

Mendeleev's Elemental Ontology and Its Philosophical Renditions in German and English

Conal Boyce

Abstract: We contrast two facets of elemental ontology, one so straightforward that it can be taught as the adjunct to a grade-school chemistry demonstration, the other involving eight decades of discourse at the graduate-school level. To explore the latter, we begin by critiquing the Lavoisier/Mendeleev relation as presented by Fritz Paneth in 1931 in German. Following the 2003 re-issue of Paneth 1962 (an English translation), one observes a gradual shift such that Paneth seems the source of the substance/element distinction that was drawn by Mendeleev in 1869. Eventually, in 2009, a certain wheel is reinvented: Mendeleev's. We advocate that the focus be returned, overtly, to Mendeleev, and to two of his words in particular, substance (вещество) and element (элемент). When suitably framed, those two words alone capture the essence of his elemental ontology.

Keywords: *Mendeleev, elemental ontology, abstract element, basic substance, Grundstoff.*

1. Introduction

The name Mendeleev is associated mainly with the periodic system, the more so in this International Year of the Periodic Table which marks the sesquicentennial of his first draft, dated 1869. In this article we focus on a different aspect of Mendeleev's thinking, one which is not widely appreciated: his elemental ontology, likewise of 1869 vintage. As prelude to Mendeleev's text, we begin Section 2 by looking at mercury (II) oxide formation and dissociation, not with reference to oxygen theory but from a naïve, grade-school perspective¹ wherein the 'disappearance' of Hg into HgO, and the subsequent 'recovery' of Hg metal, have the potential to suggest, already, a substance/element/substance paradigm which is essentially that of Mendeleev.

In Section 3, we look at certain problems that arise when translating Mendeleev's Russian. Some of these difficulties are inherent in the context of French, German, and English vocabulary as it changed over the centuries; others are specific to the Russian text itself. In particular, Mendeleev's non-standard use of the phrase 'concept of X' has caused trouble from the beginning, only to be exacerbated by Paneth's nonstandard use, in 1931, of the corresponding phrase in German.

In Section 4, the scope broadens as we turn from translation issues to those of interpretation – and, oddly enough, to something like an attribution or 'priority' issue, if you like, regarding the very idea of the transcendental element itself. Through no fault of his own, Paneth has come gradually – over the period 1931-2014 and beyond – to be seen as the one who first *drew* the crucial distinction between concrete substances and abstract elements, not the one who sought only to *interpret and promote that distinction of Mendeleev's* by correcting his 'inapt' terminology. A major facilitator of the gradual shift in attribution was the 2003 reprint of H. Paneth's 1962 translation of F. Paneth (1931), which Scerri then alludes to via the term 'basic substance' found on many pages of his influential 2007 book.² This is not to say that Scerri neglects to mention the red mercury oxide passage in Mendeleev, which is central to this article, but the way he introduces it is problematic.³ Evidence of the 'attribution drift' that I posit can be seen in Earley 2009, Ruthenberg 2009, and Mahootian 2013. In the three corresponding abstracts, Aristotle and Kant are mentioned in connection with Paneth's metaphysical element, but Mendeleev is not mentioned. Similarly, in van Brakel 2014, while Mendeleev's name appears once on p. 14 – where it is folded in with those of Crick, Pasteur, Einstein, Newton, and Copernicus – it is Paneth alone who is given credit on p. 26 for a "proposal to distinguish basic and simple substances", which is to say in plainer language, elements and elemental substances.

We advocate that Mendeleev's red mercury oxide passage be recognized as the source of the proposal that is nowadays so often attributed to Paneth, and that Paneth's terms 'simple substance' and 'basic substance' be reassessed against the backdrop of Mendeleev's straightforward terms 'substance' and 'element' which are ancestral to them.

Time out to explain my convention for referencing certain works of Friedrich Adolf Paneth (1887-1958) and his translators. By 'Paneth 1931', I refer to pages in a paper based on the lecture he delivered in 1931, known as the Königsberg lecture. Paneth 1962[1931] is the lecture's translation from German to English which was done by Heinz Paneth, his son, who is known also by his anglicized name, Heinz Post. Paneth 2003[1962] is the reprint of Paneth 1962; whenever I quote from the English translation, my page references are to this 2003 reprint. Paneth 1964[1936] is the translation into English of Paneth's 1936 Leningrad article; in this instance, the translator is Eva Paneth,

his daughter. For historical context, see the biographical sketch of Paneth by Ruthenberg (1997).

2. Two Preliminary Approaches to the Terms 'Substance' and 'Element'

Upon entering a classroom, suppose the students see, on the whiteboard, a simplified version of this: $2\text{Hg}(l) + \text{O}_2(g) \rightleftharpoons 2\text{HgO}(s)$. Let us say that these are middle-school or high-school students, to put it in U.S. parlance. Accordingly, the instructor has written the reaction(s) in the most rudimentary form, $\text{Hg} + \text{O} \rightarrow \text{HgO} \rightarrow \text{Hg} + \text{O}$, with state symbols and stoichiometric coefficients deferred for another day. Whether intended or not, a benefit of this minimalist approach is that it presents an opportunity for noticing the interplay of Hg *as* a substance versus Hg *as* an element – an aspect that would otherwise be lost to concerns about time limitations or information overload (see Figure 1).

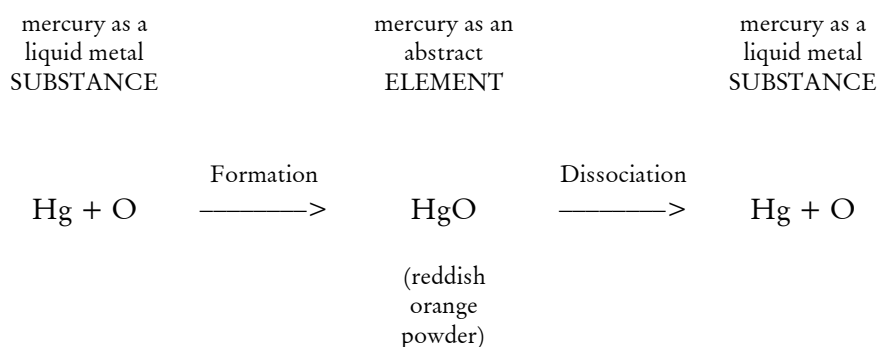


Figure 1: Illustrating mercury *as* a substance and *as* an element. For our hypothetical grade-school demonstration, we show a simplified formula to be supplemented later in the school year by the formal equation $2\text{Hg}(l) + \text{O}_2(g) \rightleftharpoons 2\text{HgO}(s)$.

Our hypothetical instructor covers the formation step verbally, by a quick retelling of the Twelve Days Experiment (Lavoisier 1789, pp. 35-36). To illustrate the dissociation step, she heats a quantity of HgO in a test tube. To emphasize the interplay of substance and element, she points out the round-tripping aspect whereby a liquid metal has, in a manner of speaking persisted, “after going *into* the reddish-orange HgO powder and coming back *out* of it”

to regain its original form and characteristics. By the end of this one short demonstration, the instructor has conveyed, at least to some members of her class, exactly what Mendeleev *intended* to convey about ‘substances’ (вещества) and ‘elements’ (элементы) in the Preface to his *Principles of Chemistry* in 1869. Namely, that standing just ‘behind’ or ‘beneath’ the substances in test tubes exists a foundational realm of the abstract transcendental⁴ element.

