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Celebration of the Periodic Table of the Elements at the Academy of Sciences of Lisbon. A Chemistry Symposium

Preface

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October 3rd, 10th and 17th, 2019

Preface

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The celebration of the sesquicentennial of the proposal by **Dmitrii Mendeleev** of a periodic system (expressed by what became to be known as Periodic Table) of the elements is well justified by the relevance of such an event which has contributed in an unparalleled way for the systematization of Chemistry and Science in general.

The observation of periodic trends, based on atomic weights, of chemical and physical properties of the elements and their compounds, inspired Mendeleev to propose a periodic system of the elements based on a "Periodic Law" of the elements (Figure 1).

We know nowadays that the observed periodicity of properties of the elements upon listing along their atomic number (instead of atomic weight) relates to the corresponding periodic recurrence of their outer shells electronic configuration. The usefulness of this relationship is well patented by the widespread use of the omnipresent Periodic Table of the elements.

In Mendeleev´s first version (1869, published in the 1st volume of the journal of the then recently founded Russian Chemical Society and in the 1st edition of his book "**The Principles of Chemistry**"), the groups of the elements were arranged horizontally, whereas in the second one (1870), they are vertically, an arrangement that is followed in the Periodic Table used nowadays.

The vertical alignment is shown in the gigantic **wall Periodic Table** in Saint Petersburg, that is based on the periodic system published in the 1906 edition (the last one during Mendeleev's life) of "The Principles of Chemistry" (Figure 1). It is a mosaic workshop by the Academy of Art, to celebrate the centennial anniversary of his birth (1834). Red elements are those known until then, whereas the blue ones were discovered later [*C&EN*, March 1995, p.84].

This wall Periodic Table, together with a Mendeleev's **statue** stand in front of the "Palata Mer i Vesov" ("Chamber of Measures and Weights") of which he was Director, and the shine of Mendeleev´s nose results from the traditional students´ touches to pray for good examination marks.

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Mendeleev received his education in Saint Petersburg, Russia, and it was also therein that he developed most of his professional career, namely gaining a professorship at the Technological Institute (1864) and later at the nowadays Saint Petersburg State University where he achieved tenure (1867), published his book "The Principles of Chemistry" (volume 1 in 1869) and proposed the "Periodic Law" and the periodic chartering of the elements (see below the Museum called after his name).

Figure 1.
Mendeleev's wall Periodic Table and statue in Saint Petersburg, in front of the "Palata Mer i Vesov" ("Chamber of Measures and Weights") of which he was Director (Courtesy of Prof. Vadim Kukushkin).

This celebration also provides an opportunity to reflect about paternity and evolution of ideas in science. Although without intending to dip into this area, it is noteworthy to mention that the discovery of the Periodic Table and of the Periodic Law, as it has occurred with other breakthroughs in science, was a continued process to which a number of scientists have contributed and it would be appropriate to evoke herein a few other representative **pioneers**.

Just to mention the 1860 decade, in which Mendeleev presented his proposal, a relevant pioneer was the French mineralogist **Alexandre-Émile Béguyer de Chancourtois** who arranged (in 1862, *i.e.*, 7 years before Mendeleev's publication) the chemical elements according to the atomic weight in a helical mode on the surface of a cylinder. However, in view of the high dimension of the chart, it could not be included in the journal (*Comptes Rendues de l´ Académie des Sciences*), although being available in the off-prints of the paper. This difficulty, associated to the fact that the publication appeared in a geological context, hampered the spread of the proposal which remained virtually unknown within the scientific community. Other important pioneers of the Periodic Table in the 1860s include the British **John Newlands** who published in 1865 (*Chemical News*) the "Law of Octaves" (by analogy with the music octaves) with an horizontal representation of the groups of elements, and the German **Lothar Meyer** of the Wroclaw University who proposed (1864) a classification of the elements, revised in 1870 with marked similarities to that of Mendeleev. Information on these pioneers' contributions can be found in an interview with Peter Wothers (University of Cambridge): http://www.periodicvideos.com/videos/first_periodic_table.htm

But such contributions towards the establishment of a chemical periodicity of the elements do not decrease Mendeleev´s merit and vision. His system not only succeeded in the arrangement of the elements in a coherent way (for the knowledge of that time), but also provided accurate predictions of missing elements (by filling gaps in the table) and of properties of their compounds, apart from correcting the atomic weights of some known elements, aspects that he properly highlighted. He associated the system to a law of nature and defended its viability along his life. Moreover, it is understandable that discoveries in science can occur simultaneously and independently in more than one place (*e.g.*, scientists can reach comparable conclusions and propose innovative interpretations and directions, based on similar sources) and that they can be recognized differently.

