

Published in  
*Journal for General Philosophy of Science*, **33** (2002), 168-174

**Book Review of**

Jaap van Brakel: *Philosophy of Chemistry. Between the Manifest and the Scientific Image*, Leuven, Leuven University Press, 2000, pp. xvi +246, ISBN 90-5867-063-5, € 17.35.

During the past two or three decades, there have been several tendencies of disintegration and ramification of philosophy of science. One is the shift toward philosophy of language and philosophy of mind, which simply reflects the shift of personal interest of former authors of philosophy of science journals. Another one, reminiscent of nineteenth-century historicism, replaces both subject matter and method and investigates the history of the philosophy of science. Trends of ramification, usually encouraged by both mistrust in simplistic 'big stories' and the professionalization of a discipline, follow the two centuries old ramification of science when the term 'physics' lost its original (Greek) meaning of natural science to denote only a particular discipline among others (cf. R. Stichweh, *Zur Entstehung des modernen Systems wissenschaftlicher Disziplinen*, 1984). Since many philosophers of science, while being reluctant to recognize the historical shift of meaning, have continued to pass their philosophy of physics as philosophy of science, conflicts were unavoidable. Some 30 years ago, against considerable disciplinary resistance, philosophy of biology did not simply emerge as a new branch but as a closed discourse rather disconnected from the equally closed philosophy of physics discourse. About ten years ago, after decades in 'national undergrounds', philosophy of chemistry appeared on the international agenda. Not only is this field growing with tremendous speed now, the development also tends to repeat exactly the former story of mutually disinterested specialization beyond need. Being involved in that process from the very beginning, I say that not without worries.

Like this journal, the book to be reviewed is an invitation to general philosophers of science because it discusses several topics of current philosophy of chemistry in general contexts. Furthermore, the book is an invitation to all those who are willing to catch up with an understanding of recent developments in philosophy of chemistry. At the present state, combining both tasks is already impossible, such that a selection of topics is required. After providing a historical survey of philosophical issues of chemistry, from Kant to the end of the twentieth century, van Brakel selects three main topics: chemical substances, chemistry's alleged reduction to physics, and modeling. The general issues include: scientific versus manifest image; reduction, supervenience, and emergence; natural kinds and essentialism; the causal theory of reference; laws and models; metaphysical monism versus pluralism.

Van Brakel's historical survey (chapter 1, "emergence of philosophy of chemistry") is particularly helpful to newcomers. On the one hand, he provides historical reasons for the notorious neglect of chemistry by philosophers, among which Kant's earlier, pre-Lavoisian view of chemistry as being no science proper is important, since many Kantians took that as the final words of their master and ignored Kant's later adoption of Lavoisian chemistry in his *Opus postumum*. In mainstream 'classical philosophy of science', with its strong ambition towards unification of science, chemistry was neglected because reduction to physics was simply taken for granted; at best chemistry served for case studies supporting one or the other competing methodological theories. On the other hand, van Brakel reviews discussions of chemistry related issues, starting with classics such as Hegel, Schelling, Engels, Peirce, Ostwald, Duhem, Broad, and Bachelard. Since chemistry figured prominently in Engel's dialectical materialism, philosophical studies of chemistry greatly flourished in Eastern European countries before 1990, and even came on the political agenda in the debates about the ontological status of resonance structures. While there were national groups in many countries in the late 80s and early 90s, van Brakel sees the birth of philosophy of chemistry in 1994, with a series of international conferences in London, Karlsruhe, Marburg, Rome, and the U.S.A. Since then, the number of publications and newly explored topics (such as foundational issues, clarification of basic concepts, methods of chemical synthesis and classification, semiotics of chemical sign language, laws and models, instruments and experimenting, relation to technology, ethics of chemistry, etc.) has grown too rapidly to be reviewed here. In addition, two journals were launched, *Hyle: International Journal for Philosophy of Chemistry* (1995) and *Foundations of Chemistry* (1999), and an international society was formally established in 1997. For the following chapters, van Brakel picks out three related topics, reductionism, chemical substances, and modeling, which all have their footings in traditional discourses and which allow him to develop a general philosophical account.

