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EDITORIAL

Guest editorial

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This Special Issue of *Foundations of Chemistry* features most of the papers presented to an international workshop held at the University of Sydney, Australia, 15–16 December, 2010, on the topic 'A philosophy of science answerable to chemistry'. The workshop was part of The International Science Linkages-Humanities and Creative Arts Programme funded by the Australian Government Department of Innovation, Industry, Science and Research and administered through the Australian Academy of the Humanities. The invited speakers we asked to address the topic of the workshop and to include a historical dimension in their deliberations, but otherwise the choice of topic was left to them. The programme was as follows:

Alan Chalmers (University of Sydney), 'Klein on the origin of the concept of chemical compound' with a commentary by Peter Anstey (University of Otago).

Ursula Klein (Max Planck Institute for the History of Science), 'Objects of enquiry in classical chemistry: Material substances' with a commentary by Stephen Gaukroger (University of Sydney).

Ofer Gal and Victor Boantza (University of Sydney), 'The "absolute existence" of phlogiston: The losing party's point of view' with a commentary by John Schuster (University of Sydney).

Jonathan Simon (University of Lyon), "Bachelard's factory-laboratory: Purity and chemical practice" with a commentary by Victor Boantza (University of Sydney).

Wolfgang Lefèvre (Max Planck Institute for the History of Science), 'Seeing chemistry through its ways of classifying' with a commentary by Nicolas Rasmussen (University of NSW).

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Robin Hendry (University of Durham), 'Science and everyday life: Water and H_2O' with a commentary by David Miller (University of NSW).

Eric Scerri (UCLA), 'What is an element? What is the periodic table? And what does quantum mechanics contribute to the question? with a commentary by Dean Rickles (University of Sydney).

These papers, revised in the light of the commentaries, the workshop discussion and the demands of referees, are published in this Special Issue, with the exception of the one by Gal and Boantza. At the time of its presentation that paper was under consideration for publication in the *British Journal for the History of Science* and was subsequently published in that place (Volume 44, 317–342, 2011).

A theme that runs through the papers concerns the nature of the entities that are the objects of chemical enquiry. Ursula Klein argues that what she calls 'classical chemistry' from the time of the birth of modern chemistry during the scientific revolution until the establishment of atomic and molecular chemistry in the late nineteenth and early twentieth century was concerned with the preparation, manipulation and study of material substances. Those substances, such as metals, acids and the salts resulting from their interaction, were the entities prepared, manipulated and studied in the laboratory. They stand opposed to and were other than Aristotelian elements, Paracelsian principles and atoms or corpuscles. A key element of Klein's thesis is that chemistry characterised as the analysis and synthesis of material substances was a practice that emerged as a coordinated practice for the first time at the beginning of the eighteenth century. Geoffroy's affinity table, which organised chemical substances according to their facility to combine with each other, encapsulated what was involved in the new laboratory practice.

Alan Chalmers is sympathetic with Klein's thesis, but is intent on modifying it to render it immune from various lines of criticism. He expresses qualms about Klein's depiction of the objects of the new chemistry as pure chemical substances that are artefacts prepared in the laboratory. It is true that in order to study chemical combination it is necessary for chemists to prepare pure samples of substances in the laboratory. However, those substances combine in nature whether they encounter each other in isolation or as components of complicated mixtures. There is a sense in which chemical substances are what they are and combine as they do independently of the manipulations of chemists. In this respect, chemical substances are natural kinds rather than artefacts. As far as Klein's historical thesis about the first emergence of the chemistry of combination of material substances around the turn of the seventeenth century is concerned, Chalmers poses problems for it by citing what appear as anticipations of aspects of the new practice in the work of Robert Boyle in the third quarter of the seventeenth century. Boyle, for instance, insisted on the identity of substances prepared in the laboratory and their naturally occurring counterparts and highlighted the need for experimental chemists to operate with pure substances. Chalmers fine-tunes Klein's position to offset such objections.

