ROYAL SOCIETY OF CHEMISTRY | CELEBRATING IYPT 2019

Historical Group

NEWSLETTER
and
SUMMARY OF PAPERS

No. 76 Summer 2019

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https://www.qmul.ac.uk/sbcs/rschg/
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From the Editor

Welcome to the summer 2019 RSCHG Newsletter. The autumn RSCHG meeting, held jointly with the Royal Institution and the Society for the History of Alchemy and Chemistry, will take place at the Royal Institution on Saturday 19 October 2019. It will commemorate the hundredth anniversary of William Crookes' death and explore various aspects of Crookes's extraordinary career and his place in science. Full details on how to register for the meeting can be found in the flyer enclosed with the hard copy newsletter and also in the online version.

This issue contains a wide variety of news items, articles, book reviews and reports and is themed around the celebrations for the International Year of the Periodic Table. These celebrations have inspired various books, exhibitions and events which are featured throughout this issue. The short articles also reflect this theme. Bill Griffith has contributed an article entitled *How the Group VIII Elements Posed a Problem for Mendeleev*. William Brock has written about *Norium, Mnemonics and Mackay,* which explores Mackay's complex method for helping children recall atomic weights. Finally, John Nicholson discusses *The Intriguing Career of Dr J.G.F. (Gerald) Druce (1894-1950),* including his interest in the search for hitherto undiscovered elements of the periodic table.

There are four book reviews in this issue with the titles featured as follows: John Blackie, *The Dyes: Scotland's Dyestuff Pioneers and a Century of Chemical Manufacturing in Grangemouth*; Susannah Gibson, *The Spirit of Enquiry*: *How One Extraordinary Society Shaped Modern Science;* Isabel Malaquias and Peter J.T. Morris, eds., *Perspectives on Chemical Biography in the 21st Century;* and Eric Scerri, *A Tale of Seven Scientists and a New Philosophy of Science*. Reports on the International Year of the Periodic Table Exhibition at St Catherine's College, Cambridge (an exhibition which will also be on display at Burlington House from 13 to 30 August 2019), the Fresenius exhibition in Wiesbaden, Germany, the Chemistry in Albertopolis conference held at the Science Museum and three meetings on Fritz Haber held in Berlin, Jerusalem and Karlsruhe are also included. Reports also appear on the RSCHG meeting held in March 2019 entitled *Celebrating the Centenary of IUPAC* and the recent joint meeting in with the IOP History of Physics Group commemorating a *Centenary of Transmutation*.

Finally, I would like to thank everyone who has sent material for this newsletter. I also want to particularly thank the newsletter production team of Bill Griffith and Gerry Moss and John Nicholson, who liaises with the RSC regarding its online publication. If you would like to contribute items such as news, articles, book reviews and reports to the newsletter please do contact me. The guidelines for contributors can be found online at: http://www.chem.qmul.ac.uk/rschg/Guidelines.html

The deadline for the winter 2019 issue will be **Friday 6 December 2019**. Please send your contributions to a.simmons@ucl.ac.uk as an attachment in Word. All contributions must be in electronic form. If you have received the newsletter by post and wish to look at the electronic version, it can be found at:

http://www.rsc.org/historical or http://www.sbcs.qmul.ac.uk/rschg/

Anna Simmons, UCL

ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP JOINT AUTUMN MEETING

William Crookes (1832-1919)

Saturday 19 October 2019, Royal Institution, 21 Albemarle Street, London, W1S 4BS

Held jointly with the Society for the History of Alchemy and Chemistry and the Royal Institution

http://www.rigb.org/visit-us/find-us

This year marks the centenary of the death of William Crookes. Journalist, chemist, photographer, spiritualist, businessman, sometime Secretary of the Royal Institution and President of the Royal Society of London, Crookes was a key figure in the science of the second half of the nineteenth century and beginning of the twentieth. This meeting, which is part of the ChemFest celebrations of the sesquicentenary of the periodic table, will examine various aspects of Crookes's extraordinary career and his place in science.

Programme

13.45 Registration
13:55 Welcome and Introduction:
Frank James, (Royal Institution and Chair of SHAC)
First Session Chair: Anna Simmons (UCL)
14.00 Richard Noakes (Exeter University)
'Two Parallel Lines'? The Trajectories of Physical and Psychical Research in the Work of William Crookes
14:20 Kelley Wilder (De Montfort University, Leicester)
William Crookes, A Life in Photo-Chemistry
15.00 Refreshment Break
Second Session Chair: Peter Morris (Chair of RSCHG)
15.30 Frank James (Royal Institution and UCL)
William Crookes and Michael Faraday
16.10 Paul Ranford (UCL)
Crookes's "Invisible Helper" – George Gabriel Stokes (1819-1903)
16.50 William Brock (University of Leicester)
The Key to the Deepest Mystery of Nature: Crookes, Periodicity and the Genesis and Evolution of the Elements
17.30 Close of meeting

REGISTRATION DETAILS

There is no charge for this meeting, but prior registration is essential. Please email Robert Johnstone (robert.johnstone.14@ucl.ac.uk) with your details, stating that you wish to attend the Crookes meeting, or use the flyer included with the hard copy version of the newsletter and send it to Robert Johnstone, SHAC Treasurer, 38 Elmtree Green, Great Missenden, Buckinghamshire, HD16 9AF. **If having registered, you are unable to attend, please notify Robert Johnstone.**

ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP NEWS

Secretary's Report for 2018

The Group held two scientific meetings at Burlington House, open to members and non-members, during 2018, as well as two committee meetings. Full reports (including summaries of the presentations) of the scientific meetings appeared in the two issues of the RSCHG Newsletter published in 2018. *Some Chemical Consequences of World War I* was held on 14 March 2018 and was attended by approximately sixty-five people, of which about twenty were students. *The History of Dyes on the 150th Anniversary of the Synthesis of Alizarin* was held on 17 October, with approximately sixty people attending. Jeffrey I. Seeman's Wheeler Lecture *Woodward's Unpublished Letters: Revealing, Commanding and Elegant. Part 2*, was published by the Group in June 2018.