Because books like that of van Brakel are written for two groups of readers, philosophers and chemists, chapter 2 ("philosophically preliminaries") provides a second comprehensive introduction. This one is for chemists, and it introduces into current issues in philosophy on which succeeding chapters draw, such as reduction, supervenience, emergence, natural kinds, and the so-called causal theory of reference. Beside that, which need not be reviewed in this journal, van Brakel outlines the frame theme of his book and his general philosophical position. Borrowing two concepts from Wilfred Sellars, the relation between the 'manifest' and the 'scientific image' is at issue as well as the question where chemistry belongs to. In the context of the book, the scientific image is largely microphysics, quantum mechanics. Unlike Sellars' concept, the manifest image covers "manifest form(s) of life, understood interculturally" (p. 42). It is probably a weakness of the book that this concept is not further elaborated on, as similar prominent concepts are, from James' "world of practical realities" to Husserl's "Lebenswelt"

and Wittgenstein's "Lebensform", to all of which van Brakel refers. It leaves the impression that everything save microphysics is included, such as an everyday perspective as well as most other sciences and technologies, 'folk psychology', intentions and meanings, morals, and even judgements about scientific standards. The main thesis of the book is that, *if* the question of priority is at stake – a question that was unnecessarily pushed by proponents of the scientific image according to van Brakel – then the manifest image can always claim priority with regard to epistemological, methodological and ontological matters. Since much of the book argues against reduction of chemistry to quantum mechanics, chemistry is located rather in the manifest image.

In chapters 3-5, van Brakel develops his complex anti-reductionist argumentation from three points of view: the chemical (chapter 3), the semantic and metaphysical (chapter 4), and the quantum chemical perspective (chapter 5).

Taking water as his main example, van Brakel argues in chapter 3 ("chemical substances") that 'manifest substances' are historically constant paradigm cases of natural kinds defined in terms of 'manifest properties'. Against microreductionist essentialism that takes molecular structure as the essence of substances, he convincingly shows that microstructures depend on experimental contexts in the same way as empirical properties do and that there is a plurality of microstructural descriptions tailored for certain purposes, such that "the manifest image determines which micro-essences are to be selected" (p. 81). Furthermore, he outlines the now broadly agreed view among philosophers of chemistry that the notion of pure substances is to be defined in terms of thermodynamic concepts on an operational basis. If we want to know how scientists actually decide about natural kinds, case studies are instructive. To that end, van Brakel discusses the so-called 'polywater' story of the 60s and early 70s, where the question arose if there is a new kind of water. Unraveling the intricate difficulties of interface and colloid chemistry, where anomalies are abundant, he concludes that the final decision was based on an interplay of arguments from "the manifest, macro-, micro, and submicro-levels, without any one playing a more crucial role than another" (p. vii).

Chapter 4 ("essentialistic realism") is addressed to the metaphysical branch of philosophers of language who, following the early Kripke and Putnam, take substance terms like 'water' to be rigid designators of molecular essences as expressed in 'water is H<sub>2</sub>O'. That approach is important in the present context because it rules out the scientific meaning of (manifest) substances and material properties by semantic definitions. Not only does van Brakel review the philosophical objections discussed in the pertinent literature (like the superimposed asymmetry of the identity statement); with admirable patience, he also informs about the scientific flaws and ambiguities in that discourse. Being myself, like van Brakel, both a philosopher and a chemist, I have always been surprised at a community that acknowl-

edges people as philosophers of science regardless of the scientific background. It might be tolerable if philosophers of language confuse empirical formulas (like  $H_2O$ ) with molecular descriptions, because chemists themselves frequently use these terms ambiguously, taking for granted that the exact meaning is clear from the context. However, philosopher of science should note that they lose credibility if they, for the purpose of their essentialist argument, neglect, for instance, the century old dissociation theory that explains the main features of substances like water just by negating 'water is  $H_2O$ '. One would expect somebody like Putnam reflecting on science to know that the simple molecular approach, while being fruitful particularly in organic chemistry for certain purposes, fails to provide a satisfying account of most solids and every dissociating and aggregating gases and liquids like water, of which a complete molecular description has not yet been achieved. In addition, van Brakel shows that the fanciful possible world talk, originating from Putnam's Twin Earth tale, has no footing in science because differences in molecular structure are, of course, derived from differences in empirical properties. Thus, even the most patient author is close to resignation: "How is one to engage in a discussion with a naturalist if the naturalist doesn't accept the inescapable consequence of the scientific truism that talking about XYZ [Putnam's molecular structure of Twin Earth water] is nonsense, empty humbug, or worse?" (p. 116). Van Brakel concludes "that the stability in the use of natural kind terms depends entirely upon manifest properties and macroscopic regularities" (p. 117).

