

Conference paper

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Levi's Periodic System vs. Mendeleev's Periodic System: two engaged views of chemistry between science and literature

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Abstract: A comparison between the figures of Levi and Mendeleev is proposed, based on their peculiar ways of conceiving their professional role of chemist, their life experiences, their achievements and their thought. The *Weltanschauung* of these two figures, despite their having lived in distinct historical periods and their belonging to distinct cultures, was deeply influenced by the fact of being chemists: chemistry was – for both of them – a tool for interpreting the world around them and acting effectively in it. The chemistry Levi talks about in his writings is not just a narrative pretext: it is part of his vision of the world and a means of survival in the hellish context of the extermination camp. Similarly, Mendeleev's idea of chemistry was always related to the life context and the human condition: this explains his pedagogical concerns and the attention paid to social, economic and cultural issues typical of his time. Both Levi and Mendeleev were chemists for whom chemistry was a means of civil engagement. Their writings show that chemistry was a source of inspiration for their ethics.

Keywords: Dmitri Mendeleev; ethics; Mendeleev 150; Primo Levi; *Weltanschauung*.

Introduction

The idea of comparing two figures that seem very far from each other as Dmitri Mendeleev and Primo Levi may surprise, as they lived in distinct historical periods, had radically different lives and belonged to distinct cultures. Nevertheless, their writings disclose hidden affinities and unexpected overlapping views. The double anniversary¹ celebrated this year provides an opportunity to risk such a comparison. My thesis is the following: Mendeleev and Levi, beyond their obvious differences, share a peculiar way of conceiving their professional role of chemist. Chemistry shapes their thought and influences their *Weltanschauung*. I will expose my thesis through a number of statements supported by selected texts by the two authors.

Both Levi and Mendeleev cast a *chemical* gaze at the world

The first, manifest common point between Levi and Mendeleev is their being chemists: their writings show that their work had a deep influence on their philosophical conceptions. Levi, as a chemist in a factory, gives

¹ The 150th anniversary of the publication of the first Periodic Table by Mendeleev and the 100th birth anniversary of Primo Levi.

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to chemistry the credit of shaping his way of living: “*I had grown up inside it, I had been educated in it, it had shaped my way of living and of looking at the world – maybe even my language*”² [1].

Mendeleev's attitude is well described by his pupil, V. E. Grum-Grzhimailo: “He imparted on his pupils his skill in *observing and thinking, which no one book can give* [...] When Mendeleev taught *to think chemically*, he not only did his job and not only the job of the whole cycle of chemical sciences, but also the job of the whole natural faculty” [2].

The expression ‘To think chemically’ discloses a peculiar epistemic attitude: the habit of conciliating distinct levels of reality (macroscopic, microscopic and symbolic), i.e. the ‘ambivalent thought’ of chemistry that “perceives colour changes, precipitations, gas releases, etc.” and, counter-intuitively, interprets these processes as “the result of events involving invisible particles”, as remarked by Cerruti [3].

This aspect is often found in Levi's writings, e.g. when he describes – as accurately as in a lab protocol – the procedures for obtaining zinc sulfate: “you had to make an *elementary stoichiometric calculation* and attack the *granulated zinc* with previously diluted sulfuric acid; concentrate, crystallize, dry at the pump, wash, and recrystallize” [4, *Zinc*, p. 685] or when he explains how a paint solidifies “In many cases, the *oxygen in the air* has a role in the process of hardening. Among the various tasks, vital or destructive, that oxygen can accomplish, what interests us paint makers most is its *capacity to react with certain small molecules*, such as those in some oils, and *to create bridges between them, transforming them into a compact and therefore solid network*: that, for example, is how linseed oil “dries” in the air” [4, *Vanadium*, p. 812]. But Levi's attitude does not change whenever he describes the human micro- and macro-cosmos, being either a witness of dramatic events in the extermination camp or a light, ironic, explorer and expert of the human spirit and conscience. Italo Calvino remarks that Levi “*is a chemist who knows human emotions no less than he knows the law of mass action*, and he disassembles and reassembles the secret mechanisms that rule human vanities, winking at us from the ironic allegories, the smiling morals that he offers” [5].