Numerous initiatives have been undertaken in the world and much has been said in this celebratory year of 2019. We should refrain from repeating herein but the following points are illustrative.

On this occasion, many Universities have made available different modes of visualizing the Periodic Table of the Elements. Among them, the **Periodic Table of videos** (http://www.periodicvideos.com/) deserves to be highlighted. It is a didactic web series coordinated scientifically by Martin Polyakoff of the University of Nottingham (videos recorded by the video journalist Brady Haran), where each of the 118 elements is described by the corresponding video.

A Periodic Table prepared freely as a collaborative **patchwork by members of the Universidade Nova de Lisboa,** under the coordination of our *Confrade* José Moura and Prof. Ana Ricardo, was on display in the Chapter Room of the Academy of Sciences of Lisbon on the occasion of the celebrations (Figure 2).

However, the Academy celebrations of the sesquicentennial of the Mendeleev periodic system proposal focused mainly on a **Celebratory Symposium** (with members of its Chemistry section) to

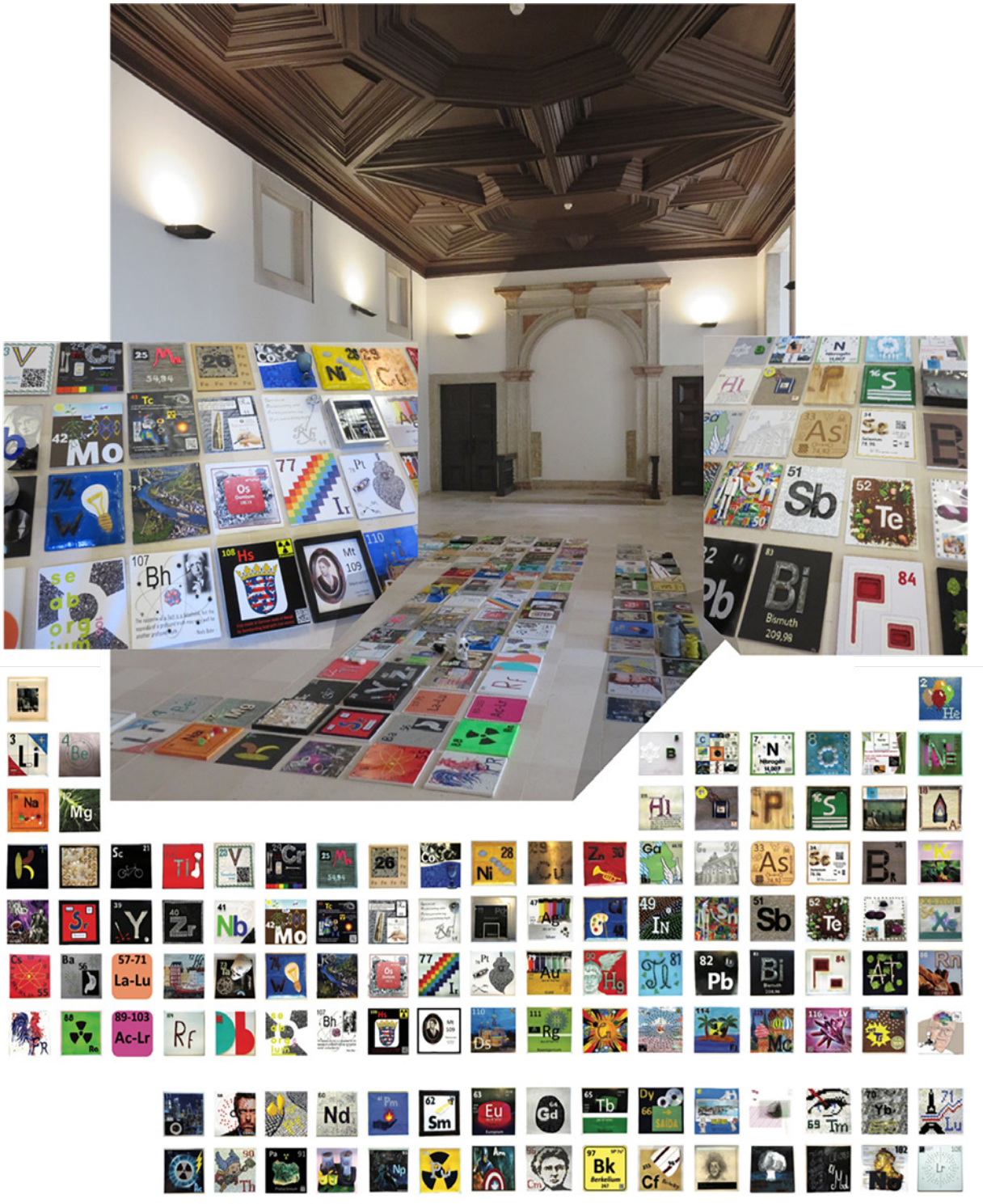

Figure 2.
Periodic Table of the Universidade Nova de Lisboa (bottom figure by courtesy of Prof. José Moura) which was on display at the Academy of Sciences of Lisbon on the occasion of the celebratory symposium (overall views and detailed parts).

illustrate the significance of elements of the Periodic Table in Chemical sciences, and I had the privilege to be in charge of its organization.

The scheduled program was combined with a visit of three Foreign Members of the Academy and according also to the convenience of the national Members of the Chemistry section of the Academy who joined the initiative. It consisted of three main sessions (held on October 3rd, 10th and 17th, 2019), with the following scientific program:

A – Catalysis and the Periodic Table

– ***Pierre Brausntein,*** *University of Strasbourg, France*
"Hybrid Ligands for Metal Complexes, Catalysts and Nanomaterials"

– ***Pierre Dixneuf,*** *University of Rennes, France*