Diversity & Inclusion

The RSC is concerned about the issues of diversity and inclusion across the various special interest groups, and requires us to report specifically on how we are addressing them. The Historical Group committee is aware of the current highly unbalanced ratio of male and female committee members, and also that the Group's prize, the Wheeler lectureship, has so far been awarded only to white middle-aged men. It is not easy to redress this balance: Last year's appeal for new committee members brought three volunteers, all senior white male chemists. However, the committee has already announced that the next two Wheeler awards will go to female historians of chemistry.

The meetings are attended by a substantial number of retired members, including a high proportion of female members. However, this demographic is not ethnically diverse. Against that, our meetings have attracted attendance by students from the London Study Centre of New York University, and this has included a high proportion of female and Hispanic students. Our meeting venue, Burlington House, is accessible for disabled people, and we have had a few elderly attendees at our meetings for whom the lift facilities have been essential. We also make use of the loop system on the p/a in order to help members who have hearing difficulties.

John Nicholson

MEMBERS' PUBLICATIONS

If you would like to contribute anything to this section, please send details of your publications to the editor. Anything from the title details to a fuller summary is most welcome.

Anna Simmons, "Trade, Knowledge and Networks: The activities of the Society of Apothecaries and its members in London, c. 1670 – c. 1800", *British Journal of the History of Science*, June 2019. https://doi.org/10.1017/S0007087419000256

This article explores the activities of the Society of Apothecaries and its members following the foundation of a laboratory for manufacturing chemical medicines. In response to political pressures, the guild created an institutional framework for production which in time served its members both functionally and financially and established a physical site within which the endorsement of practical knowledge could take place. The Society benefitted from the mercantile interests, political connections and practical expertise of its members, with contributions to its trading activities part of a much wider participation in London's medical, scientific and commercial milieu.

PUBLICATIONS OF INTEREST

Women in their Element

Published in August 2019, *Women in their Element* offers an original viewpoint on the history of the Periodic Table: a collective volume with short illustrated papers on women and their contribution to the building and the understanding of the periodic table and of the elements themselves. Edited by Annette Lyknnes and Brigitte Van Tiggelen, this book will help make historical women chemists more visible, as well as shed light on the multifaceted character of the work on the chemical elements and their periodic relationships. Stories of female input, the editors believe, will contribute to the understanding of the nature of science, of collaboration as opposed to the traditional depiction of the lone genius. While the discovery of elements will be a natural part of this collective work, the editors aim to go beyond discovery histories. Stories of women contributors to the chemistry of the elements will also include understanding the concept of element, identifying properties, developing analytical methods, mapping the radioactive series, finding applications of elements, and the participation of women as audiences when new elements were presented at lectures. Women featured include May Sybil Leslie, Kathleen Lonsdale, Harriet Brooks, Marguerite Perey, Margaret Todd and Barbara Bowen, with many of the authors, including John Hudson, Marelene and Geoffrey Rayner-Canham, Jeffrey Johnson and Sally Horrocks, well-known to RSC Historical Group members. A 25% discount on the book is available at the World Scientific web store using the code WSELEMENT25.

***Am**bix* – The Journal of the Society for the History of Alchemy and Chemistry

February 2019, volume 66, issue 1

Charlotte A. Abney Salomon, “The Pocket Laboratory: The Blowpipe in Eighteenth Century Swedish Chemistry”.

Carolyn Cobbold, “Adulation or Adulteration? Representing Dyes in the Victorian Media”.

Vangelis Antzoulatos, “Berthelot’s Pathway from Synthesis to Thermochemistry”.

Humphry Davy Double Issue for May and August 2019, volume 66, issues 3 and 4

Frank A.J.L. James and Sharon Ruston, “New Studies on Humphry Davy: An Introduction”.

Hattie Lloyd Edmondson, “Chivalrous Chemistry”.

Sharon Ruston, “Humphry Davy: Analogy, Priority and the ‘true philosopher’”.

Gregory Tate, “Humphry Davy and the Problem of Analogy”.

Tim Fulford, “Davy Takes to the Hills: Dialogic Enquiry and the Aesthetics of the Prospect View”.

Jan Golinski, “ ‘The Fitness of their Union’: Travel and Health in the Letters of Humphry and Jane Davy”.

Andrew Lacey, “New Light on John Davy”.

Frank A.J.L. James, “Constructing Humphry Davy’s Biographical Image”.

David Knight, “Sources and Resources for Davy: 1960 and Now”.

William H. Brock, “David Marcus Knight (1936-2018): An Appreciation”.

Articles on History of Chemistry that you Might Otherwise Miss

Frederick. G. Page, “Binks and a Burette: An Account of a Burette and an Analytical Chemist named Christopher Binks (1808-1873)”, *Bulletin of the Scientific Instrument Society*, No. 139, (2018), 32-41.

Jeffery I. Seeman, “Peer Review of Mendeleev’s 1869 breakthrough paper: ’I suggest eliminating the table...’, *Helv. Chim. Acta*, 102 (January 2019), online.

NEWS FROM CATALYST

A New Gallery at the Catalyst Science Discovery Centre and Museum, Widnes

The Catalyst story started in 1982 with an exhibition in the Old Town Hall, Widnes, to mark 100 years of the foundation of the *Society of Chemical Industry*. Desiring a permanent home for the exhibition and to extend its scope, it was relocated to the former Gossage’s building on the west bank of the River Mersey (1986) and christened “*The Museum of Chemical Industry*” in 1989. The Trustees of the time felt that, as a dedicated museum, its appeal might be limited so they embarked on a scheme to complement the collection aspect with a range of outreach activities for schoolchildren. To this end, in 1991 it opened a hands-on exhibition called “*Scientrific*” to entertain and instruct children in science generally and in 1994 it opened new facilities for instruction and learning. These were revamped in 2006, giving the Centre a new laboratory for school workshops and an interactive theatre. By 2018, some of the facilities were looking tired and Catalyst was pleased to receive funding from the Welcome Trust and other charitable agencies to update the Scientrific Gallery, theatre, front entrance and café.

