Book Review

Victor D. Boantza: *Matter and Method in the Long Chemical Revolution: Laws of Another Order*, Farnham, UK/Burlington, VT: Ashgate, 2013, xiv+266 pp., ISBN: 9781409418672

by John G. McEvoy

Focusing on the role of (Kuhnian) 'crises', rather than 'revolutions', in the development of science, Victor Boantza's innovative analysis of eighteenth-century chemistry connects chemistry in the seventeenth-century Scientific Revolution with the Chemical Revolution of the late eighteenth century. Boantza cites existing accounts of these revolutionary events for their adherence to one-sided 'revolutionary narratives' which downplay historical and conceptual continuity, emphasize theory over (slower-changing) practice, and draw attention to revolutionary 'winners' rather than so-called 'losers' whose contributions frequently had a subtler, more lasting impact. The problem with these accounts – whether Kuhnian or Whig – is that they treat these original events as self-contained revolutionary affairs, similar in 'form' and linked through precursors, but disparate in historical and material content. In contrast, Boantza's notion of 'the Long Chemical Revolution' considers them in concert, focusing as much on the neglected period in between as on the seminal figures of Robert Boyle and Antoine Lavoisier at either end. Unlike recent attempts to replace Lavoisier-centered accounts of early modern chemistry with a focus on the theoretical innovations and practices of earlier chemists, Boantza keeps Lavoisier well within his field of vision. He also shines an important light on British pneumatic chemistry, identified by Henry Guerlac and Larry Holmes as a crucial component of the Chemical Revolution, but entirely neglected by recent histories concerned with the *longue durée.*

Boantza treats 'crises' in science not only as markers for subsequent revolutions, but also as moments of intense confrontation and struggle, in which existing paradigms can prove their mettle or successfully defer their problems for future consideration. He uses the focus on crises to uncover "strands of continuity in chemical theory and practice *during* and *between* the two revolutions" (p. 239), otherwise concealed by revolutionary narratives of incommensurable paradigms and historical ruptures. He shows how recurrent views

HYLE – International Journal for Philosophy of Chemistry, Vol. 20 (2014), 193-196.
Copyright © 2014 by HYLE and John G. McEvoy.

of the identity and autonomy of chemistry shaped the resistance of 'chemical chemists' to the reductionist strategies of physics, whether in the form of Boyle's 'physico-chemical' program, the Newtonian laws of 'universal physics', or Lavoisier's 'gravimetric accounts' of chemical phenomena. The British phlogistic chemist William Lewis, in 1765, depicted chemistry's struggle for disciplinary autonomy as the search for 'laws of another order' than those found in 'any known mechanism'. Boantza expands this metaphor into an analytical framework for comprehending the various ways in which "the proper 'chemical' is pitted against the 'physical'" (p. 10). The result is a richly textured and finely wrought account of the complex nexus of thought styles and practices of seventeenth and eighteenth century chemistry, only the bare bones of which can be enumerated in this review.

Boantza traces the recurrent crises in eighteenth-century chemistry to a dialectic established in the late seventeenth century by the response of the chemist Samuel Cottereau Duclos to Robert Boyle's famous skeptical assault on the traditional 'chymistry' of elements and principles. Dismissing as 'reductive and incongruous' Boyle's appeal to 'mechanical corpuscular' explanations to solve the problems of chymistry, Duclos preferred to refine and reform it from within. Like Newton, Duclos upheld a strict dualism between "*physical*, superficial and reversible concretions" and a "deep-level of transmutational [irreversible] *chymical* processes" (p. 107). In a similar vein, Gabriel Francois Venel and William Lewis rebuffed the mid-century hegemonic thrust of Newtonian physics into chemistry by drawing a strict demarcation between the two disciplines. While physicist deployed strategies of simplification, abstraction, and universalization to study superficial homogeneous aggregations, or 'masses', formed by the universal force of attraction, chemists used flexible and innovative experimental procedures to make contact with the deeper level of heterogeneous molecules, combining according to the selective power of chemical affinity to produce a multiplicity of "certain bodies" and "particular principles" (p. 125). Fire (or heat) straddled this great divide, appearing in physics as an agent of repulsion (caloric) acting on the aggregate level and, in chemistry, as an agent of determinate chemical properties (phlogiston). When Lavoisier's gravimetric mode of reasoning replaced phlogiston (the principle of inflammability) with caloric (the principle of elasticity, or disaggregation), he pulled chemistry in the direction of physics, leaving his phlogistic opponent to worry about what "he was taking away from chemistry" (p. 139).