"Ruthenium Catalysts: Their Empire for Green and Sustainable Chemistry" (renamed in the publication as ""From a 175 year old Ruthenium to its Empire on Green Catalysis and Sustainable Chemistry")

– ***Luis Oro,*** *University of Zaragoza, Spain*
"Mechanistic Studies on Rhodium and Iridium Homogeneous Catalysts"

– ***Armando Pombeiro,*** *Instituto Superior Técnico, Universidade de Lisboa*
"Selected Metal Catalysts Spanned over the Periodic Table Towards Alkane Functionalization"

B – Metal Centres in Supramolecular and Biological Structures

– ***João Rocha,*** *Universidade de Aveiro*
"Nanoporous Materials: Functional Silicates and Metal Organic Frameworks"

– ***José Moura,*** *Universidade Nova de Lisboa*
"Design of Artificial Enzymes Using the Metals of the Periodic Table"

C – Carbon: an Essential Element

– ***José Figueiredo,*** *Universidade do Porto*
"The Versatility of Carbon: Custom-Made Nanostructures"

– ***José Cavaleiro,*** *Universidade de Aveiro*
"Carbon as a Natural Element, Chemistry and Life" (postponed to another session)

– ***António Varandas,*** *Universidade de Coimbra*
"Cost-effective Dual-strategy for Molecular Reaction Dynamics and the Challenging Carbon Clusters" (renamed in the publication as "*Ab initio* potentials: From CBS Extrapolation to Globalness to Riddles in the Chemistry of Small Carbon Clusters)

These contributions in Chemistry instantiate the importance of the properties of different types of chemical compounds with relevant elements, in association to their positions in the Periodic Table. They include, for instance: molecular compounds with either precious or non-precious metals in catalytic processes towards sustainable synthesis of added value organic compounds; nanomaterials and metal organic frameworks (MOFs) in supramolecular and biological structures with various applications; and carbon as a key element in nanostructures and in biology. Extended abstracts of all these contributions are gathered in this collection.

A different area, concerning Mathematics and the Periodic Table, was addressed in another Academy session organized by the Section of Mathematics (*Confrade* José Francisco Rodrigues).