It had long been a desire of HG member and Chair of the Trustees, Diana Leitsch MBE, to focus more on the local chemical industry through a consideration of some of the people involved and it was agreed that funding should be sought to mark the life and achievements of Dr Harry Baker (1859-1935). He was a student of two internationally famous chemists, Professor Sir Henry Roscoe, FRS in Manchester and Professor Robert Bunsen in Heidelberg. The exhibition concentrates on his work from 1897 onwards, when he came with his family to Runcorn. He initiated the development of chlorine production by the electrolysis of brine pumped from central Cheshire and transferred to the newly-opened factory of the *Castner Kellner Alkali Company* (later ICI, now *Inovyn*) at the site in Weston Point, Runcorn. It was an electrolytic process using mercury rocking cells which had been developed five years earlier by Hamilton Castner and Karl Kellner, with some input from Harry Baker. Complementing its historical approach, the exhibition depicts how this work links with present day science, through the many current and important uses of chlorine and chlorine products. Some 120 years on, chlorine production continues at the same site in Weston Point.

The Baker Gallery was opened on 17 May 2019 in the presence of local school children who had studied the life and work of Harry Baker. Also present were a number of his descendants who were delighted that Harry’s work was being recognised at last. It was generously funded by an *AIM-Biffa Award* Scheme and I congratulate those involved in its realisation for the informative and well-balanced exhibition they have produced.

Alan Dronsfield

FORTHCOMING EXHIBITIONS

From Nantwich to Oxygen: Joseph Priestley's Journey of Discovery

Dates: 14 August 2019 – 26 October 2019

Venue: Nantwich Museum, Pillory Street, Nantwich, Cheshire, CW5 5BQ

Developed with support from the Royal Society of Chemistry and forming part of the International Year of the Periodic Table celebrations, this free exhibition focuses on the life of Joseph Priestley, the famous scientist, theologian and teacher who lived and worked in Nantwich from 1758-1761. For further information:

http://nantwichmuseum.org.uk/

International Year of the Periodic Table Exhibition

Dates: 13 to 30 August 2019

Venue: Royal Society of Chemistry, Burlington House, London

The excellent exhibition curated by Peter Wothers and held in Cambridge in March (see review by John Hudson in this newsletter) will be on display at Burlington House in August. Visitors will be treated to a wonderful display of artefacts and documents relevant to the elements and the periodicity of their properties.

SOCIETY NEWS

Society for the History of Alchemy and Chemistry: The Partington Prize 2020

SHAC established the Partington Prize in memory of Professor James Riddick Partington, the Society's first Chairman. It is awarded every three years for an original and unpublished essay on any aspect of the history of alchemy or chemistry. The competition is open to anyone with a scholarly interest in the history of alchemy or chemistry who, by the closing date of 31 December 2019, has not reached thirty-five years of age, or if older is currently enrolled in a degree programme or has been awarded a master's degree or PhD within the previous three years. Entries must arrive before midnight GMT on 31 December 2019. The result of the competition will be announced by 30 April 2020.

For information on entering the Partington Prize please visit:

https://www.ambix.org/partington-prize/

For free access to previous prize-winning papers please visit:

https://think.taylorandfrancis.com/journal-prize-est-ambix-partington-prize/?utm_source=TFO&utm_medium=cms&utm_campaign=JOB08218

The HIST Award for Outstanding Achievement in the History of Chemistry for 2019

The recipient of the 2019 HIST Award of the Division of the History of Chemistry of the American Chemical Society is Prof. Otto Theodor (Ted) Benfey, Emeritus Professor of Chemistry and History of Science, Guilford College, Greensboro North Carolina. Born in Berlin in 1925, he was sent to England in 1936 and educated at Watford Grammar School. His parents emigrated to the United States in 1938, but Ted stayed on in England, entered University College, London in 1942 and eventually graduated with a PhD in 1947 under the direction of C.K. Ingold. Ted came to America as a post-doctoral Fellow at Columbia University but rather than pursue a career in research at a major university, Ted chose to teach at Earlham College, a small Quaker school in Richmond, Indiana. This allowed him to pursue what would become his real passions: teaching and the history of science, especially chemistry. In 1973 he was appointed the Dana Professor of Chemistry and History of Science at Guilford College in Greensboro, another school with Quaker roots. He retired from Guilford in 1988 and joined Arnold Thackray at the Beckman Center for the History of Chemistry in Philadelphia, where he edited the institution's news magazine, *Chemical Heritage,* for six years. Ted has written seven books on chemistry and the history of chemistry, has edited or co-edited six on the history of chemistry and chemical education, written fourteen chapters (mostly on the history of chemistry) in monographs, and has published eighty-nine articles and reviews in chemistry and the history of science.

OTHER NEWS

Drago Grdenić (1919-2018)

The distinguished Croatian crystallographer and inorganic chemist, Drago Grdenić, died in Zagreb on 13 September 2018, a year short of his 100th birthday. Grdenić read chemistry at the University of Zagreb where, following postgraduate studies in Moscow and with Dorothy Crowfoot Hodgkin at Oxford, he became professor of chemistry until his retirement in 1991. The first chemist to introduce X-ray crystallography in Croatia, his research was chiefly concerned with the structure of organo-mercury compounds. His Croatian textbook, *Molecules and Crystals – Introduction to Structural Chemistry* (1973) is said to be the first account of quantum chemistry in Croatia. In retirement he read extensively in the history of chemistry and produced a fine volume, *Povijest Kemije [History of Chemistry]*

(Novi Liber: Zagreb, 2001; see *Ambix* review, 50 (2003), 123) at the age of eighty. Although largely based on French, German and English secondary sources, this finely-illustrated volume of 930 pages, is distinguished by its coverage of chemistry's technological and alchemical past in the near and far east (pp. 1-391), before covering the development of chemistry in Europe since the sixteenth century. Aware that Croatian was inaccessible to most chemists and historians, Grdenić planned to make a translation into English – in which he was fluent. Sadly, as he wrote to me in February 2006, he found the task too onerous in old age.