Levi and Mendeleev conceive their being chemists as an instrument for acting effectively in the world

The conception of their own work, its dignity and its effectiveness is another common point between Levi and Mendeleev. The profession of chemist is seen by both of them as a means for acting effectively in the world and for understanding it (even beyond its materiality). In a letter addressed to his children [6], Mendeleev recommends to be concrete and generous: “Do not run after mere words. These are and always will be just the beginning. *The real centre lies in concrete things, in facts.*” He talks of work as a solid and ethical way of being in the world, as it consists in “acting in order to satisfy the needs and demands of others, and to give what is profitable for them or perhaps simply advantageous. Only in this way you will feel useful and reach such tranquillity of mind that is always the most important thing. [...] *Study is for oneself, the fruit of study is for everybody*”.

Levi, too, believes that work – and especially the chemist's work – is an instrument of human growth, because achievement and failures teach the ‘profession of living’: “I am also indebted to my profession *for what makes a man mature, that is, achievement and failure*, to succeed and not to succeed” [7].

Both Levi and Mendeleev authored a Periodic System

Both Levi and Mendeleev authored a Periodic System. Mendeleev's one is not only a systematization of chemical knowledge, but also a system of thought endowed with explicative and predictive power, as – according to Joachim Schummer – classifications “are already theories on a basic level” [8]. In fact, the incorporation

² Emphasis in the texts cited throughout this manuscript are added by myself, unless differently specified.

of new physical and chemical acquisitions (e.g. knowledge about atomic structure) into the Periodic System, has reinforced rather than challenged it: its theoretical structure has been confirmed and its explicative and predictive potential, strengthened. According to his inventor, it has the credit to “explain the unexplained, point to previously unknown phenomena” [9]. There is an aspect of the Periodic System that has gone almost unnoticed: its being the product of a complexity thought [10] *ante litteram*. Mendeleev's thought is complex in different respects: the Periodic System entangles distinct levels of reality. In fact, it is the product of a thought that is able to keep together the macroscopic level of the reactivity of substances, the microscopic level of stoichiometric combinations and the abstract level of the notion of chemical element (Mendeleev's notion of elements is clearly distinct from Lavoisier's). Scerri [11] remarks that Mendeleev was able to conciliate the experimental detail and the synthetic thought, without being diverted by the countless data: then, the Periodic System is the product of subjective choices that either include or exclude. Pushcharovsky reports that even Lothar Meyer acknowledged Mendeleev's peculiar ability to make bold choices: “I confess frankly that *I lacked the courage for far-sighted assumptions which Mendeleev expressed with certitude*” [12]. Mendeleev was well aware of the cognitive power of his Periodic System if, on June 1905, he wrote: “Apparently the future does not threaten the Periodic Law by its destruction and *on the contrary it promises the superstructure and its further development*” [12].

Tagliagambe [13, p. lxxiii] reports that – according to Mendeleev himself – the periodic law would have never been discovered without applying the ‘method of comparisons’ (*sravnenie*), that allows going beyond purely empirical observations and their specificity as it inserts phenomena into a wider and more general perspective. This method is grounded on the premise that “nothing can be defined and determined *per se*, exclusively from itself” [14], in line with a logic that assigns a primary role to the relational context, in full agreement with a complex approach. In addition, based on an essay signed under pseudonym, Mendeleev takes a stance against the irreducibility of Nature to the unity: “*A unit in nature is even unthinkable*” [...] “in everything, *in everything one feels the aggregate, the complexity, the mass of units, the collective*. Individualism, or the entire essence of our education, is a ripe and even rotting fruit of the concept of the unit” [15]. This position may not be unrelated with his main achievement, a system made by a number of elements that cannot be defined *a priori*. In addition, Mendeleev seems to assign an educational and ethical value to the irreducibility to the unit, at the anthropological level. A further complexity-related issue mentioned in Mendeleev's writings concerns the limits of scientific knowledge. He often reminds that scientific knowledge is provisional and strongly related with philosophy: “*scientific generalizations are not an already-changing limitlessness or reality, but are limited by the fact that one can only study [...] up to the point that it became possible to predict something and these scientific generalizations ought to remain unchanging until the very study of reality compels changing, expanding, and perfecting them*” [16].

Levi's Periodic System, in turn, is primarily a testimony, as almost all of his writings. A testimony of the Shoah, but also a testimony of Matter. Levi is a witness, not only because he is Jew, but also because he is a chemist, used to analytical thought: “Anyone who knows what it means to reduce, concentrate, distil, crystallize also knows that *laboratory operations have a long symbolic shadow*” [7]. Levi's gaze at the extermination camp reflects the chemist's analytical attitude, that pays attention to the meaning of details: “Undoubtedly, the title was a provocation, as was giving each chapter, as a title, the name of an element. *But it seemed to me opportune to make use of the chemist's relationship with matter, with the elements, just as the Romantics of the nineteenth century used the “landscape”*: chemical element = mood, as landscape = mood. Because *for those who work with matter, it is alive*: mother and enemy, slothful and allied, stupid, inert, dangerous at times, but alive, as the founders well knew, working alone, unrecognized, unsupported, with mind and imagination” [7].

