Book Reviews

Edited by Clément Arsenault

Book Review Editor

Eric R. Scerri. *The Periodic Table: Its Story and Its Significance*. Oxford: Oxford University Press, 2007. xxii, 346 pages. ISBN-13: 978-0-19-530573-9.

The book is about the classification of chemical elements known as the periodical system. It is described as "one of the most potent icons in science [...] One sees periodic tables everywhere: in industrial labs, workshops, academic labs, and of course, lecture halls" (p. xiii). Among all taxonomies in all domains, there is probably none more respected and more useful than this one. As Scerri states (p. 25):

> The periodic table ranks as one of the most fruitful and unifying ideas in the whole of modern science, comparable perhaps with Darwin's theory of evolution by natural selection. Unlike such theories as Newtonian mechanics, the periodic table has not been falsified by developments in modern physics but has evolved while remaining essentially unchanged. After evolving for nearly 150 years through the work of numerous individuals, the periodic table remains at the heart of chemistry. This is mainly because it is of immense practical benefit for making predictions about all manner of chemical and physical properties of the elements and possibilities for bond formation.

The periodic system provides the basic criteria for organizing knowledge about all the material stuff in the entire universe. It is thus a model that anybody with interests in knowledge organization (KO) should know. Knowledge about the history, philosophy and status of the periodic system also provides important insight for knowledge organization in general.

Eric R. Scerri is a lecturer in chemistry as well as in the history and philosophy of science at the University of California, Los Angeles. He is the founder and editor-in-chief of the journal *Foundations of Chemistry* (http://www.springerlink.com/content/1386-4238). He received his Ph.D. in History and Philosophy of Science from King's College London. The author's background in chemistry may indicate a growing recognition among scientists of the importance of conceptual and philosophical problems.

Given the importance of the periodical system, one supposes that the literature about it must be overwhelming. This is not the case, however, and the few earlier books on the subject in English are presented in the introduction. What is of special importance for us in the field of knowledge organization is that there is no other book in English that deals adequately with the conceptual and philosophical aspects of the periodical system.

The book is organized as follows:

The Periodic Table lacks a bibliography: all references are provided in the notes. There is an index, but it is not exhaustive. For example, van Spronsen is mentioned in the index, but the description of his book on p. xiv is not included in the index.

This is a high-quality scholarly work that is clear and understandable even to those without a background in chemistry and physics. While *The Periodic Table* properly belongs to the philosophy of chemistry, a new field in which the author is a pioneer, it can also be said that the book is currently the #1 best seller in chemistry. (May 2006-present as compiled by YBP Library Services, http://www.libraryjournal.com/info/CA6408230.html)

This is a well-written and well-illustrated book. The inclusion of Mendeleev's original drafts aid in understanding the development of his system (p. 107). Mendeleev was able to predict the chemical and physical properties of a number of elements to an astonishing degree, although he also made false predictions about other elements. Tables comparing the predicted and observed properties of Gallium, Scandium and Germanium are extremely useful (p. 133–34). As the Russian historian of chemistry Bonifatii Kedrov states, "the scientific world was astounded to note that Mendeleev, the theorist, had seen the properties of a new element more clearly than the chemist who had discovered it" (quoted by Scerri, p. 150). Throughout the book, different views are presented and carefully documented. The author often also presents his own view. Personally, I would have liked a discussion of Hegel's view of the elements. Browne wrote the following in a review of Hegel's *Science of Logic*:

> Another interesting aspect of this book is its innovative contributions to the world of chemistry and the origins of the modern periodic table of the elements. Hegel sheds light on the earliest days of modern chemistry, reminding us of the revolutionary processes that led up to our understanding of chemical elements and compounds. We are reminded that everything stems from and starts with the compound, and the existence of the pure elements is inferred later by analysing phenomenon such as "mixing ratios" and saturation/absorption capacities. Hegel explains these founding pillars of chemical wisdom which many modern scientists take for granted. It is admittedly interesting to read about the processes that led to the discovery of the now-ubiquitous periodic table.

(Ross James Browne is from Atlanta, Georgia, United States, and the quote is from Amazon.com dated March 10, 2003.)