Or, in his own words, wherein he too uses HgO to illustrate the distinction:

- 1 В этом отношении полезно сделать ясное различие между понятием о
- 2 **простом теле**, как об *отдельном* однородном *веществе*, и о нем же, как о
- 3 *вещественной части* или *элементе* сложных веществ [...]
- 4 В красной ртутной окиси содержится не два **простых тела** – металл и газ, а два
- 5 **элемента**: ртуть и кислород, дающих в отдельности металл и кислородный газ.
- 6 Не ртуть, как металл, и не кислород в своем газообразном виде содержатся в красной ртутной окиси:
- 7 в ней содержится только **вещество** этих простых тел, как в водяном паре содержится
- 8 только **вещество** льда, но не самый лед, или как в хлебе содержится **вещество** зерна,
- 9 но не самое зерно. [Mendeleev 1947(1869), p. 15]

- 1 In that respect it is useful to make a clear distinction between the concept of
- 2 **simple body** as a *separate* homogeneous *substance* and as
- 3 the *material part* or *element* of complex substances [compounds] [...]
- 4 Red mercury oxide does not contain two **simple bodies** – a metal and a gas, but two
- 5 **elements**: mercury and oxygen, which in their separate [states] are a metal and oxygen gas.
- 6 Neither mercury, as a metal, nor oxygen in its gaseous state is contained in red mercury oxide:
- 7 In [the HgO] is contained only the **substance of** these simple bodies, just as water vapor
- 8 contains only the **substance of** ice, not ice itself, or as bread contains the **substance of** grain,
- 9 but not grain itself. [English translation by V. Tsimmerman, edited by CB]

Let’s call this the ‘red mercury oxide passage’. In it, all italicization is original. When unitalicized, *веществе* is *веществе* (substance); *элементе* is *элементе* (element); and *вещественной части* is *вещественной части* (see discussion below). Colored font and line numbering have been added to facilitate parallel reading.

Is the passage difficult? Yes and no. By way of Figure 1, we have seen already how the words ‘substance’ and ‘element’, which occur in lines 2 and 3 above, possess the potential for conveying the whole message. The trouble comes with the half-dozen auxiliary terms that accompany them, especially the one that Mendeleev uses just ahead of them as his point of departure: ‘simple body’ (простом теле). When considered across diverse linguistic borders down the ages, the term ‘simple body’ is found to possess a number of meanings, and with them the likelihood of muddying the substance/element contrast. This problem is compounded by Mendeleev’s nonstandard use of the concept-of-X construction, as mentioned earlier. Yet another trouble spot is *вещественной части* (‘material part’ or ‘substantial part’, line 3). That term is, in my opinion, a non sequitur that the reader should simply skip over. In 1891, it proved so distracting that it caused элемент, the most important word, to be lost in the shuffle, in both the German and English translations. This issue will be revisited in Figure 2.

There are two additional hurdles to mention. In line 4 we see this: “Red mercury oxide does not contain two simple bodies – a metal and a gas”. That is another non sequitur, requiring us to read this in its stead: “Red mercury oxide does not contain two substances – a metal and a gas”; only then does the line accord with the key word ‘substance’ as introduced in line 2. Finally, there is a distinction to note regarding ‘substance’ in line 2 versus ‘substance of ice’ in line 8 (where the Russian genitive translated literally would be ‘substance ice’s’). By ‘substance-of-X’ what Mendeleev denotes is the chemical *essence* of X, which is to say the identity of X in terms of its *abstract* elemental makeup. In other words, the term ‘substance’ in the ice analogy points back to ‘element’ in line 3, not to ‘substance’ in line 2 as one might assume at first glance. The similarity of ‘substance’ in the substance/element distinction to ‘substance of’ in the ice and grain analogies is a red herring.

Before proceeding to Section 3, we should note that relative atomic mass was an important part of Mendeleev’s formulation:⁵ “Mendeleev’s genius now lay in recognizing that just as it was the ‘element’ that survived intact in the course of compound formation, so atomic weight was the only quantity that survived in terms of measurable attributes” (Scerri 2007, p. 115).

3. On the Translation of Mendeleev’s Russian into German and English

The most important phrase in the red mercury oxide passage can be distilled to the following ten-word essence:

различие между **понятием о простом теле** как веществе, как элементе
razlichkiye mezhdu ponyatiyem o prostom tele kak veshchestve, kak elemente
 the distinction between the **concept of simple body** as a substance, as an element

Reading between the lines, we deduce that Mendeleev intended the term ‘simple body’ to serve merely a vehicle for introducing his substance/element insight. However, reading those same lines *objectively*, we see that ‘simple body’ holds center stage while ‘substance’ and ‘element’ trail behind as ‘*kak*’-constructions, in the form ‘as X, as Y’. This overall structure of the phrase betrays a presumption of Mendeleev’s that concepts are fissile. Oddly enough, this unusual and wholly insupportable notion that concepts are fissile is exhibited independently in Paneth 1931. Moreover, the context in which Paneth proposes that a certain concept be split is closely associated with his misreading of the German translation of the red mercury oxide passage. Accordingly, we shall shift our focus for a moment to Paneth, before continuing with an examination of ‘simple body’, a term that has potential, on its own, to sow confusion.

The term ‘*Elementbegriff*’ is featured in Paneth’s 1931 title, and again in his heading for §5, which occupies pp. 116-121. In the lecture’s title, the phrase ‘*Stellung des chemischen Elementbegriffs*’ may be translated as ‘Status of the Concept of the Chemical Element’, and in that case ‘*Elementbegriff*’ (the concept of element) presents no problem. But in the §5 heading we have this: ‘*Doppelte Bedeutung des chemischen Elementbegriffs*’ (‘The Double Meaning of the Concept of Chemical Element’). Recall that Mendeleev wishes to break down a given concept, *as X* and *as Y*; similarly, Paneth here proposes the splitting of one *Begriff* (concept) into two *Bedeutungen* (meanings) to clarify its two *Seiten* (aspects).⁶ Whereas, in normal usage, we expect the term ‘concept’ to be reserved for something final and unitary, not something fissile. After all, in any field of inquiry, reduction to a clear inventory of concepts is one of the main goals, so well understood that one might hesitate even to voice it as such. And if we do encounter something fissile, we would usually interpret it to be an overloaded *term*, readily resolved into more *terms*, not a concept in need of dissection.

To remind ourselves of what normal usage is, let us consider the section entitled ‘*The element concept*’ in van Spronsen 1969, pp. 11-13. There he covers the ancients in India, China, and Greece, up through the Arab alchemists and on to Prout. Through it all, never once does van Spronsen suggest a bifurcation of the ‘element concept’ *itself*, only its wide variation and growth across the centuries. That approach is echoed in the phrase ‘*verschiedene historische Stadien des Elementbegriffs*’ (different historical stages of the concept of element) in Schummer 1996, p. 16. And on pp. 101-165 of the latter volume, the concept of element – as *Elementbegriff* or *Elementkonzeption* – is traced across a similarly broad expanse of historical and philosophical con-

texts. There, quite appropriately, the term ‘*Umdeutung des Elementbegriffs*’ (reinterpretation of the concept of element) occurs several times, but one will search those pages in vain for a single case where anyone proposed breaking the concept itself into two parts. I supplement the earlier example with this German-language reference lest the Anglophone reader imagine that ‘*Begriff*’ might operate in some exotically different way than ‘concept’ does in English. It does not.⁷

When Paneth speaks of the ‘concept of element’ possessing ‘two meanings’, one might try to make sense of the phrase by interpreting it this way: Nowadays, the one term ‘*Element*’ is used to cover two concepts which need to be broken out and separated. The first concept is that of *Grundstoff*, the second that of *einfacher Stoff*. Alternatively, one might try reading the phrase literally but in that case it leads immediately to a philosophical objection. Thus, Schummer’s remark that Paneth seems to have proposed *eine ontologische Verdopplung der Elemente* (an ontological doubling of elements; Schummer 1996 p. 234). This ‘serious attack’ on §5 of the Königsberg lecture is duly noted in Ruthenberg 2009, p. 88n11.