William H. Brock

Brian Glover Gowenlock (1926-2019)

Brian Glover Gowenlock CBE, CChem, FRSC, FRSE, Emeritus Professor Heriot-Watt University, died on 17 March 2019, aged ninety-three. He was a member of the Royal Society Historical Group for many years and took his degrees at the University of Manchester. He was also an honorary research fellow at the University of Exeter after he retired.

Catalytic Converters Celebrated in New Royal Mail Stamps

The 3-way catalytic convertor is one of the major achievements of British engineering of the last fifty years celebrated in a new stamp set from the Royal Mail. See https://matthey.com/news/2019/catalytic-converter-features-in-royal-mails-new-stamp-set

SHORT ESSAYS

How the Group VIII Elements Posed a Problem for Mendeleev

To mark the sesquicentenary of Mendeleev's first periodic table of 1869 this piece discusses how the Group VIII elements posed some problems for him and others, and how he sought to overcome them. The elements Fe, Co and Ni, their six platinum metal congeners Ru, Os, Rh, Ir, Pd, Pt and the coinage metals Ag, Au and Au were first collectively called Group VIII by Mendeleev in 1871. The term (occasionally called VIIIA or VIIIB) is still used by chemists to denote the nonet of elements Fe, Co, Ni and the six platinum group metals, although increasingly the IUPAC group numbers 8, 9 and 10 respectively are used.

The Group VIII Platinum Metals

Platinum has been known since antiquity. Palladium was discovered in 1802 and rhodium in 1805 by William Hyde Wollaston (1766-1826) while his friend Smithson Tennant (1761-1815) isolated osmium and iridium in 1804. Karl Karlovich Klaus (1796-1864) discovered the last of the six, ruthenium, in 1844 [1], and later arranged the six in the correct periodic order, though placing the heavier elements (Os-Ir-Pt) above Ru-Rh-Pd [2].

Classifications of the Platinum Metals before Mendeleev

Johann Wolfgang Döbereiner (1780-1849) noted that the atomic weights of certain triads of chemically similar elements are related, the weight of the middle element being close to the mean of the other two; Pt-Ir-Os formed such a triad [3]. Ernst Lenssen (b. 1837) showed that Pd-Ru-Rh and Os-Pt-Ir had similar physical and chemical properties, and that their atomic weights were similarly related [4]. The first substantial attempt to classify the platinum metals within a table was made by John Hall Gladstone (1827-1902). He placed Os, Ru, Ir, Rh, Pt, Pd and Au together in 1853, noting that Pd, Rh and Ru had similar equivalent weights while those of Pt, Ir and Os had almost double the weights of the former triad. He commented "Who has failed to remark that the platinum group has double the atomic weights of the palladium group?" [5]. These observations were made before the crucially important Karlsruhe Congress of 1860, which clarified the nature of atoms and molecules and gave some uniformity to the numerical values of atomic weights. John Alexander Raina Newlands (1837-1898) produced several tables; unlike Gladstone, Meyer and Mendeleev he did not attend the Karlsruhe Congress. In his famous Law of Octaves table, for the first time, elements are assigned numbers from 1 to 56, the first use of atomic numbers, though lacking their later significance. The elements Rh ('Ro') and Ru share no. 35 in the fifth column, Pd is no. 36 in column six, while in the final eighth column Pt and Ir share no. 50 while Os is no. 51 [6]. William Odling (1829-1921) in 1864 produced a table comprising fifty-seven elements, placing Rh, Ru and Pd vertically, side by side with Pt-Ir-Os in adjacent columns. He was puzzled by these, remarking that "many osmic reactions are altogether special" [7]. The 1870 table of Julius Lothar Meyer (1830-1895) accommodated fifty-five elements in nine groups, with Ru, Rh and Pd in group VI and Os, Ir and Pt at their side in Group VIII [8].

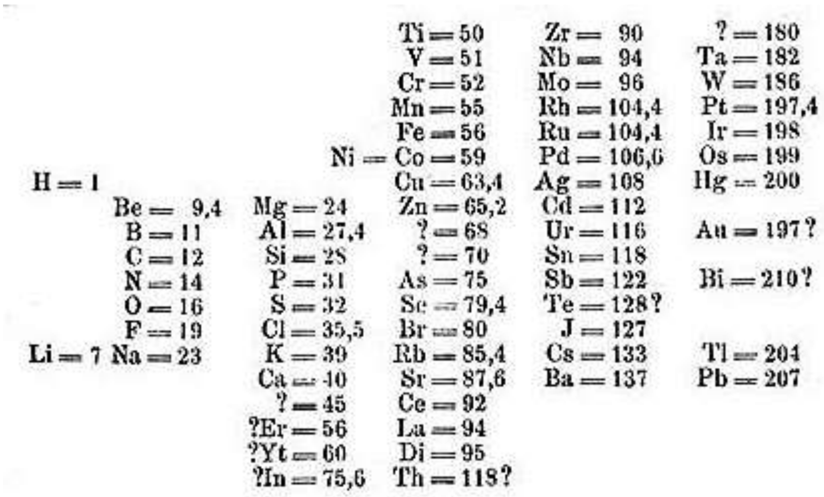
Mendeleev's Tables

Dmitri Ivanovich Mendeleev (1834-1907) produced the best periodic tables of the time, one of which has influenced all subsequent examples. He was Professor of Chemistry at St. Petersburg University during his most productive years, had studied with Bunsen in 1856 and attended the 1860 Karlsruhe congress. His remarkable story has often been told, and there are good reviews on the tables which he and others produced [9-11].

Mendeleev's First Table of 1869 (Fig. 1)

This was published in March after a preliminary sketch of 17 February 1869 (old style), entitled "On the Correlation Between the Properties of the Elements and their Atomic Weights" [12, 13]. Mendeleev wrote "if one arranges the elements ……(by) increasing atomic weight, such that the horizontal rows contain analogous elements……..one obtains the following table.” Further, “Elements which…..(have) similar chemical properties either have similar atomic weights (e.g., Pt, Ir, Os) or have their atomic weights increasing regularly (e.g., K, Rb, Cl)” [12]. He did not worry if these were occasionally not in the right sequence: “The atomic weight of an element may sometimes be amended by a knowledge of those of contiguous elements. Thus, (that) of tellurium must lie between 123 and 126, and cannot be 128.”