The Periodic System is also a testimony of Levi's conception of life, what he calls ‘the occupation of living’: “I told him that I was in search of events, mine and others’, that I wanted to put on display in a book, *to see if I could convey to the uninitiated the strong and bitter flavor of our occupation, which is a particular case, a more strenuous version, of the occupation of living.*” Levi finds odd that people know “nothing about how we, *transmuters of matter*, live”. But he is not interested in “the triumphant chemistry”, he rather wishes to tell “*stories of solitary, unarmed, pedestrian chemistry, on a human scale, which with few exceptions had*

been mine" [4, *Silver*, p. 760]. Carlo Ginzburg remarks that Levi's Periodic System uses the table of the elements "as a metaphor for the various and sundry way of impersonating the human condition" [17].

In Levi, the question about Auschwitz goes along with that on human nature. He writes "to understand how Auschwitz had been possible" and also to understand the world: "as a chemist, I want to understand the world around me" [17].

In different – but not unrelated – ways, both Periodic Systems by Levi and Mendeleev disclose their thought on both the material world and the human condition.

A peculiar aspect of Levi's Periodic System is his neat writing style: his choice of terms and adjectives is precise and sometimes sharp like a scalpel. It helps focalizing details, but also the ambiguity of things and situations: "The factory was a *dirty, disorganized, drafty* warehouse, where a dozen *arrogant, indolent, slovenly, and heavily made-up* girls wandered around" [4, *Nitrogen*, p. 786]. Levi manages to convey emotions through his 'almost scientific' style, that sometimes recalls a lab protocol: "I got a sample of the tanning bath, went to the experimental laboratory, and tried to atomize a 1:10 000 solution in the darkroom where a sample of radiographic paper was exposed. The effect could be seen a few days later: *the paper's sensitivity had disappeared, literally*" [4, *Silver*, p. 810]. He clearly inspires to technical writing style, whose credit is to be clear and understandable by everyone: "my model for writing is the 'report' that is written in the factory at the end of the week. Clear, essential, comprehensible to everyone". His aim is to offer to the reader the "*largest quantity of information and emotion possible*" [7]. His style conceals an ethics: "Writing can communicate, can transmit information or even feelings. *If it's not comprehensible, it's useless*" [7]. Just like scientific papers, his narrative aims at highlighting elements of certainty and uncertainty, before ending up with a plausible interpretation of data, logically consistent, with no claim of being the Truth. His style is *warily doubtful*: it mirrors an existential attitude open to possibilities. His doubt is never systematic, least of all cynical. There is some wisdom in such caution: it recalls the researcher's doubt in front of his results and their interpretation, that he knows to be limited and questionable.

This very same attitude is found – not without surprise – in several writings by Mendeleev: "There is no true science where people try sharply and with judgmental reception to shut the mouth of any contradiction [...] Consider as authentic science only that which is affirmed after doubts and every type of trial (observations and experiments, numbers and logic), and *you will not trust very much "the last word of science", which has not tried, and does not expect, ever newer proofs*" [16]. Here we find an open criticism to a dogmatic conception of science, in line with Gordin's remark that "claims that Mendeleev was some variant of anti-metaphysical positivist is impossible to sustain" [18].

Back to Levi and the role played by chemistry in his Periodic System, it is clear that chemistry is not just a pretext for his narrative: it is matter of survival. Levi managed to survive because he was assigned to the chemistry lab in Auschwitz, a moderately protected environment: "*I was a chemist in a chemical factory, in a chemical laboratory [...] and I stole in order to eat*" [4, *Cerium*, p. 760]. In the tale *Cerium* he explains how he managed to find expedients for his survival thanks to his chemical expertise. For example, he stole cerium-iron flints that could be exchanged with food: "I was then able *not only to survive but also to think*, to register the world around me, and even to undertake a fairly delicate job, *in an environment infected by the daily presence of death*. [...] In total, a hundred and *twenty flints, two months of life* [...] In the end, cerium would have liberated us". So, being alive is also 'to be able to think', to resist to dehumanization.