Having remarked on Mendeleev’s *concept-of-simple-body* usage and on Paneth’s similarly nonstandard *concept-of-element* usage, we return now, as promised, to the term ‘simple body’ itself:

Facet 1: ‘Simple body’ means element. In early writings, up to the time of Lavoisier, one often finds the term ‘simple body’ treated as a synonym for ‘element’. *E.g.*, “[S]imple bodies in the chemical sense are those which can be no further decomposed into unlike particles by chemical artifices; they are called by another name ‘elements’” (Gmelin 1780, quoted in Paneth 2003[1962], p. 126).⁸ While the French term ‘*substance simple*’ is prevalent in Lavoisier’s *Traité* of 1789, it is worth noting that the term ‘*corps simple*’ (‘simple body’) also occurs there (Lavoisier 1789, pp. xviii, xxxiii, 1, 124, and 193). The latter instance occurs opposite the renowned *Tableau des Substances Simples* itself on p. 192. Finally, we note that in present-day dictionaries, ‘*corps simple*’ is glossed as ‘element’, although going the other way, English ‘element’ is defined as *élément*.

Facet 2: Russian and German conventions that throw us a curve. In the late eighteenth century, Lavoisier’s ‘*substance simple*’ (‘simple substance’) was rendered into Russian *not* by простое вещество (prostoye veshchestvo, the term whose literal meaning is simple substance), rather by простое тело (prostoye telo, the literal meaning of which is simple body).⁹ Meanwhile, what happens in German? In connection with Lavoisier, often we see the straightforward translation of ‘*substance simple*’ into ‘*einfacher Stoff*’ (*e.g.*, in Paneth 1931, pp. 112-120, and Schummer 1996, pp. 134-135). Or, the term ‘*einfacher Körper*’ might be used (*e.g.*, Kopp 1873, p. 209, or Röcker 2017, p. 75, where ‘*einfacher Körper*’ and ‘*einfache Substanz*’ [simple substance] occur together

on the same page, both in the context of Lavoisier's *Traité*). So, when Paneth refers to Mendeleev and his *Begriff des einfachen Körpers* (1931, p. 121), what exactly is the intent? Does it *just* mean 'simple body', in which case the whole story is told by 'concept of simple body' in Paneth 2003[1962], p. 133? Or, since F. Paneth is critiquing a Russian writer, might he have used 'simple body' the Russian way, to refer to Lavoisier's '*substance simple*'? We shall revisit these questions in due course.

Facet 3: the 1899 /1869 discrepancy. Mendeleev's 1899 article appeared in *French*; an English translation of it is provided, for the first time, by Jensen (Mendeleev 2005, pp. 192-226). On p. 193, we find this: "The central idea that aided me [...] consists precisely in this absolute distinction between an *atom* and a *simple body*" (original emphasis). In Bent 2006 we find that passage repeated, with variations, as a kind of mantra on pp. 31, 78, 117, and 176-177. Was there a French/English translation problem? No. On p. 212 of the original Mendeleev 1899 article we find this phrase: "la distinction absolue entre *atome* et *corps simple*" (original italics); moreover, the two key terms are repeated on p. 213. So this is not a fluke, not a case of the French having been mistranslated to English. (Here we take on faith, since it probably cannot be investigated, that Cordillot made a reliable translation to French of Mendeleev's original draft in Russian; cf. Jensen in Mendeleev 2005, pp. 153, 158.) But how to reconcile the high profile of '*corps simple*' in this context with простое тело ('simple body') in Mendeleev 1869, where 'simple body' served merely as the vehicle for introducing the main event, which was the substance/element (вещество/элемент) distinction? Could it really have been Mendeleev's intent to thus supplant his own earlier distinction, which was original and cogent, by language in which some would hear echoes of pre-Lavoisier times and others would hear a reference to nineteenth century atomic theory, in which he absolutely did not believe? Unfortunately, Jensen makes no comment on this curious development. Bent, for his part, accepts Mendeleev 1899 at face value (via Jensen, that is), in apparent innocence of the discrepancy – and perhaps even in ignorance of Mendeleev 1869? I have no resolution to propose; I merely note the problematic relation of Mendeleev 1899 to Mendeleev 1869.

We now review part of the red mercury oxide passage from a different perspective: its treatment in three published translations (see Figure 2).

Why did Kamensky render Mendeleev's 'simple body' (простом теле) as 'element'? To treat those two terms as interchangeable might suggest a classical, pre-Lavoisier orientation. However, since the context in question is Russian, and post-Lavoisier, we expect the term простое теле to denote Lavoisier's *substance simple*, as explained earlier. As I read it, простое теле is merely Mendeleev's point of departure, on his way to the all-important substance/element distinction, by which he intends to breathe new life into

French ‘*élément*’, German ‘*Element*’ and English ‘*element*’, along with Russian элемент itself. But neither of the 1891 translations allows this message to be conveyed.

<p>В этом отношении полезно сделать ясное различие между понятием о простом теле как об отдельном однородном веществе, и о нем же, как о вещественной части или элементе сложных веществ.</p>	<p>Source: Mendeleev's Основы химии [<i>Principles of Chemistry</i>] 1947[1869], page 15 in the pdf of the Preface.</p>
<p>In that respect it is useful to make clear the difference between the concept of a simple body as separate homogeneous substance and as the material part or element of complex substances [compounds].</p> <p>This is a reference translation kindly provided by Valery Tsimmerman. For argument's sake, let's say this one is our 'gold standard' against which to judge the three translations below.</p>	<p>Orthography notes for the Russian text: All italics are original. The word <i>вещество</i> unitalicized is <i>веществе</i> 'substance' or 'matter'. <i>вещественной части</i> unitalicized is <i>вещественной части</i> 'substantial part' or 'material part'. <i>элементе</i> unitalicized is <i>элементе</i> 'element'.</p>
<p>It is useful in this sense to make a clear distinction between the conception of an element as a separate homogeneous substance and as a material but invisible part [-----] of a compound.</p> <p>—Kamensky tr., 1891. Extracted from a longer excerpt that appears in Scerri 2007, p. 115.</p>	<p>Discrepancies: 1. 'simple body' is rendered as 'element'; 2. 'invisible' is commentary, not translation; 3. 'element' is absent where actually needed; this is represented by '[-----]'.</p>
<p>[Mendeleev emphasizes forcefully the difference] zwischen dem Begriffe des einfachen Körpers als eines einzelnen homogenen Stoffes und als des sinnlich nicht wahrnehmbaren stofflichen Bestandteiles [-----] eines zusammengesetzten Körpers.</p> <p>—Jawein and Thillot tr., 1891, Mendelejeff, <i>Grundlagen der Chemie</i>, p. 27. This is cited in Paneth 1931, p. 121, with minor spelling variations.</p>	<p>In lieu of Kamensky's 'invisible', here we find <i>sinnlich nicht wahrnehmbaren</i> ('not perceptible to the senses'). Again this is commentary not translation, and again it leaves the reader in the dark regarding the most important word, 'element'.</p>
<p>[Mendeleev emphasizes forcefully the difference] between the concept of a simple body as a single homogenous substance and as a material constituent, not perceptible to the senses, [-----] of a composite body.</p> <p>—Paneth, 2003[1962], p. 133; see also pp. 143n47 and 144n56.</p>	<p>This is Heinz Paneth's English for the German text above. The translation appears faithful, which is to say, it further disseminates any defects of the Jawein/Thillot version.</p>

Figure 2: Mendeleev's Russian mistranslated into German and into English

In the context of philosophy, there are those who would be careful to minimize or even exclude philological forays as being off-topic. For example, Ruthenberg (2009, p. 84) dismisses one of Earley's objections to H. Paneth's

‘basic substance’ as having ‘a mere linguistic character’. Not by design, our review above of certain Russian translation problems carries with it the following subtext: One draws the philology/philosophy line too sharply at one’s peril; in the absence of carefully defined words, how can one claim to be engaged in philosophy that deserves the time and attention of the listener?

