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**Philosophy of chemistry: unkempt jungle and fertile ground**

**Eric Scerri and Lee McIntyre (eds): *Philosophy of chemistry: growth of a new discipline.* (Boston studies in the philosophy and history of science v. 306) Dordrecht: Springer, 2015, xii+233 pp, $99 HB**

**Micah Newman[[1]](#footnote-1)**

Philosophy of chemistry is a long-neglected subfield that has only in the last 15–20 years come into its own as a recognized discipline with its own specialists, and two dedicated journals—*Foundations of Chemistry* and *Hyle*—although it has grown slowly and remains largely under the radar of many philosophers and chemists. The subfields of philosophy of physics and philosophy of biology, in comparison, have had much longer official recognition. Various reasons for the field’s longstanding neglect have been suggested. Eric Scerri and Lee McIntyre, in “The Case for Philosophy of Chemistry” (which could be taken as the inaugural paper of the discipline as we know it today), note that the philosophy of physics has long been the signal subfield of interest within philosophy of science (1997: 214). Joachim Schummer, in his contribution to the predecessor of this volume, suggests that “the historically rooted pragmatism of chemists and their lack of interest in metaphysical issues” has kept many of them away from philosophizing about their discipline (2006: 21). Also, whereas biology is of palpable interest at least insofar as it concerns our place in the animal kingdom, and modern physics immediately suggests pressing metaphysical issues to do with fundamental ontology and causation, chemistry, despite its multifaceted richness, seems to have been caught in the middle. It also does not help that it has been commonplace among philosophers to blithely assert that chemistry has been “reduced to” physics, as if this were a settled fact that illustrates a case in point of ontological reduction via “bridge laws” (Nagel 1961), or causal exclusion (Kim 1993).

All this is to say that philosophers, at least, could benefit greatly from an examination of topics of interest to them as they are exemplified in chemistry; this is potentially one of the most fruitful ways in which philosophy of chemistry could benefit the larger research community. Chemistry is a rich and varied science loaded with a panoply of issues of philosophical interest, such as scientific practice, models, explanation, substance, reduction/emergence, and natural kinds. Ten years ago, *Philosophy of Chemistry: Synthesis of a New Discipline* (edited by Scerri, McIntyre, and ) was published, a valuable collection of original papers representing a “state of the discipline” still in its beginnings. It included helpful surveys of the philosophical contours of chemistry itself as well as more-focused topical essays on questions such as the status of chemical kinds as natural kinds and the purported identity of water with “H2O” (a stock example in philosophy that turns out to be facile in the light of actual chemistry). This successor volume comes as a welcome update on the field’s proceedings, but it exemplifies some worrying trends in how philosophy of chemistry is being done.

In the book’s introduction, the editors make some insightful comments on the location of philosophy of chemistry as a discipline vis-à-vis the respective interests of philosophers and chemists: “Chemists favor dwelling on specific details and are seldom quite so interested in the big picture or in reflecting on what their theories and findings generally might mean. At the same time philosophers tend to favor grand generalizations which sometimes means ignoring the grubby details of chemical research. There is always the danger that the philosopher might not have a sufficient understanding of the technical details and might not therefore be taken very seriously by the chemist. This is why continued cross-fertilization and criticism from both sides remains essential to the growth of the field.” (2) To that I would add that the chemist’s predilection of getting lost within the details, as is in fact exhibited in some of the papers of this volume, will be off-putting to philosophers with an interest in reconciling philosophical issues with concrete chemical examples.

There is a deeper problem at work here than simply the accessibility of the field to nonchemists. Some of the papers of this volume proceed by taking hold of a philosophical concept, and then without sufficiently clarifying it or clearly delineating what is at stake, dive right into the chemical details to try to make sense of the concept in purely chemical terms. The results are often suggestive of a variety of angles that future research could take in investigating such issues, but such papers are written as definitive statements, not prolegomena or springboards for future work. The problem is that there is a strong tendency to intertwine metaphysical notions with the complexities of chemical theory at the same discursive level, leaving it quite unclear what is to be explained in terms of what, or why one should favor one theoretical framework over another in applying philosophical concepts to chemistry. The common practice in recent philosophy of chemistry seems to be to try to cover so much ground, having done so little theoretic groundwork in advance, that essays sometimes read like survey articles of an as-yet undeveloped discipline whose characteristic contours can only be guessed at. Instead of trying to cash out metaphysical notions in chemical terms, which characteristically seems to involve awkwardly doing metaphysics and chemistry at the same time, I suggest that a sounder approach would be to seek to cash out chemical notions in metaphysical terms that are already generalized. This would require paying more careful attention to metaphysics proper than many philosophers of chemistry have done as yet.