Moreover, the Celebratory Symposium of the Academy of Sciences of Lisbon is complemented with an historical account on the **discovery of Mendeleev´s Periodic Law and Periodic Table**, by **Igor S. Dmitriev**, the Director of the **Mendeleev Museum** of the Saint Petersburg State University, and our *Confrade* **Vadim Yu. Kukushkin** of the same University, where Mendeleev created his periodic system. In fact, this museum (Figure 3) comprises the apartment where Mendeleev lived at the University (what reflects a treatment, a recognition and an approach to support scientists that are quite different from those followed nowadays, specially in western countries), a scientific archive with his manuscripts, personal belongings (including his desk and other furniture) and a library. It is hosted on the ground floor of the former "Twelve Collegia" which were commissioned by Peter the Great to host his Government but later became the headquarters of the University.

This complementary contribution, entitled "**Sublime Generalization: Discovery of The Periodic Law**", follows immediately this Preface, appearing at the beginning of this collection, as a vivid evocation of the Mendeleev Periodic Table discovery.

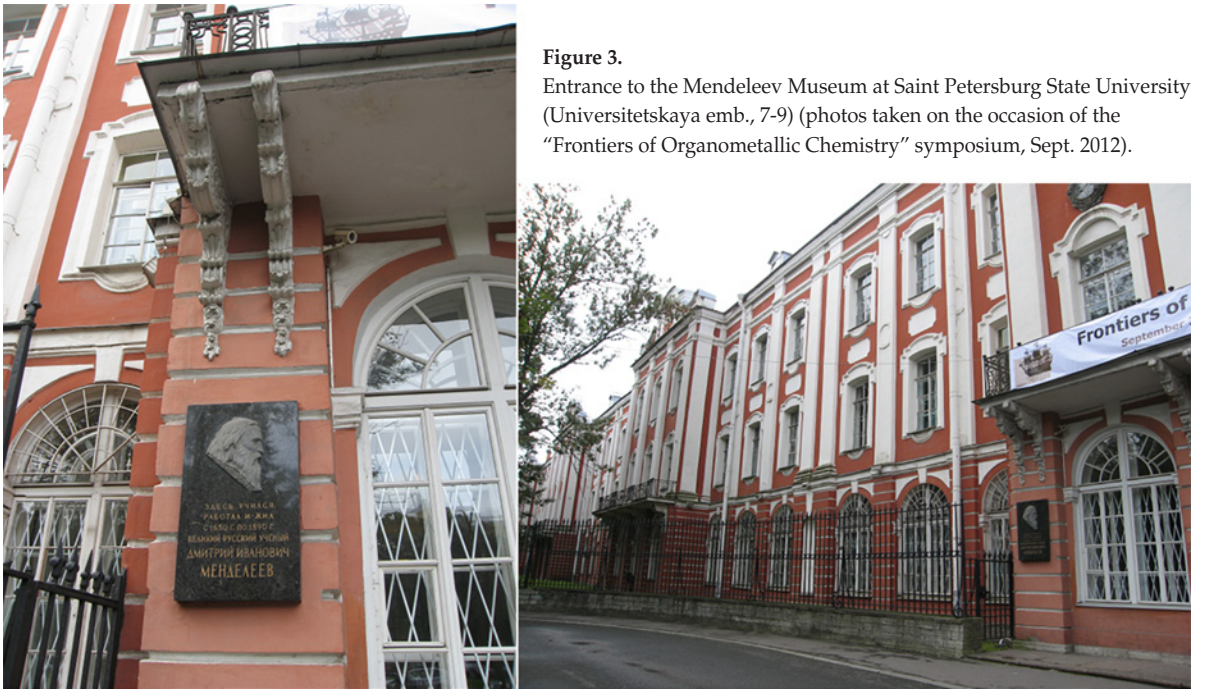

Figure 3.
Entrance to the Mendeleev Museum at Saint Petersburg State University (Universitetskaya emb., 7-9) (photos taken on the occasion of the "Frontiers of Organometallic Chemistry" symposium, Sept. 2012).

I take the opportunity to **acknowledge** all the *Confrades* and Colleagues who have contributed to the above symposium and historical description of Mendeleev's periodic table and/or to this collection (their names are indicated above), Prof. M. Fátima Guedes da Silva (Instituto Superior Técnico) for the kind editorial assistance in the preparation of the files for publication, and the President and Secretary General of the Academy (*Confrades* Carlos Salema and Salomé Pais, respectively) for their invitation to coordinate the symposium and the publication of this collection, as well as for the support provided.