Educ. quím., **24**(3), 285-287, 2013. © Universidad Nacional Autónoma de México, ISSN 0187-893-X
Publicado en línea el 3 de junio de 2013, ISSNE 1870-8404

Mendeleev and the periodic table: A response to Scerri

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ABSTRACT
This is a response to some of the issues raised by Scerri, "Some comments on the views of Niaz, Rodríguez and Brito (2004) on Mendeleev's periodic system". We thank the Editor, Dr. Andoni Garritz, for inviting us to write this response. However, due to limited space in the journal I shall restrict myself to responding to only the important issues. In order to help the reader I have maintained the same section headings as those of Scerri.

KEYWORDS: response, review, Scerri

Periodicity in the periodic table and atomic theory

According to Scerri, "They [Niaz et al.] claim that most historians take a *naïve inductivist* approach to the development of the periodic table and that they consider that Mendeleev proceeded on the basis of empirical observations rather than the atomic theory" (p. 3, italics added). Once again, Scerri writes: "It would appear that Niaz et al. believe that if they can show that Mendeleev indeed possessed the ability to 'speculate' then they can oppose the vast majority of historians of science who apparently *wrongly* hold that Mendeleev was not a speculator but merely followed the observational evidence like a good naïve inductivist" (p. 4, italics added). Actually, nowhere in the manuscript do we refer to present day historians or Mendeleev as *naïve inductivists.* On the contrary, we referred to their approach as an inductive generalization. A student of philosophy of science knows well that the two are different things. Furthermore, nowhere in our article do we refer to the approach followed by the historians as *wrong*. We simply tried to present an alternative interpretation of Mendeleev's contribution, which was accepted as such by the reviewers of *Studies in History and Philosophy of Science*.

In response to our step 4 (Niaz et al., p. 274), Scerri noted: "Needless to say, this passage does not provide very compelling ammunition for Niaz et al. for at least a couple of reasons. Firstly it is a statement made by Mendeleev a full 20 years after the discovery of chemical periodicity. Secondly it is a statement made to a general audience at an award lecture by a scientist looking back at his achievements. Such statements are notoriously prone to *grandiose generalizations* …" (p. 6, italics added). Now, let us consider the following information:

a) According to Kaji (2003), as early as 1864, in a lecture on theoretical chemistry Mendeleev stated: "In fact, while the atomic theory was strongly supported by the law of definite chemical compounds, it was also challenged by the so-called indefinite compounds" (p. 194). This shows Mendeleev's ambivalence (which we stressed throughout our article) and also the acknowledgment of the relationship between the atomic theory and the law of definite proportions. Interestingly, these views were expressed by Mendeleev a full 25 years before the Faraday Lecture;

b) Van Spronsen (1969) considers Mendeleev's Faraday Lecture of 1889 as "highly influential" (p. 348). Furthermore, a review of the literature shows that most scholars cite Mendeleev's Faraday Lecture.

Readers will note that we have presented counter evidence with respect to the two arguments put forward by Scerri and hence our line of reasoning in Step 4 has been upheld.

In response to our Step 5 (Niaz et al., 2004, pp. 274-275), Scerri stated: "Contrary to what the authors conclude in the final line quoted above, this statement is not an acknowledgment of any role played by atomic theory … Mendeleev consistently argued against the unity of matter and against Prout's hypothesis to that effect" (p. 8). If we read once again Mendeleev's quote in Step 5, it will reveal that it was not the question of Prout's hypothesis (which Mendeleev denied and we noted in our article, p. 275), but rather Dalton's law of multiple proportions, which was at stake. Actually, Mendeleev (1889) himself explains the data presented with respect to the oxides in Step 5, in the following categorical terms: "The periodic law has clearly shown that the masses of the atoms increase abruptly, by steps, which are clearly connected in some way with Dalton's law of multiple proportions …" (p. 642). It is interesting to note that we cited this explanation by Mendeleev in Niaz et al (2004, p. 275) and for some reason Scerri decided to ignore it! Similarly, Weisberg (2007) has endorsed a similar thesis: "Mendeleev showed that the quantity of oxygen in the oxides was a periodic function of the element's group (column) on the Periodic Table … This can be accounted for by the Periodic Law, but would have remained mysterious otherwise" (pp. 214-215). Furthermore, Dalton's law of multiple proportions is considered as evidence to corroborate the atomic theory by the dean of modern chemistry: "The discovery of the law of multiple proportions was the first great success of Dalton's atomic theory. This law was not induced from experimental

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results, but was derived from the theory, and then tested by experiments" (Pauling, 1964, p. 26). The similarity between the explanation provided by Mendeleev in 1864, 1889 and its endorsement by Pauling in 1964 is striking indeed!

Mendeleev as a positivist

According to Scerri: "Whereas the authors [Niaz et al., 2004] imply that Mendeleev's public statements were made for *'political reasons'* and *that he was falsely trying to pass himself off as a positivist* such an interpretation seems a little far-fetched" (p. 9, italics added). This is a gross misrepresentation of our views, as nowhere did we use such expressions, either implicitly or explicitly. On the contrary, we argued that Mendeleev was rather ambiguous/ambivalent with respect to the atomic theory and its role in the periodic table.

Prediction, novel and otherwise

According to Scerri: "… Lakatos wrote a footnote to say that post-diction should be regarded as a variety of 'prediction' the authors seem not to grasp the full worth of this concession" (p. 10). This is surprising indeed! It was Lakatos who included a footnote and hence Scerri's quarrel is not with us.