Joseph Priestley worried that Lavoisier's commitment to instrumental precision, quantification, and the new nomenclature was an "exercise in experimental exclusion" (p. 169), systematizing what is already known, but thwarting the flexible practical engagement with nature necessary for the discovery of new facts. Defending a 'chemical' conception of phlogiston, Priest-

ley and Carl Scheele developed a 'metaphysics of air', in which the unisolable and imponderable phlogiston functioned as the "primary cause of [the] transmutation" of "identifiable pneumatic entities" sequenced according to their degree of phlogistication (p. 205). Concerned more with the physical reality of phlogiston, Richard Kirwan identified it with inflammable air. He also integrated the aggregative theory of heat, associated with Alistair Crawford's view of the inverse relation between the phlogiston and heat content of a body, into an account of combustion in which phlogiston emitted from the inflammable body released the matter of heat in the air. Karan complicated the conceptual terrain of the Chemical Revolution when he moved away from Priestley's distinctly chemical approach to phlogiston, adopting a position formally similar to the French system, which located the source of the sensible phenomena of combustion – "heat, light, and flame" – in the air and not in the inflammable body (p. 198).

Even when phlogiston was stripped off all its chemical functions and properties, its dwindling supporters, as well as a few Lavoisians, like Antoine Fourcroy, James St. John, and William Nicholson, insisted on its "absolute existence" (p. 208). This claim concerned not the relative explanatory power of the phlogistic and antiphlogistic hypotheses, but the pervasive sense that the advances of the new chemistry had come at too high a price. Phlogistic chemists, like Priestley, accepted the gravimetric claim that metals gain something during combustion, but they also pointed to other 'sensory signs' – smells, colors and vapors – which, though excluded from the 'absolute facts' of gravimetric analysis, supported the claim that some kind of chemical entity was also emitted by the metal. The defense of phlogiston constituted a questioning of Lavoisier's instrumentally mediated and standardized chemistry of quantification and precise analysis imported from physics. Phlogistic chemists favored a traditional form of chemistry based on a more immediate sensory determination of the unique properties and complex affinities of particular chemical substances, shaped by differences of quality rather than differences of quantity. Boantza's narrative reveals, in the myriad of differences and disputations that characterized the changing terrain of eighteenth-century chemistry, "strands of continuity in […] shared commitments to the immunity of chemical knowledge" (p. 239) to the reductive strategies of physics.

Boantza's account of the divergence between phlogistic and antiphlogistic notions of chemical change is an exception to the overall persuasiveness of his analysis. He argues that unlike the French chemists, who explained chemical change in terms of the composition and decomposition of compounds into their constituent components, phlogistians like Priestley viewed phlogistication and dephlogistication "not at as an arithmetic addition or subtraction of discrete quantities of phlogiston", but as a "continuum of transmutational

processes", involving "essential changes and (re)generations", in which "one kind of air is turned into another" by changing the "proportion of phlogiston" in it (p. 205). But Boantza offers no textual evidence to support this claim and his reasons for it are not very clear. A more intelligible, appropriate and familiar distinction in this context is that between the chemistry of principles, wherein substances are 'transformed' by the addition or withdrawal of property-bearing principles, and the compositional chemistry of stable entities present through chemical reactions. Although the chemistry of principles has its roots in earlier Aristotelian and alchemical notions of matter acquiring form and a *substratum* modified by principles, Priestley's version of the phlogiston theory, which involved notions of the 'mode of combination' or 'proportion' of elements or principles in a substance, seems entirely bereft of 'alchemical undertones'. More significantly, Priestley used terms like 'transformed', 'extracted', 'emission', and 'generation' as part of a more general philosophy of nature which eschewed as hypothetical notions of underlying chemical composition and reaction mechanism in favor of more certain descriptions of the sensory properties and changes of substances in different perceptual circumstances. Priestley's conception of chemical change is more *sui generis* than the product of a pre-existing chemical tradition.

More research, guided in part by Boantza's ground-breaking analysis, is required to find the right balance between local knowledge and tradition in this and other aspects of eighteenth-century chemistry. Historians of chemistry will also find Boantza's account of the 'Long Chemical Revolution' intrinsically interesting and stimulating. Philosophers of chemistry concerned with the abiding problematic of 'reduction' would also benefit from an encounter with Boantza's sense of its intricate and variegated nature. This is an important book, which deserves and will reward the attention of historians and philosophers of science.

John G. McEvoy:
Department of Philosophy, University of Cincinnati, Cincinnati, Ohio 45220, USA; John.McEvoy@uc.edu