There is no mention yet of Group VIII *per se*, but the 1869 table lists sixty-three elements in six columns, each occupying a single place with chemically similar species arranged together horizontally. In the fourth row appear Mn, Rh and Pt; Fe, Ru and Ir follow in the next row with Ni, Co, Pd and Os beneath. Although they are grouped together because of their similarities and close atomic weights they are not yet in the correct chemical order [12].



			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104,4	Pt = 197,4
			Fe = 56	Ru = 104,4	Ir = 198
			Ni = Co = 59	Pd = 106,6	Os = 199
H = 1			Cu = 63,4	Ag = 108	Hg = 200
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79,4	Te = 128?	
	F = 19	Cl = 35,5	Br = 80	J = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75,6	Th = 118?		

Fig. 1: Mendeleev’s Table of 1869 [12].

Mendeleev’s Table of 1871. (Fig. 2)

In this, “On the Periodic Regularity of the Chemical Elements”, Mendeleev proposes a Periodic Law, being the first to do so. This short-form table is much superior to his earlier one [14, 15], having a startlingly modern appearance, unsurprisingly so since it forms the kernel of most modern tables. In essence it is the 1869 table turned through 90°, listing sixty-two elements with added group numbers indicating their highest oxidation states. Elements are distributed between eight vertically arranged *Gruppen* (groups) of chemically similar species in twelve horizontally-arranged *Reihen* (rows). ‘Missing’ elements are shown by a dash and suggested atomic weight. Thus, he predicted the existence of scandium (*eka*-boron, - =44); gallium (*eka*-aluminium, - =68) and germanium (*eka*-silicon, - =72). His astonishingly accurate predictions of the properties of these as yet undiscovered elements earned the table its enduring success [15].

Reihen	Gruppe I. — R^2O	Gruppe II. — RO	Gruppe III. — R^2O^3	Gruppe IV. RH^4 RO^2	Gruppe V. RH^3 R^2O^5	Gruppe VI. RH^2 RO^3	Gruppe VII. RH R^2O^7	Gruppe VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	— =44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	— =68	— =72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	— =100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce= 40	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Fig. 2. Mendeleev’s table of 1871 [15].

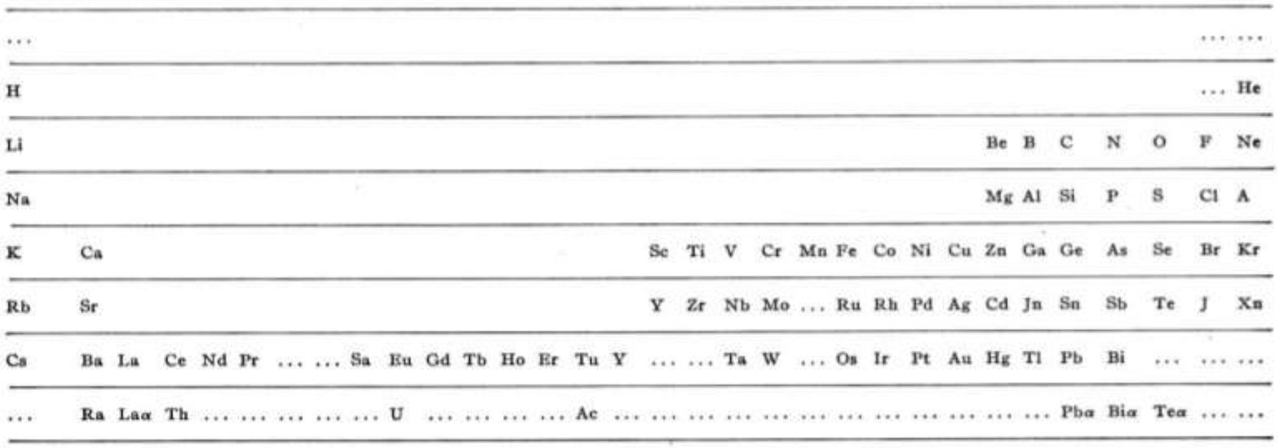
Under Gruppe VIII, sub-headed RO^4, Fe and Co appear on line four with Ni and Cu beneath; Ru and Rh appear on line six with Pd and Ag beneath, and line ten has Os and Ir with Pt and Au beneath. This implies that Fe, Ru and Os should resemble each other, as should Co, Rh and Ir and Ni, Pd and Pt, as is indeed the case. For group VIII alone Mendeleev departs from the cardinal principle of his 1869 table that each element should occupy its own space; in this new table there are twelve elements all in the single Group VIII area. He notes that their chemistries differ from those in Groups I to VII, having similar atomic weights: “only small variations in the….. atomic weights of ……analogous elements (as with Mn, Fe, Co, Ni with Pd, Rh, Ru or with Pt, Os, Ir) have been observed”. He further observes that “the elements resemble one another to the same extent as the corresponding members of V-Nb-Ta and Cr-Mo-W”. [15].

Mendeleev assigns osmium and iridium lower atomic weights than those given in his 1869 table, thus arriving at their correct chemical sequence. A number of similarities for these Group VIII elements are noted: the metals are grey and hard to melt; they have low atomic volumes; they condense and diffuse hydrogen; their highest oxides are easily reduced; only in this group do we find RO_4 (Os, Ru); all give stable alkaline cyanide complexes $[M(CN)_6]^{4-}$ (Fe, Ru, Os), $[M(CN)_6]^{3-}$ (Co, Rh, Ir) and $[M(CN)_4]^{2-}$ (Ni, Pd, Pt); they form similar ammine complexes (e.g. $MX_3.5NH_3$ (Co, Rh)) [15, 16].