Purity of chemical substances is also a focus of Jonathan Simon's discussion. He contrasts the materially and socially complex manipulations of messy, impure substances that have characterised chemical technology since its inception with the idealised combinations of pure substances that are the typical focus of theoreticians and philosophers. He takes the preparation and characterisation of steel, as opposed to iron, in the eighteenth century as an illustration of the realities of chemical practice as opposed to the idealisations figuring in chemistry textbooks and philosophy of chemistry. But Simon's focus on a historical example should not be taken as an indication that the kind of situation he characterises is a thing of the past. Contemporary chemistry has made possible the preparation to order of glasses with a range of mechanical and optical properties. But what is glass from a theoretical point of view? X-ray diffraction supports the view that glass has an amorphous structure characteristic of liquids. But, if this is the case, what is it that accounts for the difference between the various varieties of glass? Peter Harrowell is a theoretical chemist who was a participant in the workshop and whose main research project involves tackling the yet-to-be-solved problem of the nature of glass from the theoretical point of view. But the highly complex and highly developed technology of glass preparation prospers independently of his efforts!

Wolfgang Lefèvre, like Simon, is well aware of the complexities and diversity of chemical practice and, for instance, of the fact that practical chemists are concerned with mixtures as much as with pure chemical compounds. His focus is on the multiplicity of ways of classifying substances involved in chemistry. Mendeleev's Table classifies chemical elements. However, chemical substances are also legitimately classified as acids, glycols, ethers and so on. Lefèvre is concerned, not simply with the identification of the modes of classification that the various practices within chemistry engender, but also with what can be learnt about chemistry by close attention to those modes of classification. His particular focus is on the famous *Methode de nomenclature chimique* involved in Lavoisier's anti-phlogistic chemistry. By identifying the deep structure of Lavoisier's classification system Lefèvre is able to pinpoint ways in which the new anti-phlogistic chemistry involved important continuities with the past as well as significant novelty.

Robin Hendry is also concerned with classification. In particular, he is concerned with the relation between common-sense classifications and those involved in chemistry. He takes water as an example. To what extent is the water referred to in everyday discourse to be identified with H_2O? There is a sign next to a mountain stream near my home warning that the water is not fit to drink. It would seem that that water, at least, cannot be straightforwardly identified with H_2O. Even within science, the characterisation of water as H_2O is not unproblematic. Most water contains a proportion of O_{18} as well as O_{16}. This may not be seen as a threat to its status as water. But what of heavy water, which differs from ordinary water only by virtue of a replacement of an atom by its isotope, and in which fish are unable to survive? In this context at least, Hendry takes a stand against what he sees as an inappropriately liberal attitude that makes classification relative to interests. He argues the case that water, including the water of our everyday lives, is indeed H_2O and that science should be credited with the discovery of that fact.

We have already had occasion to note that Mendeleev classified chemical elements in his Table. However, there is more to it than that, as Eric Scerri insists. At its inception, the entities appearing in the Table were a subset of the material substances identified by Klein as the objects of classical chemistry. Nowadays it makes more sense to interpret those entities as atoms of the elements, given that it is atomic number that forms the basis of the classification. But the fact that atomic structures associated with atomic number lie behind the ordering of elements in the Table does not alter the fact that the significance of the table lies in the extent to which it shows a periodicity in *chemical properties*. A key issue underlying Scerri's discussion involves the interplay of the quantum mechanical considerations concerning the energy levels of atoms and the properties of chemical substances involved in the practical manipulation of them in the laboratory. Another issue involves making philosophical sense of the degree of abstraction involved, exemplified in the fact that carbon occupies only one place in the table in spite of the fact that, at the level of material substance there are several allotropes of carbon and, at the atomic level, there are several isotopes of carbon.

As this editorial makes clear, there are common themes in the articles appearing in this Special Issue. But there are tensions and disagreements lurking in the various treatments of those themes. It is to be hoped that they will provide the raw material on which further work can be based.