With respect to novel predictions Scerri states: "In addition many articles have sought to explore this issue more deeply in the context of the periodic table. Although Niaz et al. cite some of these papers they seem to miss the central point since they immediately return to discussing Lakatos and his view of prediction in the narrower sense of novel prediction" (p. 10). Readers would certainly have liked to see some references that treat 'this issue more deeply'. However, Scerri provides not a single example.

According to Scerri: "The article by Scerri and Worrall argues that Brush should not draw back from even applying his view to the acceptance of the periodic table" (p. 11). Actually, Brush (2007) has not drawn back and stated clearly: "Having found little evidence for predictivism in physics, I did find it in chemistry, in particular in the case of Mendeleev's periodic law" (p. 257). So what is the argument!

Once again, Scerri asks a rhetorical question: "Why should the only alternative to the inductive piling up of knowledge be just the use of theory?" (p. 12). Readers would have liked to know some alternatives and Scerri provides none.

According to Scerri: "Are we to understand that Niaz et al. are here even wanting to equate the notion of a hypothesis with that of a scientific theory?" (p. 13). The relationship between hypotheses, predictions and theories is important in both science education and the philosophy of science. According to Lawson (2010): "Persons at Level 1 view science as an inductive and descriptive enterprise. Persons at Level 2 view science in terms of hypothesis generation and test. Persons at Level 3 see science as theory driven. That is, theories are generated and their postulates are tested via planned tests with predicted consequences and *theories are used to generate specific hypotheses*, which are in turn tested in a similar manner" (p. 257, italics added). Interestingly, Lawson considers our interpretation of Mendeleev's contribution as an example of Level 3 epistemology. According to Brush (2007): "It should be recognized that physicists (and some other scientists) use the word 'prediction' to mean 'deduction' (of an empirical fact from a hypothesis or theory) regardless of novelty" (p. 257, n. 1). This clearly shows that hypotheses, predictions and theories are intricately related. Consequently, Wartofsky's (1968) assertion that Mendeleev, "… was using the periodic table as a hypothesis from which predictions could be deduced" (p. 203), necessarily refers to a theoretical framework. On page 13, Scerri reproduced this quote, but without the necessary quotation signs, thus seeming to attribute this statement to Niaz et al (2004). We consider this to be a misrepresentation. In this context, it is important to note that Scerri in an endnote (n. 8) states, "… arguments by Niaz et al. for claiming that Mendeleev was acting as a theorist consist of one single quotation from the physicist *Ziman who was perhaps not being too reflective* …" (p. 17, italics added). A novice student of philosophy of science may wonder if this is how philosophers reason when the evidence goes against them.

In another endnote (n. 6), Scerri states: "The only historian or philosopher of science to my knowledge that has argued for a 'theoretical' reading of Mendeleev's discovery is Michael Weisberg, whose article I have criticized in a recent publication (Scerri, 2012). This makes interesting reading as Scerri's criticism of Weisberg was published in a journal whose Editor is Scerri. Once again a novice student would like to know if Weisberg was invited to respond. Furthermore, readers would like to know what exactly Weisberg (2007) asserted: "… Mendeleev had no empirical knowledge that there were any empty slots to be filled … He first needed to hypothesize the existence of the missing elements by analyzing the *theoretical structure he had created*. Then he was able to use the trends posited by the Periodic Table to make predictions about the properties of the 'missing' elements. This prediction was a theoretical, not merely classificatory, achievement" (p. 214, italics added). Now as Scerri claims that he criticized Weisberg's thesis, let us see what exactly was rebutted: "Unfortunately, Weisberg says nothing to support his claim that Mendeleev examined 'the theoretical structure that he had created'. This claim need to be motivated by some reference to Mendeleev's own writings, although I do not think this will be possible from my knowledge of the Russian chemist's writings" (Scerri, 2012, p. 277). Indeed, it would be interesting to see what Scerri found in the 'Russian chemist's writings'. For the time being we have Weisberg's (2007) elaboration of Menedeleev's theoretical structure, that was ignored by Scerri: "When the elements were properly ordered, Mendeleev argued, one could see the periodic dependence of elemental properties on their atomic weight. This principle, which Mendeleev called *The Periodic Law*, is one of the bedrock principles which organizes chemistry" (p. 213).

Niaz et al. on laws of science

According to Scerri: "If as Cartwright suggests all scientific laws strictly lie, then of course Mendeleev's law too cannot be considered as a strictly valid law of science" (p. 15). A student of philosophy of science knows well the context in which Cartwright suggested that scientific laws 'lie', namely the inclusion of *ceteris paribus* modifiers can make the laws to be better approximations. In our view, if laws are at best approximations, so are theories and hence Mendeleev's theoretical framework needs improvement. This idea has been explained by Weisberg (2007) in cogent terms: "While it is true that Mendeleev's periodic system is in need of further theoretical explanation, the same could be said of any theory that is not a fundamental physical one" (p. 215).

Conclusion

Scerri has gone to considerable length (5845 words) to critique our views about Mendeleev's periodic table. Nevertheless, we have demonstrated (despite limitations of space) that none of his criticisms can be considered as valid, and that at times he simply misrepresents or ignores our position. Interestingly, we have shown that at least three philosophers of science (Wartofsky, Weisberg and Ziman) endorse the view that Mendeleev's periodic table can be sustained by a theoretical framework.

Acknowledgments

I would sincerely like to thank Michael Weisberg (University of Pennsylvania) and Paul Needham (University of Stockholm) for having read the first draft of this 'Response' and made important suggestions for its improvement.

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