Later Adjustments to the 1871 Table

Mendeleev’s inclusion of the coinage metals Cu, Ag and Au in Group VIII is clearly wrong because they lack high oxidation states despite their closeness of atomic weights. He must have been aware of this because he also accommodates them, much more appropriately, in Group I. In 1879 a series of notes was published in *Chemical News,* essentially a modified translation of his 1871 *Annalen* paper [15], in some of which he tries to address this and other problems [16]. In a new long-form table he splits Group I to VII elements into left-hand ‘even’ and right-hand ‘odd’ blocks with the Group VIII nonet centrally placed between the two. In this arrangement Cu, Ag and Au are now accommodated in Group I of the right-hand ‘odd’ block [16a]. He comments ruefully that Group VIII elements are ‘special’ and ‘independent’ [16b], noting how later redeterminations of the atomic weights of Os, Ir, Pt and Au reinforce his arrangement of these elements [16c]. His 1871 placing of manganese, uncomfortably situated in Group VII adjacent to the halogens, is clearly wrong. Had *eka*-manganese, listed in the table as ‘- =100’ and *dvi*-manganese been identified before his death in 1907, as were scandium, gallium and germanium, things might have been different. Unfortunately *dvi*-manganese (rhenium) was not isolated until 1925, and the man-made technetium even later in 1939. In Mendeleev’s last table of 1904 Group VIII remains essentially as it was in his 1871 table with the addition only of the noble gases in a new Group 0 [17]. It was not only Mendeleev who had problems with Group VIII: Crookes thought of the nine elements as ‘interperiodic’ which have “often been regarded as modifications of one single form of matter” [18], and a later suggestion by Reynolds that manganese simply be added to the Fe-Ni-Co triad of Group VIII does not solve the problem [19].

The hero of our story is of course Mendeleev, but a second hero must be Alfred Werner (1866-1919), pioneer of transition metal chemistry, a 1913 Nobel chemistry prize laureate. He realised that the nine Group VIII elements are not really as singular as they seemed – their vertical triads are indeed chemically similar, but so are those of other periodic groups [20]. In 1905, before Moseley’s work [21] establishing the primacy of atomic numbers rather than atomic weights giving a much-needed theoretical basis for periodic tables, Werner produced a remarkably prescient table of the eighty-three elements then known (Fig. 3). He removed the Group VIII elements from their crowded Mendelevian strait-jacket, producing a long-form table with the old Group VIII nonet now occupying three columns, with the noble gases in the last column. He also solved also the manganese problem by placing it between chromium and iron [20].



…																														…	…
H																														…	He
Li																									Be	B	C	N	O	F	Ne
Na																									Mg	Al	Si	P	S	Cl	A
K	Ca															Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr															Y	Zr	Nb	Mo	…	Ru	Rh	Pd	Ag	Cd	Jn	Sn	Sb	Te	J	Xn
Cs	Ba	La	Ce	Nd	Pr	…	…	Sa	Eu	Gd	Tb	Ho	Er	Tu	Y	…	…	Ta	W	…	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	…	…	…
…	Ra	Laα	Th	…	…	…	…	…	U	…	…	…	…	Ac	…	…	…	…	…	…	…	…	…	…	…	…	Pbα	Biα	Teα	…	…

FIGURE 8.—WERNER'S PERIODIC TABLE

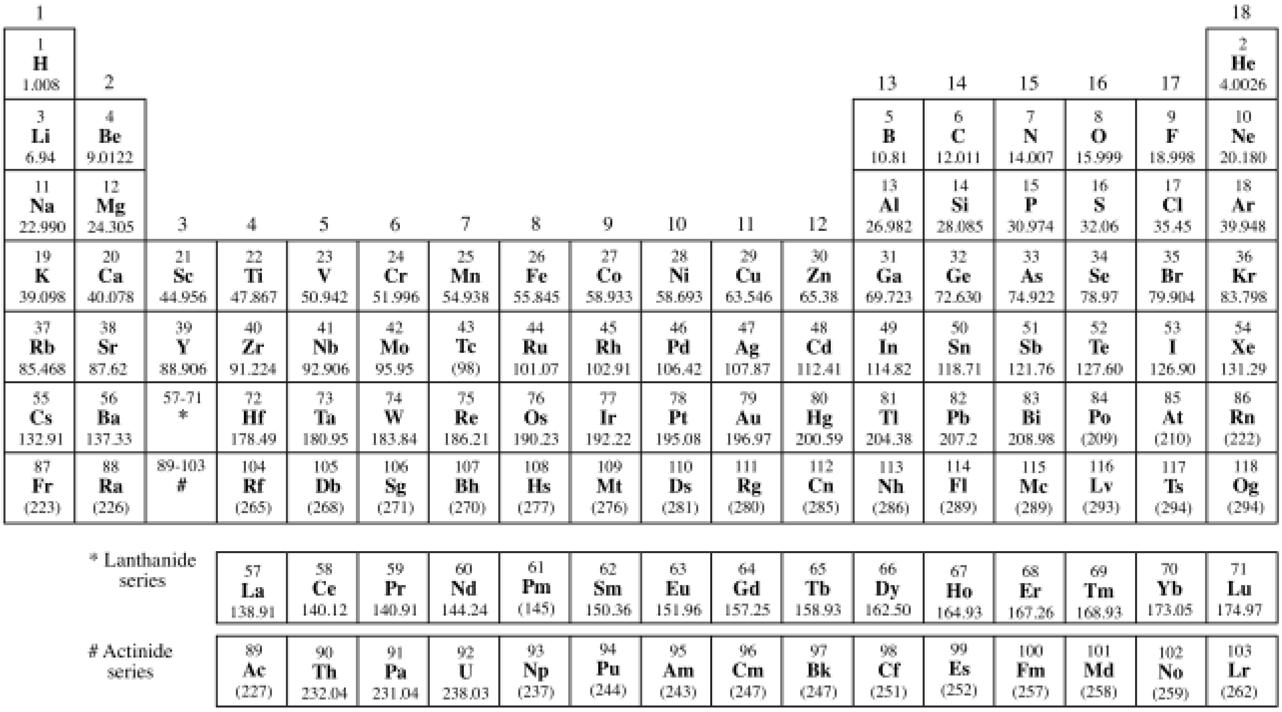
Fig. 3: Werner’s table of 1905 [20].