The crucial word ‘element’ is missing at ‘[-----]’ in all three of the published translations shown in Figure 2. Small wonder then that Mendeleev’s elemental ontology was not immediately understood outside of Russia. And long before the 1891 translations, the waters had been muddied by the Beilstein incident as well. In an 1869 article in *Zeitschrift für Chemie*, Beilstein had rendered Mendeleev’s phrase ‘yavstvennyuyu *periodichnost*’ svoystv’ (which means ‘distinct *periodicity* of properties’, original emphasis) into German as *stufenweise Abänderung in den Eigenschaften* (which means ‘gradual change in properties’). That error – involving the single word, ‘*periodichnost*’ – led to ten years of strife between Mendeleev and Lothar Meyer over the priority question (see Gordin 2015, pp. 55–64, 345n12–n15). Gordin takes *stufenweise* to mean ‘phased’ rather than ‘gradual’ but the upshot is the same: The phrase ‘distinct *periodicity*’ is lost in the shuffle. Was Beilstein only harried and not paying attention, as suggested by Gordin? Was this yet another case of someone gratuitously ‘interpreting’ a word instead of simply translating it? Perhaps it is best to take the Beilstein incident as a cautionary tale about working ‘at the edge’ of any field, where the translator may be honestly in a quandary, precisely because the author *is* blazing a new trail?

4. A Chemist-philosopher (1931) and the Philosophers of Chemistry (1962–2014)

In the previous section, not because one wished to be more philological than philosophical, but only to build a necessary foundation across several linguistic borders and time periods, we found ourselves operating generally at the level of individual words. The discussion now moves to a higher semantic plane, and brings us into direct contact with the chemist-philosopher, philosopher-chemist, and philosophers of chemistry proper.¹⁰ In this section, we are concerned with how the substance/element distinction of Mendeleev gave way to a ‘simple substance’ / ‘basic substance’ contrast which, in turn, came to be seen, over the decades, as the intellectual property of Paneth, not Mendeleev. I hasten to add that Paneth himself is innocent of that shift in perceived ownership away from the author of the idea. Nor is Paneth responsible for the gradual emergence of Kant’s name in connection with his own, as candidate for Spiritual Father of Dualism in Chemistry. Paneth made it clear

that his own point of reference was Hartmann, not Kant, as Earley (2009, p. 68) reminds us. In Ruthenberg 2009, p. 84, too, we are reminded of Hartmann, yet Ruthenberg goes on to spend twice as much time on Kant and on possible threads of connection from Kant to Paneth (pp. 85-86). And, by the time we come to Mahootian in 2013 (see pp. 171, 176 and *passim*), *only* Kant¹¹ is mentioned in connection with Paneth.

Lavoisier	<i>substance simple</i>	≈	<i>élément</i>
Mendeleev	The essence of the formulation resides here		
различие между понятием о простом теле	как вещество	как элементе	
<i>razlichiyе mezhdu ponyatiyem o prostom tele</i>	<i>kak veshchestve</i>	<i>kak elemente</i>	
the distinction between the concept of	simple body	as SUBSTANCE	as ELEMENT
<i>Unterschied zwischen dem Begriffe des einfachen Körpers</i>	<i>als Stoffes</i>	<i>als des sinnlich nicht wahrnehmbaren stofflichen Bestandtheiles eines zusammengesetzten Körpers.</i>	
Paneth	<p>Mendeleev “emphasizes very forcefully the difference ‘between the concept of simple body [<i>einfachen Körper</i>] as a single homogeneous substance [<i>Stoff</i>], and as the material constituent [<i>stofflichen Bestandtheiles</i>], not perceptible to the senses, of a composite body.’ Only in the latter sense does he call a simple body an ‘element’.”</p> <p>[So far so good, but now Paneth conflates the first two members of the tripartite formulation:]</p> <p>“I can think of only one reason why his very justifiable distinction [has] not produced any echo in later chemical textbooks; namely, his inapt terminology. ‘Element’ [<i>élément</i>] and ‘simple body’ [<i>einfacher Körper</i>] were introduced by Lavoisier explicitly as synonyms [...] and it is thus hardly possible to use them to designate opposites. For this reason I have preferred to speak of basic substance [<i>Grundstoff</i>] and simple substance [<i>einfacher Stoff</i>] as different aspects [<i>Seite</i>] of the chemical concept of element.”</p> <p>—Paneth 2003[1962], p. 133, italics removed; German inserted from Paneth 1931, p. 121.</p> <p>Later, Paneth offers this retrospective on his 1931 lecture: “I attempted to define more precisely the epistemological status of the chemical concept ‘element’, and especially to do justice to the double meaning that [Mendeleev] had in mind [for it]”; Paneth 1964[1936] p. 58. Assuming the translation by Eva Paneth to English is accurate, this 1936 passage only compounds the confusion, as F. Paneth now conflates the first and <i>third</i> constituents of Mendeleev’s formulation whereas in 1931 he had conflated its first and second members.</p>		

Figure 3: Details of how Paneth misreads Mendeleev and the Mendeleev/Lavoisier relation. Source for the Russian: Preface to *ОСНОВЫ ХИМИИ [Principles of Chemistry]* 1947[1869], p. 15, abridged to bring out the bare bones of Mendeleev’s formulation. Translation to English by CB. The formulation has a tripartite form as indicated by the boxed items. Regarding the rendition into German by Jawein & Thillot (1891, p. 27), see Figure 2.

Still, the blame does fall on Paneth for planting a seed of confusion out of which the distortions referred to above would eventually grow over an eighty-year period. It all begins with Paneth's misreading, in 1931, of a single sentence in the Jawein/Thillot translation of the red mercury oxide passage, which itself was already problematic, partly because of Mendeleev's 'concept of' usage, partly because of Jawein/Thillot's loose translation of his Russian to German.

In the 'Mendeleev' panel of Figure 3, the Russian is not a verbatim quote, but (again) a distillation from the 1869 text, with English and German translations. There are three boxed items which call out the tripartite syntax of Mendeleev's exposition. In the next panel, I show a key passage from the Königsberg lecture, in English translation, with important German terms inserted in brackets. As represented there, Paneth seems at first to be following Mendeleev faithfully, as he refers to the three constituents of Mendeleev's tripartite structure each in turn, as *einfacher Körper*, *Stoff* and *stofflicher Bestandteil* (per the Jawein/Thillot translation, that is, to be revisited in a moment). But then, in Paneth's account of Mendeleev, we find the first two pieces of the tripartite structure collapsed into one. This conflation error we indicate with a pair of arrows leading down in a large V-shape, from 'einfachen Körpers' and 'Stoffes' in one panel to a single term in the next panel. At this point one must conclude that Paneth has – in a small but crucial way – misconstrued Mendeleev's intent.

Paneth opines that Mendeleev should not have tried presenting *einfacher Körper* and *das Element* as opposites since Lavoisier had treated *substance simple* and *élément* as synonymous. At a superficial level, that admonition of Paneth's 'makes sense', given the backdrop of the nonintuitive usages that we detailed earlier in 'Facet 2': The alignment of *einfacher Körper* (simple body) with *substance simple* (simple substance) looks odd but is, in that limited sense, correct. The trouble with the admonition is in its intended purport, which lacks a logical foundation. Mendeleev's actual proposal is built upon his own term *veshchestvo* ('substance') – plain and simple. I find no justification for believing that he sees *prostom tele* as the 'opposite' of element (элемент). To remain preoccupied with the part of our diagram that contains the loaded term 'substance simple', beneath which we see *prostom tele*, 'simple body', and 'einfachen Körpers', is to miss the point of his formulation. Read correctly, his *prostom tele* is like the raft that one leaves behind on the shore, after having crossed the proverbial stream.

