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# ESSAYS IN THE PHILOSOPHY OF CHEMISTRY

## ERIC SCERRI AND GRANT FISHER (*EDS*)

Reviewed by Julia Bursten

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### *Essays in the Philosophy of Chemistry*

Eric Scerri and Grant Fisher (*eds*)

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Eric Scerri and Grant Fisher's edited volume, *Essays in the Philosophy of Chemistry* boasts a variety of insightful perspectives on the application of philosophy of science to issues of chemical interest and the application of chemistry to broader debates in philosophy of science. The division of the collection's sixteen essays into their respective sections is occasionally puzzling, and in a few cases a potential for scholarly dialogue between essays is diminished as a result. So, while there are standout contributions in each section, which are discussed in more detail below, the whole does not transcend the sum of its parts.

The essays are subdivided into four sections: 'History and Philosophy of Chemistry', 'Reduction and Explanation', 'Metaphysical Issues', and 'Theory and Practice'. Of these, 'History and Philosophy of Chemistry' coheres most strongly. Its three essays all focus on revolutionary periods in the history of chemistry, specifically the late scientific, chemical, and quantum revolutions, and each approaches its case through historical and historiographical details on the way to a philosophical analysis of an aspect of chemistry's development as a discipline. Alan Chalmers develops a rigorous study of Robert Boyle's atomistic philosophy

during the late scientific revolution. Nicholas Best's analysis, 'What Was Revolutionary about the Chemical Revolution?' is an especially careful and thought-provoking perspective on the titular question. Best argues that Lavoisier's move from a small, fixed number of chemical principles to an open-ended list of simple substances generated the fundamental conceptual shift of the chemical revolution, and he supplements this analysis with an engaging discussion of the linguistic shifts that accompanied this change.

The section on reduction and explanation immediately follows the historical section, and in the crossover an opportunity is lost. The final historical essay, Kostas Gavroglu and Ana Simões's 'Philosophical Issues in (Sub)Disciplinary Contexts: The Case of Quantum Chemistry', addresses inter-theory reduction during the quantum chemical revolution and generates a perceptive assessment of the historical situation. They claim that the project of reduction is a tool of physics that is inappropriate to apply in the pursuit of chemical ends. Their evaluation, which is a fresh and historically anchored take on the perennial question of chemistry's relation to physics, is not discussed in any of the essays in the ensuing section. Instead, the reduction and explanation section juxtaposes two essays on supervenience with contributions on the periodic table, chemical education, and reaction mechanisms.

This section is a weak point in the collection. The loose weave of the threads of reduction and explanation hardly hang the contributions together, and each might have found its target audience more readily in a different specialty journal. The supervenience essays, the first by Jean-Pierre Llored and Marina Banchetti-Robino and the second by Lee McIntyre, each take up an analogy between Jaegwon Kim's analysis of mental causation relative to physical causation and the relation between laws in chemistry and laws in physics. While the analogy holds, it is unclear what discussion its acknowledgement is meant to advance, since the field has widely acknowledged the difference in kind between chemical and physical law. Of the remaining essays in the section, Scerri's article is a retrospective of his own account of the relation of the periodic table to its quantum-chemical basis, in which he defends reductionism against his former account. Noretta Koertge's essay, 'Contingencies in Chemical Explanation', is a high point in the section for its perspective on the pedagogical losses that would be incurred by a reduction of chemical theory to physical theory in pre-collegiate educational settings. Finally, chemist Richard Pagni's study of the notion of a reaction mechanism runs that concept up against a variety of high-profile ideas from general philosophy of science in order to develop an account of what a reaction mechanism is. He considers both Glennan's ([1996]) and Machamer, Darden, and Craver's ([2000]) accounts of mechanism as applicable to reaction mechanisms; the project of evaluating mechanistic models of reactions according to explanatory power; and the question of whether reaction mechanisms are falsifiable. Surprisingly, he gives only the barest lip service to extant philosophical theories of reaction mechanisms, such as Mark Goodwin's ([2011]) sophisticated account of the conceptual and explanatory role of reaction mechanisms in organic chemistry, which is an unfortunate oversight, since it would have provided a more apt foil for Pagni's discussion than those he highlights from general philosophy of science.

The next section, 'Metaphysical Issues', contains four chapters and, overall, is more successful. As with the previous section, though, there were missed opportunities for productive discussion among the individual essays. The section contains three case studies in the chemical perspective on issues in general philosophy of science: causation, realism, and natural kinds. The remaining essay in the section, chemist Joseph Earley's 'How Properties Hold Together in Substances', takes a more naturalistic approach to chemical metaphysics by generating a taxonomy of chemical properties on the way to a philosophically and historically informed metaphysics of chemistry. Earley articulates three kinds of chemical properties and four historically informed modes of closure among relations of chemical properties and concepts in chemical theory. This essay reads

like a prospectus for a monograph on Earley's own metaphysics of chemistry, one that would make a welcome contribution to the field.

