Book Review

Hasok Chang: *Is Water H_2O? Evidence, Pluralism and Realism*, Dordrecht: Springer, 2012, XXI + 316 pp., ISBN 978-94-007-3932-1

by Joachim Schummer

Hasok Chang, Professor of History and Philosophy of Science at Cambridge University, has written a most remarkable book that draws lessons from the history of chemistry for general philosophy of science. His historiographical focus is on the period from the late 18th century to the mid-19th century, when chemistry through its early professionalization was indeed the dominating science in Europe. He selects three subsequent episodes, the Chemical Revolution, early electrochemistry after Volta's invention of his electric pile, and the development of atomic and constitutional chemistry, which he all relates to each other by his guiding question: Is Water H_2O? What the mainstream analytical philosopher of science takes for granted from elementary high school courses in chemistry (or the consumption of a misleading paper by Hilary Putnam), Chang picks to pieces by historical and philosophical analysis. In fact he convincingly argues that the customary answer in the affirmative has never been fully conclusive – up to today! Shaking the grounds of conventional wisdom, he suggests 'active realism' and 'epistemic pluralism' as the philosophical positions that are most appropriate for the scientific endeavor.

With a strong interest in alternatives and less-successful approaches in science, and a profound understanding of experimental practice, Chang digs out neglected work in the history of chemistry that whiggish, winner-celebrating historiography has frequently made us ignorant of. While Joseph Priestley has been made famous for his stubborn rejection of Lavoisier's chemistry, the author takes him seriously in chapter 1 and rehabilitates the phlogiston theory as being not inferior to the oxygen theory (see also his 'The Hidden History of Phlogiston', in *Hyle*, 16-2 (2010) pp. 47-79). Thus, the well-known 'synthesis' experiment of water (by Scheele and Cavendish) could with equal evidence be interpreted as the reaction of phlogisticated and dephlogisticated water, leaving water an element rather than a compound. Moreover, in what he calls 'counterfactual history of science', Chang argues

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that the too rash abandonment of the phlogiston theory, as an unwelcome rival, deprived chemistry of important conceptual resources that had later to be developed anew through concepts such electrons and chemical potential.

Neither the 'synthesis' nor the 'analysis' experiment in the form of the electrolysis of water in 1800 brought conclusive evidence for the compound nature of water, as chapter 2 illustrates. On the contrary, because hydrogen and oxygen emerge at different electrodes that are separated from each other by a distance, it was more plausible to consider them the synthesis products of water with negative and positive electricity, respectively, as Johann Wilhelm Ritter and many phlogistonists did. When mainstream chemistry nonetheless adopted the compound nature of water, the unsolved 'distance problem' remained, before the advent of the ionic theory, a source of continuous concern in electrochemistry. However, Chang argues that this created a climate of mutual tolerance, in which several approaches could compete with each other for the benefit and progress of the field.

Chapter 3 deals with the development of relative atomic and molecular weights and constitutional chemistry up to the early 1860s, what the author together calls 'atomic chemistry'. Focusing on the issue of whether water is H_2O or HO, he distinguishes five different systems that differed from each other not only in their theoretical assumptions but also in putting different emphasis on experimental practices and chemical aims. Although I think that the clear-cut distinction between five systems is exaggerated, what he indirectly concedes by calling them 'contemporary fictions' (p. 163), Chang convincingly argues that their common commitment to operationalization allowed chemists to develop in fruitful competition a converging and successful approach to what had hitherto been impossible: the scientific investigation of atoms and molecules. For that kind of success, it was less important whether water was decided to be H_2O or HO and whether hydrogen is considered an element or a compound of a protons and electrons.

Chapters 4 and 5 employ the three previous case studies from chemistry for developing general views in the philosophy of science. Chang moves from the received theory-focused debate in the analytic tradition towards a philosophy of scientific practice, in which active epistemic commitments matter for the research process, rather than retrospective opinions about the truth of this or that theory for the armchair philosopher. To that end he draws two main historical conclusions: First, there have always been several consistent approaches competing with each other without one being clearly superior over the others (descriptive pluralism). Second, science flourished and was most successful regarding its own aims when pluralism ruled, rather than dogmatism and monism that prematurely suppressed alternatives. Turning the historical insight into a normative position, he advocates 'active realism', the commitment to maximize our learning from reality in a pluralist context, by systematically arguing, first, against standard views of 'scientific realism', and second, for the epistemic benefits of pluralism.

As to 'scientific realism' – which I think, since my PhD thesis about that topic in the early 1990s, is largely a reformulation of mathematical physicalism with only poor connection to philosophical realism –, Chang wipes off all its recently developed scholastic defense apparatus with a series of fresh and cunning arguments that perhaps only insiders can fully enjoy reading. Because 'scientific realism' is a (physicalist) version of monism, and probably the most outspoken one, it is clear that this is his main opponent. Instead he recommends an active commitment to pluralism, including even societal support for alternatives, by pointing out the various epistemic benefits that result from pursuing different approaches both independently from each other as well as in competition and collaboration.

Sometimes the book has a too narrow focus on the British-American literature, regarding both primary and secondary texts in the history and philosophy of science. For instance, access to the literature by and on Johann Wilhelm Ritter, who figures prominently in chapter 2, would allow a much richer picture. Or, references to the philosophy of chemistry, from Gaston Bachelard's *Le pluralisme cohérent de la chimie moderne* (1932) to current approaches, would have placed his views on pluralism and realism into a longer tradition than the references to and demarcations from Popper, Kuhn, and the like can obviously do. On the other hand, Chang's occasional comparisons between philosophical terms in English and his native Korean provide illuminating insight into the linguistic limitation of monolingual thinking.

The book is also an interesting experiment in textual composition because each chapter is divided into three sections that address different needs and interests of readers. Section one sets the stage and develops the entire argument in an easily accessible manner for students, the second section goes into detail for the scholarly reader, whereas the last one answers objections to be expected from critical experts. Of course that goes hardly without redundancies, at least for the expert, but the prize is acceptable for the benefit of multi-functional usage. Introductory abstracts of each chapter, numerous cross-references and a comprehensive index further improve the possibilities of non-linear reading.

Like his previous book, *Inventing Temperature* (2004), this one is full of fresh insights and unconventional thinking that challenge the professions of both history and philosophy of science. Chang's unique style of combining the two, in the service of improving science, makes it invaluable reading also for scientists.

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