As for Jawein and Thillot, they honor the tripartite form itself, but effectively ruin it a different way. Rather than trust the German word 'Element' to translate Russian элемент, they introduce a phrase of their own invention that skips over 'element' itself while endeavoring to convey its purport with a dozen other words: "the material constituent, not perceptible to the senses,

of a composite body” (*des sinnlich nicht wahrnehmbaren stofflichen Bestandtheiles eines zusammengesetzten Körpers*).¹² Whatever their good intentions may have been, to explain how an element can be transcendental, what we notice today is that they left their German readership in the dark as to Mendeleev's actual text. To his credit, Paneth manages to read between the lines and deduce *Element* as the missing piece of the puzzle. (See “Only in the latter sense...” as quoted in Figure 3.) But thereafter, Paneth becomes preoccupied with Mendeleev's supposed clash with Lavoisier, and thus goes astray.

In a 1936 article, Paneth again criticizes Mendeleev's terminology, now taking this tack which leads, as Paneth would have it, once again back to Lavoisier: “[T]he terms used by Mendeleev are not very appropriate [and] by coupling them to the pair of concepts, *molecule* and *atom*, he seems to have missed the essential point. It is hardly possible in chemistry to introduce a contrast between elements and simple bodies, as the definition of the element since Lavoisier is based on the simple body” (Paneth 1964[1936], p. 57, original italics).

How do we get from ‘element’ versus ‘simple body’, on which Paneth's 1931 critique was focused, to atom-versus-molecule as the focus of his 1936 critique of Mendeleev? As of 1936, I suspect that Paneth might have been looking at the first page of Mendeleev's 1871 article:

Just as the words ‘molecule’ [and] ‘atom’ [...] were used indiscriminately [in the past], so now the terms ‘simple substance’ and ‘element’ are often confounded with one another [...] The idea of a simple substance corresponds to that of a molecule [...] [I]n opposition to this, the term ‘element’ designates those material particles of simple and compound substances which determine their behavior from a chemical and physical point of view. The word element corresponds to the idea of an atom. [Mendeleev 2005 (1871), p. 38]

As I read it, the above passage takes the form of an A:B::X:Y analogy. In that analogy, it is not Mendeleev's intent that we couple A-to-X and B-to-Y; rather, he is making a comparison of A-*and*-B against X-*and*-Y, which is to say that he intends ‘atom’ only in the retrospective, pre-Lavoisier, classical sense. This reading of the analogy is supported by Bensaude-Vincent 1986, p. 11. It appears that Paneth adopts the other reading, according to which one would associate the term ‘atom’ with nineteenth century atomic theory. And that would be to once again put words in Mendeleev's mouth. Note that this confusion about the term ‘atom’, as used in Mendeleev 1871, is separate from the confusion engendered by Mendeleev 1899, the article published in French that we discussed already as part of ‘*Facet 3*’ above.

Let's suppose, for argument's sake, that Paneth was the one who (re-)introduced to the world the idea of a concrete/transcendental distinction, not Mendeleev. The way Paneth handles the job is itself problematic:

Ich habe immer dann von einem *Grundstoff* gesprochen, wenn die *unzerstörbare, in Verbindungen und einfachen Stoffen vorhandene Substanz bezeichnet werden sollte*. [Paneth 1931 p. 117, original emphasis, bolding on ‘Substanz’ added by me]

I have referred throughout to ‘*basic substance*’ whenever *the indestructible substance present in compounds and simple substances was to be denoted*. [Paneth 2003[1962] pp. 129-130, original italics; bolding on ‘substance’ added by me]

I have referred throughout to ‘*basic substance*’ whenever *the indestructible stuff present in compounds and simple substances was to be denoted*. [van Brakel 2014 p. 26. Here van Brakel is citing the 2002 prerelease of the Paneth reprint; I’ve added bolding to show where his citation diverges from what appears the following year in *Foundations of Chemistry* 2003 itself.]

Gone is the simplicity and clarity of Mendeleev’s ‘element’; instead we are now invited to contemplate an ‘indestructible substance’ (*unzerstörbare Substanz*). But ‘substance’ is the very last word we want to see when trying to conjure a notion of the *transcendental* nature of the elements. Note that someone (either an editor during the interval between the 2002 prerelease and the actual 2003 reprint, or perhaps van Brakel on the fly) changed ‘indestructible substance’ to ‘indestructible stuff’. True, this emendation helps mirror – albeit backwards – the lexical distinction of *Stoff* vs. *Substanz* in the German original, but it leaves untouched a more important issue: How can *any* such word be accommodated in a passage whose aim is to sensitize us to the metaphysical, transcendental, *abstract* facet of the elements? It cannot. Whether translated as ‘substance’ or ‘stuff’, the word *Substanz* has no business being there at all.

Awkwardly though the distinction is drawn by Paneth, he is the one who nowadays is routinely given credit for it (see Earley 2009, p. 75; Mahootian 2013, pp. 171 and 176; van Brakel 2014, p. 26; and others). Here is a representative statement: “Immanuel Kant has built up a dualistic epistemology that seems to fit to the peculiarities of chemistry quite well. Friedrich Paneth used Kant’s concept and characterised simple and basic substances [*einfacher Stoff* and *Grundstoff*] which refer to the empirical and to the transcendental world, respectively” (Ruthenberg 2009, p. 79). In that article, there is a fleeting mention of Mendeleev, but it exemplifies just that special flavor of inaccuracy that manifests so often across linguistic borders in general, and in particular in connection with Paneth and Mendeleev:

If we say, as did Boyle, that elements are the last products of analysis, then we are using the concept of empirical entities, which Paneth, *like before him Mendeleev* (see e.g. Paneth 1936, and Scerri 2007, pp. 120-121) and Urbain (see, e.g. Kragh 2000, p. 443) called ‘*simple substances*’ (*einfache Stoffe*). [Ruthenberg 2009, p. 83, italics added]

But as the reader of this article understands, the term 'simple substances' occurs not in Mendeleev but in Paneth, and there only in Paneth's own separate formulation that *follows* his synopsis and critique of Mendeleev (see Figure 3).

How is it that Paneth feels the need in 1931 to introduce fresh vocabulary (*Grundstoff*) rather than face the problem head-on by dealing with the German word, 'Element'? From the passage quoted earlier (Paneth 1962[1931] pp. 132-133) we gather that he believed the word 'élément', along with its counterparts in diverse non-French languages, must remain untouched, post-Lavoisier, for all time. The following two passages help clarify Paneth's view of the matter: "[I]t is impossible to overcome metaphysics – as Lavoisier thought he had done by [his anti-traditional redefinition of *élément*]" (Paneth 1962[1931], p. 124). "[In my Königsberg lecture] I endeavored to demonstrate [...] how closely Lavoisier's [...] concept of the element resembles the maligned 'metaphysical' principles of the philosophers and alchemists" (Paneth 1964[1936], p. 65).

Now Mendeleev knew what элемент means – or what he was at pains to make it mean again; and Paneth's 'philosophical writers' (his *philosophische Schriftsteller* of the day) knew what 'Element' means. The only ones who still seemed unaware of or unmoved by the transcendental facet of the word were, specifically, grade-school instructors and textbook authors.¹³ The problem was with usage of the word 'Element' in those certain *parts* of the German education system circa 1930. To tackle this problem by promulgating a brand-new piece of vocabulary which was intended to overshadow or even supplant 'Element',¹⁴ seems wrongheaded. It just barely made sense to entertain the *Grundstoff* idea briefly *within* the borders of the Germanophone world. Never was it fit for export across those borders as a *fait accompli*.