Levi and Mendeleev are citizens of the world and share an engaged vision of chemistry

Mendeleev's and Levi's thought is deeply shaped by chemistry and by the cognitive attitude typical of chemical science. Nevertheless, their thought is not enclosed in a disciplinary fence: chemistry acts as a filter, an interpretation key, but they gaze at reality in its wholeness. The chemistry described in their writings is not a splendidly isolated, aseptic science. On the contrary, it is always related to a context, imbued with real life and it nourishes their civil engagement.

Tagliagambe describes Mendeleev as “a cosmopolitan scientist, who chooses the entire planet as the field of his thought and action” [13, p. xlv]. For him, to be a chemist implies facing the challenges issued by the socio-economic context of Russia, at that time. In fact, the scientific and creative activity by Mendeleev “stretched over such distant fields as industry (17 % of his publications are related to this area), economics (14 %), metrology (11 %), aeronautics (9 %) and agriculture (7 %)” [2]. Such multifaceted range of interests is readily explained by Mendeleev: “I was told: “you are a chemist and not an economist, why you enter not your affairs?” It is necessary to answer to this as, first, *being a chemist does not yet mean keeping oneself aloof from plants and factories and their role in the State* and, therefore, the essence of relevant economic problems. [...] The voices of not only jury economists but also of other experts should be heard *for the profit of population and the State*” [2]. Here we find Mendeleev's constant concern about the development of Russia and of his population, but we also recognize his ethical conception of work. Mendeleev has a political view of science: scientists are called to take on the challenge represented by the socio-economic development of Russia.

From 1892 on, as the *Scientific Custodian* of the Depot of Standard Measures and Weights, Mendeleev is involved in the transition from Russian to International units, a crucial step for settling Russian economy on the international stage [13, p. lxxv]. This charge offers him the opportunity to frame a clear picture of the economic problems and necessities of his country. The kind of development that Mendeleev wished for was unpopular amongst aristocracy, that feared industrialisation and the birth of the working class. In his 1881 essay *O vobuždenii promyšlennogo razvitija v Rossii* (On the stimulation of industrial development in Russia) [20] Mendeleev invokes Russian industrial development as historically unavoidable because Russia is already “part of the group of nations involved in such big endeavour that is the development of mankind” and must participate in the process with all its peculiarities and qualities.

Another ground for Mendeleev social engagement is education. In his liberal socio-economic view, the development of Russia and the need for a general access to education are strictly entangled. But education has its cost: “Education is needed for the access to a steady, not ephemeral, accumulation of wealth; in turn, generalised education cannot be realised without the availability of material resources” [19, p. 255].

Mendeleev envisages progress as a controlled change, a “combination of invariance and change, continuity and discontinuity”. He calls himself a realist, opposite to those idealists and materialists that “see the possibility of changes only in revolutions, realism instead recognizes that actual changes occur only gradually, according to an evolutionary development”. In Mendeleev's view, such ‘realism’ is the peculiar attitude of science [19, p. 253].

Levi's civil engagement is primarily the engagement of the witness, in which chemistry has a role: “Why are you a chemist and write?” I answer, “*I write because I am a chemist.*” I need my profession to *communicate experiences*” [7]. In Levi's writing, the chemical behavior of substances often becomes metaphor of human behaviors, either individual or social. In the tale *Zinc*, zinc reactivity is the metaphor that fosters a reflection on race purity, an issue tragically exploited by Nazis and Fascists: “Tender, delicate zinc, so yielding in the face of acids, which makes a single mouthful of it, *behaves quite differently when it's very pure: then it stubbornly resists attack*. Two opposing philosophical conclusions could be drawn: *praise of purity, which protects us from evil like a hauberk; praise of impurity, which lets in change – that is, life.* [...] For the wheel to turn, for life to live, impurities are needed [...] Fascism does not want them, forbids them, and so you're not a Fascist; it wants everyone to be the same, and you are not the same. But immaculate virtue does not exist, or if it does it is detestable.” The metaphor is pushed as far as to identification: “*I am the impurity that makes the zinc react*” [4, *Zinc*, p. 686].

Just as Mendeleev did, Levi was strongly concerned with school education, whose goal is to foster critical thinking in students, as a means to prevent false and violent ideologies. A recurrent issue in Levi's writings is the reject of superficiality and inaccuracy. The improvident exchange between sodium and potassium, two closely related elements, gives the chance for an ethical comment: “*You must not trust the almost-the-same* (sodium is almost the same as potassium; but with sodium nothing would have happened), *the practically the same, the nearly, the or, any surrogates or stopgaps.* The differences may be small but can lead to radically diverse results, like railroad switches; *the chemist's work consists largely in watching out for*

these differences, in knowing them from close up, in predicting their effects. Not only the chemist's work" [4, *Potassium*, p. 705]. Here, the key-sentence is "not only the chemist's work" that urges everyone to be vigilant and accurate.

