The new chemistry of the elements

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In May 2014, a discussion meeting entitled ‘The new chemistry of the elements’ took place—the first ever linking the Royal Society and the German Academy of Sciences, Leopoldina. The meeting confirmed and highlighted that the periodic table not only still represents the best way of understanding and mastering the fascinating and diverse science and technological applications of the known 114 chemical elements, but also underpins diverse multi-disciplinary research, inspiring and catalysing new advances and new avenues of research across the physical, biological and medical sciences.

The periodic table, first developed by Mendeleev almost 150 years ago, describes the fundamental building blocks of everything that constitutes our natural world: all substances, living organisms and species are combinations of these elements. Therefore, the periodic table is the fundamental system of classification and organization of the 114 chemical elements and represents the unifying principle for understanding, rationalizing and predicting the behaviour and properties of matter.

An awareness of ‘The new chemistry of the elements’ within the periodic table—the most fundamental natural system of classification ever devised—is essential to anyone in the broad scientific community who wishes to disentangle the complexities of our natural world and see how it is built from its fundamental building blocks. The fascination of ‘periodic correlations’ was a recurring theme throughout the meeting. The existence of a myriad of relationships among and between the chemical elements, ranging from their electronic structure to physico-chemical property relationships, allows the community to direct and focus attention on major unsolved problems. For example, what were the major features of evolution guided/dictated by the inevitable changes in the chemistry of the elements arising from the transition from reducing to oxidizing conditions on our planet? Where and how are the next generations of catalysts, medicines and functional materials going to be discovered, and how are their properties to be harnessed?
The meeting targeted the confluence of chemistry with physics, materials science, biology and medicine and set out to establish ‘The new chemistry of the elements’ as a supra-discipline that will promote fruitful interactions and synergies between and across ‘conventional’ individual disciplines. By highlighting—and then utilizing—the intellectual and practical challenges of this supra-discipline, and the deep insights and unifying science that it provides, we will gain profound understanding and insights of the world around us—from materials to medicine.

An array of world-renowned scientists and early-career researchers took part in the meeting to highlight the fascinating and challenging prospects emanating from ‘The new chemistry of the elements’, as reflected in continuing advances and fundamental discoveries that continue to emerge across physics, materials, biology and medicine. Many of these scientists have now written articles for this discussion meeting issue of Philosophical Transactions of the Royal Society A. By collecting these articles, our core focus and emphasis has been on the understanding and integration of physico-chemical, materials and biological properties of the chemical elements and the ability to rationalize, and also predict, trends in the behaviour of the chemical elements under various physical, chemical, biological and planetary conditions. Our aim is to illustrate that in modern, broad and multi-disciplinary science, ‘The new chemistry of the elements’ represents a natural, over-arching, supra-discipline in which the borders and frontiers between individual subjects are rapidly—and naturally—disappearing.

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