And yet, there it is, exported into English as the term 'basic substance', in Paneth 2003[1962], pp. 125 and 129-133 *passim*. On prosodic grounds alone, some might be concerned when a streamlined bisyllabic word in one language (*Grundstoff*) is rendered into another by a graceless seesaw term: 'ba-,sic 'sub-,stance. But the main problem for 'basic substance' resides on the semantic plane. The English qualifier 'basic' is found in dozens of existing terms such as 'basic training', 'basic attitude', 'basic French', 'basic utilities', and 'basic furnishings'. In none of those usages does 'basic' hint at the resonances suggested by the tight-knit collection of terms found in Paneth 1964[1936], p. 53n. There, the translator Eva Paneth provides this German/English glossary: *Urmaterie*, primordial matter; *Materie*, matter; *Urstoff*, primary substance; *Stoff*, substance; *Stoffbegriff*, concept of matter; *Grundstoff*, basic substance; *einfacher Stoff*, simple substance. In an addendum to that list, she notes on p. 58n that in passages featuring *Stoffbegriff*, she translates *Stoff* as 'matter' not 'substance'. Thus, *Stoffbegriff* can be seen as a bridge that connects the X-*Stoff*

side of the semantic web – which is associated naturally with chemistry via *Kohlenstoff* (C), *Sauerstoff* (O), *Stickstoff* (N) and *Wasserstoff* (H) – to the *Materie* side, which goes lower than *Grundstoff*, all the way down to *Urmaterie*, the realm of physics. In English, a ‘substance’ is something that forever has a specific texture, color, or/and odor. In German, *Stoff* is a word that *may* be employed in a similar manner; see for example the four-tiered *Experimentelle Hierarchie der Stoffe* in Schummer 1996, p. 181, figure 3. But *Stoff* also has the potential for resonating with the rich semantic web that E. Paneth defines for us above, which is uniquely German in its constituency and flavors. Our English term ‘substance’ cannot be turned into something abstract and transcendental (Paneth 1964[1936], pp. 64-65) by the simple act of placing the qualifier ‘basic’ in front of it. Moreover, as one of the referees for this piece pointed out, the term ‘basic substance’ is already spoken for in the very lexicon of chemistry itself, as the conjugate of ‘acidic substance’.

The word ‘substance’ when employed as the *left*-hand side of Mendeleev’s substance/element distinction seems a natural choice. But when it is used in connection with *Grundstoff*, even if modified by ‘basic’, it strikes me as feeble and out of place. Some would say that in eschewing ‘basic substance’ I am right for the wrong reason. Earley (2009, p. 68) and Mahootian (2013, p. 177) presume that Paneth chose *Grundstoff* for its ‘neutral’ flavor and that the trouble with rendering *Grundstoff* as ‘basic substance’ is that ‘substance’ is weighted by *too much* historical baggage – which amounts to roughly the opposite of my own objection.

But moving beyond the question of how ‘basic substance’ relates to *Grundstoff*, is there a need in English to find a substitute for ‘element’? Consider the following collection of references wherein we find not the slightest hint of ‘help’ needed from outside the text itself: “[S]o now the terms ‘simple substance’ and ‘element’ are often confounded with one another” (Mendeleev 2005 (1871), p. 38). “In this bound state the simple-substance was called an *element* [...] [T]he elements must be taken as *abstract* species [...] The distinction between the concepts of *element* and of *simple substance* is immediately apparent [in the English and German translations of 1891(1869) and in the *Ann.* (Chem. Pharm.), Suppl. of 1871]” (van Spronsen 1969, pp. 37, 58, 62n47, 62n48, italics added). More recently, we find the terms ‘element’ and ‘abstract notion of chemical element’ employed by Dmitriev (2004, pp. 248, 249, 272) – once again, with no special explanation of the verbiage thought necessary by the author.

Scerri 2007 is the major vector nowadays of the term ‘basic substance’; ironically, it is that book which also provides one of the strongest arguments in support of my contention that the term ‘element’ works perfectly well on its own, without exegesis, and without the help of ‘basic substance’. Readers of Scerri 2007 encounter the term ‘element’ (or ‘abstract element’) on pp. 16,

114, 115, 289n3, 291n31, 294n8, and 304n25, and in all of those cases they know exactly what the author intends. And yet, in counterpoint to that thread, the term 'basic substance' also makes its presence felt, on pp. xvi, 109, 304n21 and especially on pp. 278-286, *passim*. Why is it there? Far from conveying something new and important that is not conveyed already by the term 'element' in the same volume, 'basic substance' only sows confusion, causing the reader to wonder, repeatedly, "What have I missed?"¹⁵

Earley (2009 p. 69) notes that the translation of *Grundstoff* as 'basic substance' is problematic because the Königsberg lecture "clearly implies that a *Grundstoff* is *not* 'a substance'". Also, in Earley's view, "the word 'element' should properly be assigned to the components of specific stuffs rather than to substantial materials" (*ibid.*, p. 69). Here, what we notice is a strong resemblance to Mendeleev 1869, p. 15, but for Earley the point of reference is Paneth 1931. For *einfacher Stoff*, Earley would prefer "elementary substance" rather than 'simple substance' or 'element'. Why? Because this makes 'element' available "for exclusive use as an English translation of '*Grundstoff*'" (*ibid.* p. 75). Here we have come home at last to *вещество* (substance) and *элемент* (element) of the red mercury oxide passage. Mendeleev's wheel is thus reinvented, after an interval of 140 years. But Earley himself (*ibid.*, pp. 69, 75) gives no indication that he acknowledges having thus closed the circle upon Mendeleev, whom he mentions only in passing on p. 67.¹⁶ Five years after Earley, we find expressions of the same notion that the element/substance distinction somehow belongs to Paneth,¹⁷ when it in fact belongs to Mendeleev: "There seems to be consensus concerning Paneth's (1931) proposal to distinguish basic and simple substances" (van Brakel 2014 p. 26).

5. Conclusions

From a distance, our presentation of Mendeleev's substance/element distinction may be taken as adjunct to the International Year of the Periodic Table. Viewed more closely, it is a cautionary tale about the misuse of language in philosophy of chemistry. In a kind of 'telephone game' that lasted nearly a century and a half (1869-2009), Mendeleev's formulation suffered ever more distortion, first at the hands of translators, then at the hands of its interpreters, until someone (Earley 2009) altered it one last time in such a way that it came full circle. Or, in connection with those who were unaware of the circle thus traversed, the phrase 'reinventing the wheel' comes to mind. Nor is Mendeleev an innocent bystander in all this; the 1869 formulation itself contains at least two non sequiturs and a nonstandard application of the word

‘concept’ (понятием), the combined effect of which immediately handicapped his translators in 1891. Still worse, Mendeleev’s 1899 article in French took a brand-new tack, vexing in its failure to connect with his 1869 formulation. Sometimes less is more. The “calcination and revivification of mercury” (McEvoy 1995, p. 126) as depicted in Figure 1 is the short path to understanding the abstract element. Why not let it be also the preferred path?