The Modern Periodic Table

Many more periodic tables were proposed after Mendeleev’s seminal one, and more are still being published [9-11]. Some have unusual shapes, but the most widely accepted pattern is the ‘medium long form’ recommended by IUPAC

(Fig. 4). By Werner's time most of the fourteen lanthanides – always a major headache for Mendeleev - had been identified and were accommodated in a row of their own (marked * in Fig. 4). That thorium, protactinium and uranium were best regarded as part of a new row called the actinides (marked # in Fig. 4) to be placed under the lanthanides, foreshadowed by Werner [20], was made clear by discoveries of Seaborg *et al* of the fourteen man-made elements from neptunium to lawrencium [22]. Subsequent work showed that elements after lawrencium, *viz.* $_{104}$Rf (rutherfordium) to the recently confirmed $_{118}$Og (oganesson), complete the transactinide series. Amongst these are the three congeners of the platinum-group metals, all made in the Darmstadt linear accelerator: $_{108}$Hs (hassium, made in 1984 from $_{96}$Cm and $_{12}$Mg); $_{109}$Mt (meitnerium, named after Lise Meitner, from $_{83}$Bi and $_{26}$Fe in 1982), and $_{110}$Ds (darmstadtium, from $_{82}$Pb and $_{28}$Ni in 1994). Chemical information on these is sparse, but hassium forms a volatile tetroxide just like Ru and Os. In the now universally accepted IUPAC table (Fig. 4) 118 elements are confirmed and named. There are eighteen groups, the old group VIII elements now appearing under groups 8, 9 and 10 [23].

Many papers continue to be published on periodic tables - a typical recent one [24] gives a formalised mathematical structure of periodicity. Mendeleev's iconic examples of 150 years ago still provide the bedrock for such advances, and interest in periodic tables, both chemically and historically [25], continues to prosper.



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.630	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Fig. 4: The current IUPAC table [23].

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Bill Griffith

Norium, Mnemonics and Mackay

When John Tyndall joined the University of Marburg in 1848, where he initially studied chemistry with Robert Bunsen, he also attended a class in mnemonics, the art of memory. Although I have not come across any other nineteenth-century university offering such classes, mnemonics were clearly useful in elementary teaching and we all recall learning such aids as “Richard of York gave battle in vain” as a way of recalling the colours of the rainbow, or more sophisticated ones for remembering equations in maths and physics.

One of the keenest exponents of the art of memory was the Scots Free Church clergyman, Alexander Mackay (1815-95). A farmer’s son, Mackay attended King’s College at the University of Aberdeen (MA 1840) before becoming minister at Rhynie in Aberdeenshire where he became interested in local geology. His correspondence with the geologist Hugh Miller and London gentlemen geologists led to his election to the Royal Geographical Society in 1859. Two years later he published an outstandingly successful *Manual of Modern Geography* (1861; 12th ed. 1872) which was to be followed by another half dozen geographical textbooks for parochial schools. Awarded an honorary LLD by his alma mater in 1866, he abandoned the church in 1867 to devote himself entirely to writing textbooks, living first in Edinburgh and finally (from 1878) at Ventnor on the Isle of Wight. He had married in 1846 and one of his five sons, the engineer Alexander Murdoch Mackay (1849-90) is remembered for his missionary work in Uganda. Among Mackay’s published curiosities is a *Rhyming Geography* (1873), and the schoolboy’s Gradgrind nightmare, the alarmingly-titled *Facts and Dates* (Blackwoods: Edinburgh, 1869; 3rd ed. 1879). Its subtitle explains all: “The leading events in sacred and prophane (*sic*) history and the principal facts in the various physical sciences. The memory being aided throughout by a simple and natural method. For schools and private reference.” There were 317 pages.

Mackay’s memory aid involved using consonants to represent numbers (and hence dates), with the complication that two or three letters could represent a single number. Thus b and c meant one; and j, k and s might mean 4; w, x and y all meant zero. On the other hand, the numbers 5 and 7 were represented by the single letters l and r, the reason being that l and r began far more words than any others. Vowels were not used. Pupils were led to recall dates by learning a brief phrase bearing on an historical event or piece of information, such that the initial letter of an italicised words expressed a date or figure required for recall. A phrase might need to have several redundant words to make sense, but only italicised letters counted. Two examples from the section on “Facts in Chemistry” will make this clearer. Thus, to recall the “existing *number* of *elements*” we take the *n* and *l* only which stand for 6 and 5 respectively, and so recall that there are only 65 known elements in 1869. (The *e* of *elements* is ignored since it is a vowel.) Curiously, Mackie did not provide mnemonics for remembering the names of elements, which might have been useful, but did expect children to recall their atomic weights (called equivalent weights by Mackie). For example, to recall the equivalent weight of iodine, we must remember the phrase “in *colour* and *odour peculiar*”. That gives the letters *c, o* and *p,* which stand for 1, 2 and 7 respectively, so that the atomic weight is 127. Mackie gave additional mnemonics for specific gravities, freezing and boiling points of liquids and the fusion points of metals, though why any child should be expected to recall such data was left unexplained. There were more memory aids for astronomy, physics, botany and zoology, but the bulk of the book was devoted to dates relevant to geography, Bible history and history.