In chapter 5 ("the alleged reduction of chemistry"), van Brakel first reviews the origin and spread of the idea that chemistry would be reduced to quantum mechanics, and the implicitly or explicitly drawn conclusion that "in the philosophy of science it [chemistry] should not figure at all" (p. 122, quote from H. Dingle). In the past decades, philosophers, quantum chemists, and physicists have done much serious work on the reduction issue, all leading to negative results as to reduction. This chapter provides a good overview on the pertinent literature and is highly recommended to those who are willing to leave the surface level and go into technical details. Besides the century old debate on thermodynamics and statistical mechanics, van Brakel provides an in-depth investigation of quantum chemistry, *i.e.* that branch of chemistry that exploits quantum mechanics for chemical purposes and where, if at all, reduction is at issue in science. He shows that at all levels of quantum chemical model building, the necessarily required assumptions and decisions are guided by presupposed chemical knowledge and adopted to chemical problems. This is even true of the notion of molecular structure that cannot be derived from quantum mechanical principles but arises from classical structural chemistry. Comparing the successful approaches of quantum chemistry with standard notions of reduction in philosophy of science, van Brakel concludes that reductionist claims have no support.

Chapters 6 & 7 (“*ceteris paribus*” and “modeling in chemical engineering”) expand on the topic of modeling and aims at general epistemological conclusions. It might be argued that there are no strict laws in chemistry because of the many exceptions in particular contexts, and that excluding exceptions by explicitly restricting contextual conditions goes at the expense of universality. Drawing on epistemological views of Nancy Cartwright, van Brakel argues that all laws include *ceteris paribus* conditions about contexts, if models are derived from the abstract formulations to fit the world. The success of models “is a matter of mutual attunement of both model and reality” (p. vii), i.e. both adopting experimental contexts to models and implicitly introducing *ceteris paribus* conditions for laws. Going beyond quantum mechanics, van Brakel shows that this is equally true at all levels of abstraction, not only for theoretical laws but also for so-called phenomenological laws. For that purpose, he provides two case studies of modeling in applied chemistry, capillary wetting of porous media and dimensional analysis in chemical engineering. Furthermore, if all laws are *ceteris paribus*, then this is also true of the so-called bridge laws that connect laws of different discourses with each other, like that of physics and chemistry. Therefore, van Brakel concludes that such interdiscourse relations are “not pieces of metaphysical glue” for asymmetrical reduction but symmetrical relations between certain types of idealizations; i.e. there are no *strict* interdiscourse relations.

That rises the general metaphysical issue “how to fit it all together”, which van Brakel discusses in his final chapter (“conclusion”). To that end, he extends Davidson’s “anomalous monism” from the body/mind discourse to include also the different views of physics, chemistry, and others. According to that view, which sounds to me like a variant of perspectivism, the world consists of primary events and their causal relations which are independent of and prior to specific identifications and causal explanations from certain perspectives, such as those from physics, chemistry, biology, psychology, etc. Various perspectives can provide equally true descriptions of the world and may develop their own ‘ontology’ (“promiscuous realism or realism-with-a-small-r”, p. 198), whereby interdiscourse relations may connect perspectives with each other in a symmetrical manner leaving the autonomy of each side. While I sympathize with perspectivism and pragmatic realism, for both of which I have argued elsewhere, I have some difficulties with the assumption of primary events and causes. If “there is no God’s-Eye-point-of-view-meta-description that gives the only true identification of events” and causes (p. 197), I do not see any justification to claim their existence, beyond the need of avoiding a Goodmanian proliferation of worlds. Nor would I see the need for such a metaphysical assumption, if van Brakel’s ‘manifest image’ were not overloaded with too much science/chemistry.

In the final section, van Brakel argues again for the primacy of the manifest over the scientific image, this time with particular reference to

judgments about epistemic virtues and criteria of quality and usefulness of science. If the ‘manifest image’ may also claim primacy in ontological matters (chapter 2) that would seem to be enough to guarantee the unity of the world without further metaphysical assumptions (chapter 8), provided the unity of the “manifest form(s) of life, understood interculturally”. There is a certain tension between the beginning and the end of the book arising from a too broad meaning of ‘manifest image’. If there are only symmetric instead of asymmetric or hierarchic relations between the sciences, it is unclear in what sense chemistry is closer than physics to the manifest image, for which epistemological, methodological, and ontological primacy is claimed. It might be related to the historically contingent fact that, unlike physicists, biologists, sociologists, psychologists, historians, etc., chemists never seriously challenged common sense with a philosophically inflated Theory of Everything.

In sum, the book is an invitation to general philosophers and philosophers of science, both to learn from recent developments in philosophy of chemistry and to enter discussions. As Rom Harré remarked in a recent book review in *Hyle*: “If anyone doubted that there is a philosophy of chemistry, full of interesting issues, this book should convince the skeptic.”

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