A further aspect of Levi's civil engagement is the commitment to well-done job, even in critical conditions. This is the leading issue of Levi's novel 'The Wrench': work provides dignity; a well-done job is a good way to stay in the world: "Love of one's work (a privilege enjoyed, unfortunately, only by a few) is *the best, most concrete approximation of happiness on earth*" [21].

Levi's narrative is often permeated by a light sense of humor, that leads him to address to people and to himself a sometimes pungent, but never rude, irony. So, the library of our Institute of chemistry in Torino is described as an impenetrable *sancta sanctorum*: "As soon as possible I went to the library: I mean, to the venerable library of the Chemistry Institute of the University of Turin, which at that time was *as impenetrable to infidels as Mecca, and scarcely penetrable even to the faithful, like me*" [4, *Nitrogen*, p. 787]. Even in the Lager laboratory there is room for irony, as regards to the properties of polyethylene, that (unfortunately) didn't exist at that time: "It would have been useful to me because it is flexible, light, and splendidly impermeable, but *it is also a little too incorruptible, and not for nothing the Heavenly Father Himself, who, though a master of polymerization, refrained from patenting it – He doesn't like incorruptible things*" [4, *Cerium*, p. 761]. Irony, that is a peculiar trait of Jewish literature, is vital and helps preserving Levi's mind from the horror of the extermination camp. Irony is a sort of cautious wisdom, a kind of indulgence whose practice in everyday life may serve as antidote against rudeness and moralism.

Levi's and Mendeleev's relationship with the truth of the physical world

'Truth' is a term often encountered in Mendeleev's writings, but it is much less frequent in Levi's. Nevertheless, both of them consider the scientific approach to the physical realm as a respectful practice towards Nature and its truth. An explicit reference to the intrinsic truth of people and things may be found in the introduction of Levi's tale 'The truce': "My daily profession [...] educated me to concreteness and precision, to the habit of "weighing" each word with the same scrupulousness as someone carrying out a quantitative analysis. Above all, it accustomed me to that state of mind we call objectivity; that is to say, *to acknowledgment of the intrinsic dignity not just of people but of things, and to their truth, which needs to be recognized and not distorted if one does not want to fall into vagueness, emptiness, and falsehood*" [22]. This is a strongly ethical statement: the chemist profession is an exercise of respect towards the intrinsic truth of whatever exists.

The seek for truth is certainly one Mendeleev's concern (and a passion). In his last University lecture, in 1890, he says: "The truth is not concealed to men, *it is amongst us, diffuse and distributed all over the world*. One can look for it everywhere: in chemistry, mathematics, physics, history, literature" [13, p. lxiv]. Mendeleev breadth of view keeps together science and humanities. Science must dialogue with other disciplines in order to let human knowledge to grow. Most of all, it is not 'the last word' on things: "Science is certainly and only a new search for truth, but *from this it does not follow at all that it claims to reach some form of "last word"*" [19, pp. 455]. Mendeleev believes that the knowledge of Nature may enlighten the knowledge of Man: "Man, his conscience, are only part of a whole, which *can be best understood from what is external, rather than from what is internal to human nature*" [13, pp. xxxviii].

Levi, being a chemist and a writer, embodies this same openness in his own figure. Interestingly, the investigation of Nature plays to Levi a similar role as Mendeleev: "*Understanding matter is necessary in order to understand the universe and ourselves.*" To the point that the Periodic Table is metaphorically compared to "*a poem, loftier and more solemn than all the poems we had absorbed in high school: if you thought carefully, it even had rhymes!*" [4, *Iron*, p. 692].

Conclusion

Despite the distance between their historical and social contexts, and even between their own personalities, Levi's and Mendeleev's experience of chemistry is an existential experience. For both of them, chemistry is a key for interpreting events and for narrating the human and material world; it is an antidote against shallowness and false beliefs; it is an instrument of search for the truth of the world and a teacher of clarity in the expression of one's thought. Finally, for both of them chemistry is a means of civil engagement. Both Levi and Mendeleev were chemists, but their greatness lies in their not being *just* chemists. Their commitment reminds present-day's chemists that the value of the chemical trade extends far beyond its own technical-disciplinary aspects: it offers the opportunity for a peculiar interpretation of reality and implies a responsibility towards it.

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