In 'Causality in Chemistry', Rom Harré considers what notions of cause operate in the context of chemical sciences. Hasok Chang's 'Scientific Realism and Chemistry' is a gauzily veiled tutorial in Chang's particular brand of realism, which he calls 'active realism' and ties to his notion of epistemic pluralism. Chang walks readers through his discontent with various contemporary theories of realism and offers characteristically witty correctives to Ian Hacking's ([1983]) and Stathis Psillos' ([1999]) accounts (for example, on Hacking's entity realism: 'You may be able to spray something without knowing much about what it is that you're spraying', p. 243). These discussions give way to a summary of active realism, which is drawn from Chang's pluralistic account of the history of chemical theory and practice. The chapter is welcome for its succinct overview of Chang's position in the realism debate and his explanation of how chemistry contributes to his view, but the emphasis is certainly on the former, rather than the latter, subject in the title. Finally, Robin Hendry's 'Natural Kinds in Chemistry' provides a useful primer on the historical trajectory and present state of that subject, detailing both the connection to the causal-baptism theory of naming and the debate within philosophy of chemistry between microstructural and macroscopic conceptions of a substance. This chapter should find a happy home in philosophy of science syllabi and reading lists looking to include connections between chemistry and broader philosophical issues, and it is an approachable article that introduces readers to the view of chemical kinds found throughout Hendry's oeuvre.

The collection's final section, dubbed 'Theory and Practice', begins with Hinne Hettema's essay, 'Chemistry and "The Theoretician's Dilemma"'. As one would expect from such a title, the essay considers theoretical objects in chemistry. The dilemma Hettema uses to motivate his chapter—namely, Hempel's ([1958]) worry about the eliminability of theoretical terms—is more epistemological than it is metaphysical, which nominally distinguishes it from the metaphysical concerns of the previous section. However, Hettema's essay is primarily targeted at the metaphysical end of the range of problems that arise from the dilemma, particularly at those issues surrounding the ontological status of theoretical objects. His central concern is with the notion of a chemical object, and his main claim, developed through a series of fascinating case studies, is that theoretical and conceptual objects in chemistry stand in a plurality of grounding relationships to the target systems they aim to represent and describe. As such, the chapter is more closely aligned with Chang's epistemic pluralism and active realism projects, and with the concerns of the metaphysical issues section more broadly, than with the other contributions in the 'Theory and Practice'.

In the next essay, chemist Guillermo Restreppo applies Mary Jo Nye's ([1993]) criteria for the demarcation of a discipline to mathematical chemistry, successfully arguing that it constitutes a discipline unto itself. Rein Vihalemm's posthumously published treatise on the scientific character of chemistry is thought-provoking and a fitting legacy. It pairs well with Restreppo's article, though its reflections on the relation between physics and chemistry would have been better complemented by Gavroglu and Simões's and Koertge's essays than Hettema's and Fisher's.

Fisher's chapter, 'Divergence, Diagnostics, and a Dichotomy of Methods', draws on an extended case study of the Woodward–Hoffmann rules for predicting stereochemistry in pericyclic reactions in organic chemistry. The Woodward–Hoffmann rules are widely recognized in chemistry as exceptionally explanatory, making use of the concept of molecular orbitals and orbital symmetry to develop systematic, accurate rationalizations of allowed and disallowed geometries. Fisher's theory of diagnostics in computational chemistry draws on the contemporary literature in modelling and simulations from philosophy of science to explicate this power of

the Woodward–Hoffmann rules in terms of their contribution to chemical understanding. He succeeds in making a novel contribution to the modelling and simulation literature in the form of his account of diagnostics, which unites and refines a variety of accounts of the epistemology and methodology of computer simulations. This essay is also exceptionally naturalistic among the contributions in the collection. That is, Fisher motivates his philosophical queries from problems native to the particularities of chemical theory and practice, as opposed to applying puzzles in general philosophy of science to chemical cases, which was the *modus operandi* of many of the chapters. The success of this essay is a high point of the book and a promising herald of what may come in the next phase of philosophy of chemistry's growth as a discipline.

Overall, a smattering of standout articles, particularly those by Best and Fisher, make this collection a worthwhile, but not a must-have, addition to a philosopher of chemistry's bookshelf. However, when taken as a whole, it is a collection in want of some curation, a custodial feat that is not achieved by the perfunctory introduction. The organization of the essays works against a greater understanding of issues both native and central to the philosophy of chemistry, and there is little dialogue among the individual contributions. Or, to put the point in the language of the volume's subject, no synthesis proceeded from the component reagents of the individual contributions.

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