Prime examples of this tendency can be found in a cluster of essays herein that treat of the notion of reduction. In importing the metaphysical concept of reduction into the chemical realm, philosophers of chemistry should at least first carefully explain what reduction is supposed to mean (on this point, see also Scerri (2007).) Philosophers of chemistry have by and large wanted to resist the common blanket claim that chemistry is “reducible to” physics, but they have gone about this using a variety of methodologies without providing much in the way of independent justification for them, and they also tend to insufficiently explain what “reduction” would mean to begin with, so as to provide a criterion by which to decide whether an attempt at reduction has been successful. For example, “Reduction for a Dappled World: Connecting Chemical and Physical Theories,” Heine Hettema provides a broadly Nagelian template of how the elusive “bridge laws” between chemistry and physics might be reconstructed. While the technical details may be of theoretical interest to specialists, the upshot is that the proposed bridge laws are not only supervenient on, but part of, the reducing theory, in that they displace the theory “below” it. But this leaves it unclear as to whether this would count as reduction, which is left undefined. To know whether it would, we would at least have to know what the metaphysical status of the referring theories are, and how they would be related to each other since it seems they would turn out to be incommensurable on this conception.

Next, Olimpia Lombardi’s “The Ontological Autonomy of the Chemical World: Facing the Criticisms” follows up on an earlier paper by Lombardi and LaBarca (2005) that argues from a “Kantian” perspective against chemical reduction, and for viewing chemical entities as “ontologically autonomous.” But it still remains unclear what being “ontologically autonomous” is supposed to amount to, or why the proffered “Kantian” outlook that takes chemical ontology as *sui generis* is to be preferred over other perspectives. Lombardi here urges that the concept of “reduction” makes little pretheoretic sense, but then goes on to reiterate the claim that ontological reduction of chemistry fails. This is puzzling, as it is hard to see how one would succeed in making a positive argument against a notion that it is impossible to make sense of in the first place. As in many treatments of this subject in the philosophy of chemistry, the primary motivation in resisting reduction seems to be the desire to retain the claim that chemical entities are part of the world’s complete ontology, and are nonredundant with the more ‘fundamental’ elementary particles of physics (one can only assume that the failure of reduction would at least mean this), but little basis seems to be given for why one should make use of one theoretical approach over another in explaining how this is so. There are other nonreductive metaphysical frameworks, which do not make use of underexplained notions like “ontological autonomy” (see, *e.g.,* Pereboom 2002, Markosian 2005, Schaffer 2009, Baker 2009, Elder 2013, Heil 2015), and it would seem a better methodology to try to do chemical metaphysics in terms of an independently-motivated scheme that has already been proposed within metaphysics itself instead of trying to do metaphysics from within chemistry.

Emergence is another possible nonreductive outlook, which is tackled in Alexandru Manufu’s “A Novel Approach to Emergence in Chemistry.” Manufu says he is after the same “ontological autonomy” for chemistry as Lombardi. He takes a stab a definition of ontological autonomy, saying that “a discipline is ontologically autonomous from another if the ontology of the first is distinct from the ontology of the second.” So far, so good. But what are we to include in our ontology? “To be informative, this proposal must specify what…is meant by “ontology.” Luckily, we have a pretty decent understanding of what an ontology is. Arguably, an ontology must include entities, processes, phenomena, properties, laws. To this list one may add explanations, if they are viewed ontically, not just epistemically.” (41–42) After reading this passage, I jotted down the phrase “madcap reification” in the margin; there is no justification given for why absolutely everything that has a theoretic role should be included in one’s ontology. I, for one, can’t see any reason why laws or explanations would need to be included in any ontology as such. And without a principled way to determine what an ontology, whether reductionistic or not, should include, the proposal ends up amounting to something that perhaps only the author understands. Manufu goes on to pursue a theory of “functional emergence,” which seems to model its nonreductive outlook on the functionalist multiple-realizability thesis from the philosophy of mind, but since “emergence” itself is not clearly defined here, the import of the thesis remains somewhat obscure. He appeals to concepts such as Hamiltonian functions and quantum decoherence, and then seems to want to ‘read off’ a theory of emergence directly from them. Also, if a functionalist theory of chemistry is on offer, then surely it should provide a response to Jaegwon Kim’s (1993) influential criticisms of multiple realizability as applied to the philosophy of mind as a path to stave off reduction. To leave that out would be simply to fail to interact with the basic larger philosophical literature on the subject. To get its bearings, philosophy of chemistry should be integrated into philosophy as a whole and not remain insular.