Recently, Hegel's views of chemistry have been somewhat rehabilitated after having been exposed as "grotesque mistakes" almost from the time of their publication (Ruschig 2000), which is why it would have been interesting to have Scerri's view of Hegel although this omission may be justified given the perspective of the book. Scerri's book is based on deep, first-hand knowledge of a very large number of sources.

For the remainder of this review, I would like to concentrate on my own motivations for reviewing this book, as well as demonstrate the general importance of *The Periodic Table* for information science. Researchers in knowledge organization tend to ignore the literature about scientific and scholarly classification and sometimes even speak of it in ways that seem to justify such ignorance. (See, for example, Hjørland & Nicolaisen 2004 and Nicolaisen & Hjørland 2004.)

Some of my own working hypotheses for a general theory of classification are:

> That any classification reflects a theory of the domain it classifies.
>
> That a classification should be based on pragmatic criteria related to the purpose for which it is constructed (as opposed to "objective" criteria). This is related to the problem known as "natural kinds".
>
> That knowledge is fallible and that different views compete in any domain. Each view implies its own criteria for description and classification of the phenomena in the domain. Competing views are basically related to different epistemological views, of which the most important are empiricism, rationalism, historicism and pragmatism (of which pragmatism is the most advanced theory, subsuming the other theories).
>
> That basic conceptions and classifications often first develop in science and scholarship, from which they spread to public media and library classification systems, among other areas.

How does the present book contribute to illuminating these hypotheses?

Concerning (1). The periodic table was mainly constructed before the discovery of quantum mechanics. How can a classification system endure in spite of such a theoretical revolution? The answer is that the periodical system is based on the periodical law stating "that after certain regular but varying intervals the chemical elements show an approximate repetition in their properties" (p. 16). This law is unaffected by later discoveries. In fact, it contributed much to them. The discovery of isotopes did shake the periodic system, but it was rescued by, among other things, a conception of the elements as "basic substances" and not as "simple substances."

Concerning (2). The periodical system is probably one of the most difficult classification systems to defend from a pragmatic point of view. However, it is also important to test our views against the most pre-eminent classifications if our arguments should be convincing.

First, it is clear that although there is only one periodic law, there are many periodical tables (more than 700 different tables have been published), which serve different pragmatic purposes:

Thus, there are many forms of the periodical table, some designed for different uses. Whereas a chemist might favor a form that highlights the reactivity of the elements, an electrical engineer might wish to focus on similarities and patterns in electrical conductivities (Scerri, p. 20).

Scerri discusses elements and their groupings as "natural kinds". The general idea is that the elements represent the manner in which nature has been "carved at the joints": "[o]n this view, the distinction between an element and another one is not a matter of convention" (p. 280). The same is said about their relations: "[i]f periodic relationships are indeed objective properties, as I argue here, it would seem to suggest that there is one ideal periodic classification, regardless of whether or not this may have been discovered" (p. 280).

In the past, this issue has been debated in the literature:

> [S]he [Bryant 2000] nevertheless argues (p. 88–92) that even in the case of chemical elements more than one kind of causal essentialism is scientifically legitimate, that no one kind is privileged.

The fact is, modern scientists classify atoms into elements based on proton number rather than anything else because it alone is the causally privileged factor. Thus nature itself has supplied the causal monistic essentialism. Scientists in their turn have simply discovered and followed (where "simply" ≠ "easily") (Stamos 2004, p. 138–39).

One way to solve this problem has been suggested by John Dupré (2006):

> It is often supposed that one of the goods delivered by successful science is the right way of classifying the things in the world. […] The standard paradigm for such a successful scientific classification is the periodic table of the elements.

However, there is also much potentially wrong with the supposition just mentioned. Most importantly, there is a highly questionable implication of there being some uniquely best classification. Classifications are good or bad for particular purposes, and different purposes will motivate different classifications. It may be that there is such an ideal classification for chemistry, but if so it is because of the specific aims implicit in the history of that discipline. Chemistry aims at the structural analysis of matter and if, as appears to be the case, all matter is composed of a small number of structural elements, a classification based on those elements will be best suited to these purposes. It is also often the case that chemical structure will be the best guide to the properties of kinds of matter, but not necessarily. Two quite distinct chemicals are referred to as 'jade' and, despite some serious debates on the issue, Chinese jade carvers have decided that both are real jade (LaPorte 2004) (Dupré 2006, p. 30).