Acknowledgements

I am indebted to Valery (‘Larry’) Tsimmerman for directing me to *Mendeleevia*, which is available courtesy of the Department of Chemistry at Moscow State University, chem.msu.ru, as an archival source for Russian texts in electronic form. My heavy debt to the HYLE editors and to two anonymous referees is too wide-ranging and complex to synopsise here.¹⁸

Notes

- ¹ Traditionally, HgO is associated with oxygen theory: “The red calx of mercury [had been] taken up by Lavoisier [...] as the paradigm case showing [...] oxidization and de-oxidization” (Chang 2012, p. 23). “Recognizing that Lavoisier’s experiment on the calcination and revivification of mercury by heat alone provided a ‘principal fact’ in favor of the oxygen theory and against the phlogiston theory, Priestley responded in 1783 with a ‘principal fact’ of his own” (McEvoy 1995, p. 126). In this article, I present HgO in terms of a lecture-demonstration that I recall from eleventh-grade chemistry at Berkeley High School circa 1959, in which the contrast between mercury as a substance and mercury as an abstract element was emphasized.
- ² Although the term ‘basic substance’ is ubiquitous in Scerri 2007, its genesis in Paneth 2003[1962] is explained only belatedly, on pp. 279, 327n63.
- ³ I acknowledge a debt of gratitude to Scerri for quoting Mendeleev’s red mercury oxide passage on p. 115 of his 2007 book, since that passage, which reawakened an old fascination with HgO, became the seed for this article. However, in the surrounding text on pp. 114-115, far from elucidating Mendeleev’s straightforward substance/element distinction, Scerri allows its outline to be blurred in the needlessly vague language of ‘simple substance’ (p. 114) and ‘basic substance’ (p. 115), neither of which terms even occurs in Mendeleev.
- ⁴ In this article, I follow Paneth in using the term ‘transcendental’ in a nonKantian sense: “I wish to emphasise particularly that, like Hartmann, I am using the word ‘transcendental’ in its epistemological sense only, *i.e.*, meaning ‘beyond the sphere of consciousness’” (Paneth 2003[1962], p. 138n3). Similarly, I would like to employ the term ‘metaphysical’ in the straightforward sense of ‘*beyond*-physical’, as illustrated by the instance of ‘Hg’ that occurs inside the symbol ‘HgO’ at the cen-

ter of Figure 1. But such usage is an uphill battle because that adjectival form, 'metaphysic-al', is almost always understood to be pejorative nowadays, in all European languages. The pejorative flavor probably dates back at least to Lavoisier, if not earlier, as in the following remark: "Tout ce qu'on peut dire sur le nombre & sur la nature des élémens se borne, suivant moi, à des discussions purement métaphysiques." (Lavoisier 1789, p. xvii; 'All that can be said on the number and on the nature of elements is limited, as I see it, to purely metaphysical discussions.'

- ⁵ For an overview of the relative mass data available to Mendeleev, see Jensen 2005 p. 28, and compare the various Cannizzaro values shown in Langford & Beebe 1995 pp. 30-31. As for the potentially embarrassing question of physics versus *meta*-physics, on more than one occasion Scerri has broached that subject, too: "It would appear that the elements [...] had lost their fully metaphysical characteristic [...] since they now possessed one important attribute" (Scerri 2005, p. 6; see also pp. 8, 22n15). "The more prosaic explanation given in contemporary chemistry is that what survives of each of the elements is the number of protons" (Scerri 2007, p. 304n22; see also 327n71).
- ⁶ In Paneth 1964[1936], p. 58, we find this: "In a lecture three [sic] years ago I attempted to define more precisely the epistemological status of the chemical concept 'element', and especially to do justice to the double meaning that Mendeleeff had in mind [for it]". Here we find Mendeleev's nonstandard use of 'concept' and Paneth's nonstandard use of 'concept' crossing paths. The result is a kind of negative synergy; see Figure 3.
- ⁷ As yet another example of standard usage, here is a line that we could have cited from Paneth himself: "Of the two senses [*Bedeutungen*] in which the expression [*Ausdruck*] 'chemical element' may be used, philosophical writers of today usually consider only one" (Paneth 2003[1962] p. 132). There, the splitting of one *Ausdruck* into two *Bedeutungen* is unremarkable. But if anything, examples of this kind only throw his nonstandard *Begriff* usage into higher relief.
- ⁸ "Aristotle defined an element or 'simple body' as 'one of those bodies into which other bodies can be decomposed'" (Partington 1989, p.14). There is also Zosimos (circa 300) to consider who distinguished 'bodies' (metals) versus 'spirits' (vapors); and Boyle (1627-1691) who even applies capitalization to the word Body (Partington pp. 23, 70-71). Let us note in passing also the important role of 'body' in the glosses for 'Element', 'Radical', and 'Weight, Atomic' in Daubeny 1850[1831], pp. 497-502, a contemporary of Mendeleev.
- ⁹ For this important piece of the puzzle, I rely on one of the anonymous journal referees.
- ¹⁰ For context, see Schummer 1996, Chapter 3 (*Die Chemie: ein Stiefkind der Philosophie* [Chemistry: a Stepchild of Philosophy]), pp. 89-100. The chapter begins with a discussion of Paneth's opening paragraph (1931 p. 101; 2003[1962] p. 113) which concerns the place of chemistry in philosophy of science circa 1930. In using the term 'chemist-philosopher' I am thinking primarily of Paneth here, although Mendeleev clearly fits the concept as well.
- ¹¹ I do not deny that Mendeleev's formulation resonates with dualistic themes in diverse philosophies. For example, his 'substance/element' relation might be worth exploring in connection with the Māyā/Brahman relation in Vedānta (see Earley 2009, p. 69, re the *Vedas*). What concerns me is how Mendeleev's name has been gradually overshadowed by that of Paneth, and how Paneth's clear statement about Hartmann (see Note 4) has been gradually lost in the shadow of Kant.

- ¹² Spelling variation: In citing the Jawein/Thillot translation of Mendeleev, Paneth 1931 p. 121n3, has ‘*Begriff*’ and ‘*Bestandtheils*’ where Jawein & Thillot 1891, p. 27, has ‘*Begriffe*’ and ‘*Bestandtheiles*’.
- ¹³ From a quick sampling of books on my shelf, I find that the problem Paneth identified in Germany circa 1930 is evident in chemistry textbooks by U.S. authors in both the XX and XXI centuries. In those books, the word ‘element’ tends to be introduced in this curt, *substance*-centric fashion: ‘Substances, if simple, are called elements’. I base that paraphrase on Zumdahl 1989, p. 24; Ebbing 1993, p. 45; Petrucci *et al.* 2002, p. 5; Moore *et al.* 2005, p. 15; Kotz *et al.* 2012, §1-4. In other words, I agree with Paneth’s description of the situation; my objection is only to his way of addressing it.
- ¹⁴ The Latin loan-word ‘*Element*’ has been part of the German language ever since the 13th century. By contrast, it was four centuries later that *Stoff* was borrowed into German, from Dutch (Duden 2006, pp. 177, 816). Accordingly, the reasonable approach would be to work *with* the venerable word ‘*Element*’ rather than quarantine it and promote ‘*Grundstoff*’, all because of what befell the French word ‘*élément*’ 142 years earlier, counting back from 1931.
- ¹⁵ For background on certain sociological factors that might be at play here, see Earley 2009, p. 67n3 and n4.
- ¹⁶ On p. 67, Earley (2009) asserts that Mendeleev claimed a “double meaning of the concept of a chemical element”. As readers of this article understand, that puts words in Mendeleev’s mouth; it is Paneth, seen by Earley through the lens of Scerri 2000. Cf. Scerri 2007 p. 114, which is somewhat closer to Mendeleev’s actual verbiage, though still distorted through the lens of Paneth 1962[1931].
- ¹⁷ From Earley 2009, p. 75, it would seem that Paneth alone must have put forth the notion of the abstract element. Cf. Mahootian 2013, pp. 176-178, which contain strong references, direct and indirect, to Earley p. 75.
- ¹⁸ For an early draft of this article, I had counted up instances of the respective Russian, German, and French words for ‘body’ versus ‘substance’ and speculated at length on the significance of one or the other of them being prevalent in the writings of Mendeleev, Paneth, and Lavoisier. My elaborately worked out speculation was nonsense. I owe a huge debt to one of the HYLE referees who explained that, “Already in the late eighteenth century, Lavoisier’s ‘substance simple’ was translated as *простое тело*. Mendeleev was simply using what had for generations been the standard term in the Russophone chemical community”.