The pitfalls of taking philosophical concepts directly into the chemical realm to see if anything sticks, as is done in various ways in the essays on reduction in chemistry discussed above, might be illustrated with an analogy. Contemporary neuroscience has sometimes been appealed to in order to draw the pop-science-level conclusion that science has demonstrated that free will does not exist. But going directly to science to prove or disprove free will assumes that one can extract a philosophically sound and motivated notion of free will from science and then let science decide on that. But since the concept of free will itself is not one generated from within any science, it must be philosophically defined first, and then care must be taken to avoid any of a number of possible invalid arguments that proceed too quickly from scientific descriptions to metaphysical conclusions (Mele 2014). Likewise, searching within the details of chemistry for notions of substance, reduction, etc., entangles the philosophical concepts with the chemical ones, which leads to arguments, insofar as one can make them, that are invalid. If philosophers of chemistry want to successfully treat of chemical concepts in metaphysical terms, I suggest they should at least first more carefully map out the correspondence between concepts in one discipline with those of the other.

On other topics, Paul Needham’s “One Substance or More?” is more circumspect in its treatment of its target philosophical concept with respect to chemistry, but it does involve chemical technical details that require philosophers to know a significant amount of chemistry to navigate. And here, the conclusion may disappoint philosophers interested in substance, as it turns out that the very concept has to be radically reshaped to account for the various kinds of homogeneity and heterogeneity characterized by chemistry, which leaves the substance concept either irrelevant or well-nigh unrecognizable. The application of mereology with respect to chemistry is another topic that has come up from time to time, which Rom Harré explores in “Mereological Principles and Chemical Affordances.” Thus far, the consensus with regard to chemical mereology seems to be just that classical extensional mereology is an insufficient tool with which to capture the relation of chemical parts to wholes. Unfortunately, Harré’s discussion of chemical affordances does not seem to advance the topic much, in that it does not seem plausible that one could locate chemical affordances as residing in certain parts of a molecule, as a holistically-constructed entity. When chemicals undergo change to become different chemicals by addition or subtraction, the affordances that were present in the formerly detached ‘parts’ are no more, and different affordances appear in their place. Therefore there is no way to ‘track’ what part of what molecule remains before or after the change. So, since the mereological fallacies of composition and division both certainly apply in chemistry, as Harré notes, it seems to me that mereology itself, the axiomatic logic of parthood, is strictly irrelevant to chemistry, aside from the trivial fact that chemical entities take up space that can be carved into arbitrary parts, a characteristic that molecules have in common with regions of empty space.

Scholarship in philosophy of chemistry thus far seems to have been most successful when it either engages in what might be called metachemistry, expanding the theoretic borders of chemistry itself, or in inquiries in the history of chemistry. The last three essays in this volume represent the former category: Klaus Ruthenberg’s “Radicals, Reactions, Realism,” Grant Fisher’s “Orbital Symmetry, Idealization, and the Kairetic Account of Scientific Explanation,” and Jean-Pierre Noël Llored’s “Investigating the Meaning of the Ceteris Paribus Clause in Chemistry.” These works pursue hitherto underexplored but philosophically suggestive byways of chemistry that touch on issues that remain within the scope of what would be normally considered philosophy of science, such as theories, discovery, laws, and explanation. To the extent that they are successful in remaining within a manageable scope, however, essays such as these may enjoy relatively limited appeal compared with the ‘sexier,’ more ambitious, attempts to jump with both feet into chemical metaphysics. The history of chemistry in itself represents a dynamic, mercurial, and often fascinating tapestry of ingenuity and discovery, the exploration of which has constituted a significant part of philosophy of chemistry. Such historical studies in this volume include Marina Paola Banchetti-Robino’s “From Corpuscles to Elements: Chemical Ontologies from Van Helmont to Lavoisier” and Pieter Thyssen and Koen Binnemans’ “Mendeleev and the Rare-Earth Crisis.” Scholars of science will find works such as these to be rewarding reading.

