wholes in individual explanations and showcases the navigational tools of chapter 3. The authors that come in for criticism will have qualms. Kaiser criticizes my claim that temporality is an aspect of reductive explanations by claiming that temporality is not a determinant of whether an explanation is reductive (126). This misses the fact that temporality is necessary for distinguishing two different types of reductive explanations: causal claims about parts explaining the behavior of wholes and compositional claims about parts explaining properties of wholes by virtue of constitution. Regardless, the different views are treated charitably and substantively, and many of the criticisms hit their mark (e.g., her worry about ambiguities in how fundamentality is construed in my own account).

In chapter 5, Kaiser starts by characterizing the notion of "ontic" in her account of explanatory reduction. She distinguishes two forms of ontic explanation: a strong form where explanations are entities that exist in the causal structure of the world and a weak form where explanations are true or accurate descriptions or representations of that causal structure. Although she thinks both perspectives are coherent, Kaiser favors the weak form because the strong form's exclusive focus on explanations as things in the world is unmotivated, falsely assumes that concentrating on explanations as accurate representations is inherently subjective, and completely severs explanation from understanding.

Next Kaiser turns to exploring whether and how commitments about explanation impinge on different views about reduction with the aim of remaining neutral (where possible). She identifies a defining commitment in reductive explanation to lower levels being explanatorily prior. Since representing phenomena "at" levels depends on the context of inquiry, one might worry that relating them to one another reductively in explanations is somehow subjective. Kaiser urges that we interpret claims of reduction in explanations as intersubjective and transdisciplinary because scientists choose among different types of explanation (causal, etiological, topological, historical) with different but objective representational requirements on how relations of reduction are explanatorily relevant. This yields a form of explanatory pluralism that permits

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different kinds of phenomena to be reductively explained in different ways and even the same kind of phenomena to be reductively explained (or not) in different ways. Thus, there is not a uniquely correct level of explanation, and Kaiser is agnostic about whether different reductive explanations of the same phenomena are incompatible and cannot be unified into a single explanatory picture (Mitchell 2003).

The culmination of Kaiser's analysis is chapter 6, where we get the details of her ontic account of explanatory reduction. Two concepts are central—biological parthood and levels of organization—and both receive formal articulation. Space precludes working through them in full detail, but we can see their significance in broad outline. Biological parthood has three conditions: spatial inclusion, temporal inclusion, and relevance. The first uses the notion of a natural boundary to cash out what it means for a part to be located "inside" a system. The second is a requirement that a part operates in the temporal interval of a process pertinent to a system's behavior. The third adds the stipulation that a part must not only be present and operate but also make a difference. Natural boundaries are important to this characterization despite spatial inclusion not being a necessary condition of biological parthood. Although Kaiser appeals to "common paradigmatic examples," such as cell membranes, these examples could be dissected in more detail and might yield significant insights. For instance, the extracellular matrix lies outside the cell but is responsible for structurally supporting cells and conveying interactions across the cell membrane (Frantz, Stewart, and Weaver 2010). The capacity of cell receptors (biological parts) to respond to molecular signals can be modulated by changes in the tension of the extracellular matrix.

For Kaiser, levels of organization are defined relationally ("Object *X* is located on a lower level than object *Y*") by biological parthood and membership in a general biological kind. The latter requirement is intended to avoid characterizing levels in an overly restricted fashion, such as only for a particular compositional hierarchy of a mechanism (Craver 2007, chap. 5). It permits the multifunctionality of parts at levels (i.e., they are not defined solely as components of one mechanism for a particular behavior) and distinguishing boundaries of mechanisms from natural boundaries (since the two often do not coincide). Although scientists sometimes do appeal to levels of organization more broadly than as locally circumscribed hierarchical features of a mechanism, it is less clear that there is consensus about "a single level on which all molecules are located" (185), in part because levels are characterized diversely across different investigative contexts (Brooks 2017). Since Kaiser's idea of kind membership is not analyzed in depth, further work is needed to characterize this more global account of levels.

With biological parthood and levels of organization formally defined, Kaiser fleshes out three criteria for reductive explanations. They must (1) rely only on factors at a lower level than the system being explained, (2) appeal only to

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biological parts ("internal") of the system, and (3) represent each part as if it were isolated from its original context. These three criteria are illustrated with a rich set of examples from different areas of biology (e.g., biomedicine, community ecology, developmental biology, molecular biology, physiology), although they are drawn primarily from "scrubbed" textbook contexts. I think they do reveal elements of explanatory practice but ignore others that are critical, such as how mechanism diagrams are constructed (Sheredos et al. 2013). Kaiser's metaphysical commitments also appear between the lines of explanatory practice: "do we really want to say that the organism causally affects its parts? I doubt this" (194). While Kaiser may find this unappealing, it is not obviously true and enough to start a bar fight among philosophers and scientists analyzing causality in biological systems. And, similar to above, whether the molecular level is *the* fundamental level of reductive explanations in biology is subject to worries about whether most biologists in practice conceptualize a single fundamental level.

The second criterion on reductive explanations picks out the significance of focusing on internal factors. Biological parthood underwrites this focus. Kaiser illustrates the criterion negatively by showing how it fails in the case of protein folding, which requires an appeal to external molecular factors, and positively by how it accounts for the intentional simplification or ignoring of context in explanations of signaling pathways. The third criterion requiring that each part be represented in isolation, which Kaiser takes to be necessary, may sound implausible since it is widely acknowledged that "what the protein does is defined by context" (Kirschner 2005, 503). However, Kaiser's thesis is subtle because it does not mean parts in isolation from any context but rather in isolation from the original context. The properties of the parts appealed to as explanatory must be studied in different contexts, which includes modifications of the original context (e.g., additions or subtractions) or in vitro conditions. This means these properties need not be intrinsic, only stable under some set of contextual variations. Importantly, Kaiser is seeking a defensible set of criteria that do not stack the deck for or against reductionism as a broader philosophical position. If this third criterion seems too strong or too weak, this may say more about one's native philosophical inclinations than her formulation of it.

In summary, Kaiser's analysis of reductive explanations in biology is a major contribution and repays reading at multiple levels. I have engaged with a number of its key ideas but have ignored many others (e.g., comparisons of mechanistic explanation and reductive explanation). Each chapter can be tackled relatively independently, which is extremely helpful given the vast and variegated analytical landscape that Kaiser works on throughout the book. Inevitably, this leads to some redundancy, but it also displays a deep systematicity in Kaiser's discussions. Her account of reductive explanation should become a touchstone for future analyses of reductionism in biology. This is not be-

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cause everyone will agree but because the theses and their criteria of adequacy are sufficiently detailed and developed to engage with in fruitful ways. In this sense, it is an exemplar of how to philosophically investigate biology and an achievement worthy of emulation.

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