I see four possible ways of defending the pragmatic view. The first is to assume that (at least certain features of) the periodic system is still open to debate. The second is like Dupré to provide a kind of ad hoc explanation for chemistry: The pragmatic nature of the periodical system is related to the purpose of chemistry, which is the structural analysis of matter. The third is to operate with very general purposes for the sciences, in which case an ideal classification can be understood as the best tool with which mankind can control nature. The fourth is to question the generality of the periodical system's organization of "similar" elements. Chemists are often organized according to pragmatic categories such as agrochemistry, food chemistry, fuel chemistry, pharmacology and toxicology. The periodical system (a "cognitive classification") seems to be somewhat opposed to such "social classifications" of chemists, thus indicating a limit to the prediction of properties.

The properties of objects are not arbitrarily distributed. On the basis of some properties in an object, other properties may be predicted. The atomic number is a strong predictor of basic chemical properties (like the DNA is a strong predictor of biological properties). Thus atomic number and DNA may be considered criteria of natural kinds. Whether or not they are the most relevant criteria in a given classification is another question. Not all properties are predicted by atomic number or DNA, for example. For some purposes, other classification criteria may be more useful.

Concerning (3). Empiricist, rationalist, historicist and pragmatist views can be traced as competing views in relation to the periodical system. This is most clear in relation to the understanding of an "element". Throughout the book, Scerri discusses two ways of understanding chemical elements: as "basic substances" and as "simple substances", which correspond respectively to a rationalist and an empiricist view. According to Scerri, "it is difficult to fully understand the classification of the elements without first attempting to understand what an element is and how such a concept has changed over time" (p. xv). This consideration of conceptual developments in the understanding of the periodical system (often associated with teaching chemistry) is an indication of the importance of the historicist view (again, the consideration of Hegel's view might contribute to strengthening of this view because Hegel is a leading figure in the criticism of empiricism and rationalism). In the chapter about the evolution of the elements, it is stated that "[t]he elements are now believed to have literally evolved from hydrogen by various mechanisms" (p. 250), which also indicates that a historicist metaphysics and epistemology are at play. Finally, the pragmatist view can, for example, be seen in the weight attributed to chemical respective physical properties when determining the "similarities" among the elements. Scerri's view about whether the periodical systems should be explained (and thus reduced to) quantum mechanics alone or whether chemistry has interests of its own can thus be viewed as an indication of the role of a pragmatic philosophy in the development of the periodical system.

Concerning (4). Has the periodical classification influenced the way in which chemical substances are classified in library classification systems, thesauri, etc.? In fact, it can be traced in the UDC (Universal Decimal Classification) and the MEDLINE database. It seems rather obvious that the concepts and criteria used to organize information in library and information science are first developed in other fields—such as chemistry. This, however, is seldom reflected in the methodology of knowledge organization. As already stated, books like Scerri's seem to be ignored in our field.

It should be mentioned that in library and information science, the periodical system was dismissed as a classification system by Hulme (1911), originator of the principle of "literary warrant." Hulme wrote:

> In Inorganic Chemistry what has philosophy to offer? [Philosophy here means science, which produced the periodical system]. Merely a classification by the names of the elements for which practically no literature in book form exists. No monograph, for instance, has yet been published on the Chemistry of Iron or Gold.
> …

Hence we must turn to our second alternative which bases definition upon a purely literary warrant. According to this principle definition is merely the result of an accurate survey and measurement of classes in literature. A class heading is warranted only when a literature in book form has been shown to exist, and the test of the validity of a heading is the degree of accuracy with which it describes the area of subject matter common to the class. Definition [of classes or subject headings], therefore, may be described as the plotting of areas pre-existing in literature. To this literary warrant a quantitative value can be assigned so soon as the bibliography of a subject has been definitely compiled. The real classifier of literature is the book-wright, the so-called book classifier is merely the recorder (Hulme 1911, 46–47)

Hulme's principle of literary warrant seems not to conflict with the way in which the periodical classification has been used in systems like UDC and MEDLINE: if there is no warrant for a given element, the broader category may be applied. However, this issue points to some vagueness in the concept of "literary warrant."