The remaining contributions reflect on the language and practice of chemistry. In “The Methodological Pluralism of Chemistry and Its Philosophical Implications,” Joachim Schummer takes what seems to be a Wittgensteinian “don’t think, but look!” outlook to the question of realism and truth in chemistry. He suggests skipping the usual question of scientific realism with regard to chemistry and attending instead to the variety of ways in which chemists do their work, which is ultimately predicated on pragmatic concerns rather than philosophical concerns about truth as such. The implication seems to be that the methodological pluralism of chemistry is best understood in pragmatic terms, rather than in terms of a single conception of truth to which all chemical inquiry answers. But Schummer does not seriously consider alternatives such as pluralist conceptions of truth itself (Lynch 2009), and in fact seems simply uninterested in the philosophical question of truth. Further, in a bold stroke of equal parts chutzpah and apparent philosophical naivety, he asserts that philosophical questions to be answered of chemistry’s subject matter have already been answered from within chemistry: “in chemistry we have a privileged access of analysis of analysis that allows conclusions beyond metaphysical speculations. For, chemistry has addressed the realism/nominalism issue, which is sometimes misleadingly called the issue of natural kinds, by experimental means, largely unnoticed by mainstream philosophy. Rather than only adjusting our concepts to the world as it is, chemistry also adjusts the world to its concepts by creating experimental systems that best fit its frameworks.” (62) Schummer is intent to paint a picture of the broad outlines of chemistry, and in doing so, as with several other essays in the book, there is a palpable dearth of argument as to why the given picture should be thought to be the correct one. He makes an intriguing suggestion in connection with reduction, stating that attempts at reduction make a “monist” assumption about chemical theories and practices (65–66). But the attempt to block reduction by way of a pluralistic conception can only get off the ground if it is done in terms of ontology, the very notion of which Schummer seems to reject out of hand. This leaves a deadlock with respect to more traditionally realist perspectives toward chemistry, against which Schummer does not provide much in the way of argument.

Joseph Earley’s “Pragmatism and the Philosophy of Chemistry” examines the relevance of the pragmatic philosophies of such as C.S. Peirce and John Dewey to chemistry. It is a survey of broad strokes meant to call attention to relatively neglected philosophical systems, mainly Peirce’s, which seems broadly relevant to chemistry but just as relevant to almost anything else; Earley’s paper also briefly covers culture, learning, language, and civilization. A particularly suggestive section is unfortunately left until the end, where Whiteheadian process philosophy is briefly brought to bear on chemical processes and ontology (85–86). This seems a promising arena for further research, especially in light of Earley’s earlier reference to Thomas L. Short’s observation that “the narrowness of the contemporary philosophical understanding of causation (a baleful influence, he says, of David Hume’s ghost) has had unfortunate effects.” This is surely one area in which contemporary metaphysics, long saddled with a Cartesian-Newtonian mechanistic philosophy of nature, can and should learn a lot from chemistry. Farzad Mahootian’s “Metaphor in Chemistry: An Examination of Chemical Metaphor” likewise gives a broad overview of a topic of philosophical interest as it generally applies to scientific expressions as well as to those specifically of chemistry. Interesting, but survey-type articles such as Mahootian’s and Earley’s make it look as though philosophy of chemistry is still a fledgling discipline trying to find its own legs. Maybe it still is.

Directly following the above-quoted passage from the editors’ assessment of the current state of the field, they go on to say, in a footnote, that “[s]uch cross-disciplinary fertilization has not occurred to a sufficient degree in our opinion. In addition, philosophers of chemistry have not always responded to criticisms from within their own community. We believe that such a fledgling discipline as philosophy of chemistry can ill-afford such omissions. It is all very well to hold sessions at meetings like the Philosophy of Science Association to air views among the small audiences that typically attend these gatherings. It is another to put one’s own house in order so as to be of some relevance to the far wider chemical community.” (2) In line with this exhortation, in expanding the field’s audience it might turn out to be easiest for philosophers of chemistry, most of which seem to have come from within chemistry, to attract more chemists, than to attract more philosophical attention by making their theories more metaphysically robust. If the latter strategy is adopted, then philosophers of chemistry should proceed by attending more closely to non-chemical philosophy than they have been, and also modeling their efforts after the philosophical rigor that they find there.

As the editors also allude to, progress in philosophy of chemistry seems to have been hampered by a kind of ‘methodological solipsism’ (if I may co-opt a philosophical term and give it my own meaning) in which researchers seem more inclined to continually devise novel theories and approaches than to build on what has already been done. Instead, philosophers of chemistry might do well to take a cue from analytic philosophy and defend relatively limited claims, and proceed on the outlook that philosophical progress is to be made gradually if it is to be made at all. It could be that the shortcomings here discussed are due simply to an overexuberance in researchers excited about chemistry and eager to explore it on a philosophical plane. Philosophy of chemistry overall needs tightening up, however, if it is to progress beyond where it is now. This new collection is not the most ideal place to start for those wanting to get up to speed on philosophy of chemistry; instead, I would recommend starting closer to the beginning, maybe with the 2006 companion to this volume.

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1. mnewman@tarleton.edu

Department of Social Sciences, Box T-0660, Tarleton State University, Stephenville, TX, 76402, USA [↑](#footnote-ref-1)