References

- Bensaude-Vincent, B.: 1986, ‘Mendeleev’s periodic system of chemical elements’, *The British Journal for the History of Science*, **19**, 3-17.
- Bent, H.: 2006, *New Ideas in Chemistry from Fresh Energy for the Periodic Law*, Bloomington, IN: AuthorHouse.
- Chang, H.: 2012, *Is Water H₂O?: Evidence, Realism, and Pluralism*, Berlin: Springer.
- Daubeny, C.: 1850[1831], *An Introduction to the Atomic Theory*, Oxford: Oxford University Press.

- Dmitriev, I.S.: 2004, 'Scientific Discovery in *statu nascendi*: The Case of Dmitrii Mendeleev's Periodic Law', *Historical Studies in the Physical and Biological Sciences*, **34**(2), 233-275.
- Duden: 2006, *Das Herkunftswörterbuch: Etymologie der deutschen Sprache (Der Duden in 12 Bänden, Band 7)* Mannheim: Dudenverlag.
- Earley, J.E. Sr.: 2009, 'How chemistry shifts horizons: Element, substance, and the essential', *Foundations of Chemistry*, **11**, 65-77.
- Ebbing, D.: 1993, *General Chemistry*, 4th edn., Boston: Houghton Mifflin.
- Giancoli, D.: 2005, *Physics*, 6th edn., Volume II, Pearson Prentice Hall.
- Gordin, M.D.: 2015, *Scientific Babel. How Science Was Done Before and After Global English*, University of Chicago Press.
- Jaffe, B.: 1976[1930], *Crucibles: The Story of Chemistry from Ancient Alchemy to Nuclear Fission*, 4th edn., Dover: New York.
- Kopp, H.: 1873, *Die Entwicklung der Chemie in der neueren Zeit*, München: Oldenbourg.
- Kotz, J.C.; Treichel, P.M. & Townsend, J.R.: 2012, *Chemistry and Chemical Reactivity*, 8th edn., Belmont: Brooks/Cole Cengage Learning.
- Langford, C. & Beebe, R.: 1995, *The Development of Chemical Principles*, New York: Dover.
- Lavoisier, A.: 1789, *Traité Élémentaire de Chimie*, Paris: Cuchet.
- Mahootian, F.: 2013, 'Paneth's epistemology of chemical elements in light of Kant's *Opus postumum*', *Foundations of Chemistry*, **15**, 171-184.
- McEvoy, J.G.: 1995, 'Priestley Responds to Lavoisier's Nomenclature: Language, Liberty and Chemistry in the English Enlightenment', in: Bensaude-Vincent & F. Abbri (eds.), *Lavoisier in European Context*, Canton, MA: Science History Publications, pp. 123-142.
- Mendelejeff, D.: 1891, *Grundlagen der Chemie [The Foundations of Chemistry]*, translation of the 5th Russian edn. of 1889 by L. Jawein & A. Thillot, St. Petersburg: C. Ricker.
- Mendeléeff, D.: 1891, *The Principles of Chemistry*, translation of the 5th Russian edition of 1889 by G. Kamensky, London: Longmans & Green.
- Mendeleev, D.: 1899, 'Comment j'ai trouvé le système périodique des éléments', *Revue générale de chimie pure & appliqué*, **1**, 211-214, 510-512.
- Mendeleev, D.: 1947[1869], Preface to *Osnovy Khimii* [ОСНОВЫ ХИМИИ], 13th edn. [available online at: http://www.chem.msu.ru/rus/mendeleevia/txt/Mendeleev_Osnovy_1947_Vved_OCR.pdf, accessed 11 February 2018].
- Mendeleev, D.: 2005 [1871], 'On the Periodic Regularity of the Chemical Elements', in: D. Mendeleev, *Mendeleev on the Periodic Law: Selected Writings, 1869-1905*, ed. by W.B. Jensen, New York: Dover, pp. 38-109 [trans by W. Crookes and W.B. Jensen].
- Mendeleev, D.: 2005, *Mendeleev on the Periodic Law: Selected Writings, 1869-1905*, ed. by W.B. Jensen, New York: Dover.
- Moore, J. W.; Stanitski, C.L. & Jurs, P.C.: 2005, *Chemistry: The Molecular Science*, 2nd ed., Belmont, CA: Thompson Brooks/Cole.
- Paneth, F.A.: 1931, 'Über die erkenntnistheoretische Stellung des chemischen Elementbegriffs', *Schriften der Königsberger Gelehrten Gesellschaft, Naturwissenschaftliche Klasse*, **8**(4), 101-125.
- Paneth, F.A.: 1962[1931], 'The Epistemological Status of the Concept of Element', *British Journal for the Philosophy of Science*, **13**, 1-14, 144-160 [translation by H. Paneth of 'Über die erkenntnistheoretische Stellung des chemischen Elementbegriffs', Königsberg 1931].

- Paneth, F.A.: 1964[1936], 'Chemical Elements and Primordial Matter: Mendeleeff's View and the Present Position', in: H. Dingle & G. Martin (eds.): *Chemistry and Beyond: A selection from the writings of the late Professor F. A. Paneth*, New York: Interscience Publishers, pp. 53-72 [translation by E. Paneth of 'Chemische Elemente und Urmaterie: Mendeleevs Ansicht und der heutige Standpunkt', Leningrad 1936].
- Paneth, F.A., 2003[1962, 1931], 'The Epistemological Status of the Concept of Element' [reprint of Paneth 1962], *Foundations of Chemistry*, 5, 113-145.
- Partington, J.: 1989[1937], *A Short History of Chemistry*, Dover.
- Petrucci, R.; Harwood, W. & Herring, F.: 2002, *General Chemistry*, Upper Saddle River, NJ: Prentice Hall.
- Röker, K.D.: 2017, 'Gepaarte Verbindungen', *Mitteilungen, Gesellschaft Deutscher Chemiker/Fachgruppe Geschichte der Chemie*, 25, 74-124.
- Ruthenberg, K.: 1997, 'Friedrich Adolf Paneth (1887-1958)', *Hyle: International Journal for Philosophy of Chemistry*, 3, 103-106.
- Ruthenberg, K.: 2009, 'Paneth, Kant, and the philosophy of chemistry', *Foundations of Chemistry*, 11, 79-91.
- Scerri, E.R.: 2005, 'Some Aspects of the Metaphysics of Chemistry and the Nature of the Elements', *Hyle: International Journal for Philosophy of Chemistry*, 11(2), 127-145.
- Scerri, E.R.: 2007, *The Periodic Table: Its Story and Its Significance*, Oxford University Press.
- Schummer, J.: 1996, *Realismus und Chemie. Philosophische Untersuchungen der Wissenschaft von den Stoffen*, Würzburg: Königshausen & Neumann.
- van Brakel, J.: 2014, 'Philosophy of Science and Philosophy of Chemistry'. *Hyle: International Journal for Philosophy of Chemistry*, 20, 11-57.
- van Spronsen, J.W.: 1969, *The Periodic System of Chemical Elements: A History of the First Hundred Years*. Amsterdam: Elsevier.
- Zumdahl, S.S.: 1989, *Chemistry*, Lexington, DC: Heath.

Conal Boyce:

Century College, White Bear Lake, Minnesota, U.S.A.;

conalboyce@gmail.com