Conclusion

Scerri's book demonstrates how one of the most important classification systems has evolved and what kinds of conceptualizations and classification criteria are at work in it. It is probably *the best book about the best classification system ever constructed*. It should belong to any library supporting teaching and research in knowledge organization.

References

Bryant, Rebecca. 2001. *Discovery and decision: exploring the metaphysics and epistemology of scientific classification*. Madison, NJ: Fairleigh Dickinson University Press.

Dupré, John. 2006. Scientific classification. *Theory, culture & society* 23(2/3): 30–32.

Hegel, Georg Wilhelm Friedrich. 1989. *Science of logic.* New York: Prometheus Books. (Translated from the German: *Wissenschaft der Logik*, first published in 1812).

Hjørland, Birger and Nicolaisen, Jeppe. 2004. Scientific and scholarly classifications are not "naïve": a comment to Beghtol (2003). *Knowledge organization* 31: 55–61.

Hulme, E. Wyndam. 1911. Principles of book classification. *Library Association record* 13: 354–58, Oct. 1911; 389–94, Nov. 1911 & 444–49, Dec. 1911.

Nicolaisen, Jeppe and Hjørland, Birger. 2004. A rejoinder to Beghtol (2004). *Knowledge organization* 31: 199–201.

Ruschig, Ulrich. 2000. Hegel's philosophy of the chemical process: a rehabilitation. Book review of Burbidge (1996). *Hyle-international journal for philosophy of chemistry* 6: 175–77.

Stamos, David N. 2004. Book Review of: *Discovery and decision: exploring the metaphysics and epistemology of scientific classification*. *Philosophical psychology* 17: 135–39.

Professor Birger Hjørland, Royal School of Library and Information Science, DK-2300 Copenhagen S, bh@db.dk

Marc Ereshefsky. *The Poverty of the Linnaean Hierarchy: A Philosophical Study of Biological Taxonomy*. Cambridge: Cambridge University Press, 2007. x, 316 p. ISBN-13: 978-0-521-03883-6.

This book was published in 2000 simultaneously in hardback and as an electronic resource, and, in 2007, as a paperback. The author is a professor of philosophy at the University of Calgary, Canada. He has an impressive list of contributions, mostly addressing issues in biological taxonomy such as units of evolution, natural kinds and the species concept.

The book is a scholarly criticism of the famous classification system developed by the Swedish botanist Carl Linnaeus (1707–1778). This system consists of both a set of rules for the naming of living organisms (biological nomenclature) and principles of classification. Linné's system has been used and adapted by biologists over a period of almost 250 years. Under the current system of codes, it is now applied to more than two million species of organisms. Inherent in the Linnaean system is the indication of hierarchic relationships. The Linnaean system has been justified primarily on the basis of stability. Although it has been criticized and alternatives have been suggested, it still has its advocates (e.g., Schuh, 2003). One of the alternatives being developed is *The International Code of Phylogenetic Nomenclature*, known as the *PhyloCode* for short, a system that radically alters the current nomenclatural rules. The new proposals have provoked hot debate on nomenclatural issues in biology.

Ereshefsky's book is organized into three parts and eight chapters:

A good starting point is Chapter Six, in which it is stated that Linné's system was based on the assumption that plants have two vital functions: "nutrition which preserves the individual, and reproduction which preserves the kind. To know what kind a plant is one needs to study its function in reproduction, in particular, those parts that play a role in its reproduction" (p. 202). This was Linné's main reason to focus on reproductive organs in classifying plants. Another factor in his decision was that "fructification characters are easy to work" with because they are the "most complex organ-system of plants" and "provide a large number of characters" and "can be described with precision" (p. 202). Linnaeus used thirty-one sexual characteristics and four variables, which he calculated would "suffice for 3,884 generic structures or more than will ever exist."

He [Linné] often lacked representatives of all species of a genus and thus was unable to determine the