Mackay’s chemical information came, as he says, from Henry Roscoe’s *Lessons in Elementary Chemistry* (1868), Wilhelm Hofmann’s *Introduction to Modern Chemistry* (1866), and especially George Wilson’s *Inorganic Chemistry* as revised by Stevenson Macadam (1866). This meant he was up-to-date with his facts. This explains the curious anomaly that a pupil has to remember there are sixty-five elements even though no information for one of them existed, namely *norium.*

The discovery of norium was first announced by the Swedish chemist and mineralogist Lars Fredrik Svedberg (1805-78) in 1845 after analysing a Norwegian ore of zirconia – hence the name, norium, from the ancient name for Norway, *Nore* [1]. His German account was logged by Berzelius in his annual report and thereby became widely known in 1846. Svedberg rightly suspected, as did many others including Edgar Fahs Smith in Philadelphia, that zirconium, the element first isolated by Berzelius in 1824, was mixed with another element in its ores. However, Svedberg and others (including Charles Marignac) found it impossible to separate the putative norium from zirconium and gradually it disappeared from the literature and never appeared in Mendeleev’s original periodic tables. In 1911 Georges Urbain, suspecting a missing element in Group 4 below zirconium, named it *celtium*, but this was not confirmed by Henry Moseley’s earliest work on X-ray spectra in 1913-14. Moseley did, however, predict a missing element with atomic number 72. It was not until 1923, when X-ray spectra techniques had improved, that the Hungarian chemist George de Hevesy working in Copenhagen with the Danish chemist Dirk Coster were able to confirm the x-ray spectrum of element 72 in zirconium. It took another two years for them to separate the unknown element and, to avoid past confusion, they chose to name it hafnium from the Latin name for Copenhagen, *hafnia.*

How would Mackay’s pupils have remembered hafnium-norium’s atomic weight? What about “*Copenhagen’s peculiar* metal *recovered*” (c=1, p=7, r=8 : 178).

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William. H. Brock

The Intriguing Career of Dr J.G.F. (Gerald) Druce (1894-1950)

Gerald Druce was a minor but interesting chemist of the first half of the twentieth century. He was considered sufficiently important to warrant an obituary in *The Times* [1] and an entry in the *Oxford Dictionary of National Biography* [2], though he made no major contributions to chemistry, and even his minor ones were flawed. Nonetheless, his role as a published researcher while being a schoolmaster by profession was unusual at the time and probably impossible today. His life also included some distinctive scholarship on science in what was then Czechoslovakia, and he undertook editorial work as the penultimate editor of William Crookes’ *Chemical News* (1924-30). We should recognise, though, that this was at a time when the journal had declined in importance compared with its position in the late nineteenth century.

Early Life

Druce was born to parents of modest means in Leamington Spa in 1894 [3, 4]. When he was young, his family moved to Reading, where he attended Kendrick school. For the 1911-12 session, he was a student at University College, Reading, after which he moved to University College, London where, in 1915, he graduated BSc in chemistry and botany. During his time at UCL, Druce met and formed a lasting friendship with Jaroslav Heyrovský (1890-1967), the pioneer of polarography. This friendship was to have a major influence on Druce’s life and career [2-4].

Druce joined the Chemical Society in 1915, and became an Associate of the Institute of Chemistry (AIC) in 1919. At the time, a university degree gave exemption only from the theoretical papers, and to obtain AIC a graduate was required to sit a practical examination [5]. Later, in 1925, Druce became a Fellow of the Institute of Chemistry (FIC). This was generally awarded on the basis of examination, but whether Druce obtained his FIC this way, or through the allowed option of “distinction in chemistry” [5] is not known.

Beginning Research

On leaving UCL, Druce began his research career at what was then the Borough Polytechnic Institute in south London (now London South Bank University). His earliest research is described in two papers published by the Chemical Society [6, 7]. The first described the preparation of the stannate salt K_2SnCl_6 [6], the second some quaternary ammonium complex salts of Sn(II), such as $[Et_2NH_2^+][SnCl_4^{2-}]$. In 1920, Druce was awarded the MSc (London) formally for “independent research” and these two publications represented a substantial part of his higher degree work.

Druce’s role at the Borough Polytechnic Institute is unclear. His papers are both solo contributions, and there is no mention of anyone who might have been his research supervisor, or even a senior colleague. It is possible that Druce held a junior appointment, such as assistant lecturer, though no record exists of this. The Chemistry Department at the Borough Polytechnic Institute had existed from at least 1897, when Sir William Perkin’s youngest son Dr Frederick Mollwo Perkin was appointed its head [8]. Indeed, the Department may have existed from the foundation of the Polytechnic in 1892. Perkin had left before Druce worked there, having moved into consultancy in 1909. However, the department continued until the mid-1980s, and it was where I undertook my PhD, also on tin chemistry, which I obtained in 1981. Despite the similarity of our topics, there was no long-term history of research in tin chemistry in the department and, for many years, research was actively discouraged.

Druce's research career received a major boost in 1920, when he accepted an invitation from Heyrovský to visit Czechoslovakia. This was the first of many visits that Druce made, and initially led to his becoming associated with the Charles University in Prague. He made frequent return visits to the Charles University, though was never actually based there, and in 1923, he was awarded his doctorate, the degree of *Doctoris Renum Naturalium*, by that university [3, 4]. This was a rare distinction indeed for an Englishman.

Teaching Career and Private Life

In 1920, too, Druce became chemistry and botany master at Battersea Grammar School. Later he was to become head of the chemistry department [3, 4]. Battersea Grammar School could trace its history back to the late 1660s, when Sir Walter St John Bt founded a school on his estate at Battersea [9]. The school underwent various transformations to emerge as Battersea Grammar School in 1893. By the time Druce joined its staff it had 450 pupils and occupied a fairly cramped site at St John's Hill, near Clapham Junction station. In 1936, the school moved to larger premises at Streatham, into accommodation designed for 540 pupils. The school continued until 1977, when it was one of the schools incorporated into the new Furzedown Secondary School, a school which itself underwent further amalgamation to create Graveney School, Tooting in 1986.

Away from teaching and research, the 1920s were busy years for Druce. In 1921 he married Elsie (née Caudell) and they went on to have one son, also called Gerald. The Druces spent their lives in south London, initially living at 26 Heslop Road, Balham, SW12 and later moving to 56 Bishop's Park Road, Norbury, SW16. Both houses are still standing. In 1924, Druce became editor of *Chemical News*, a role he held until 1930. In 1925, he published his first book, a brief account of the history of science [10]. This book was Druce's first foray into history, but he was to return to this field at intervals for the rest of his life.

Research at Battersea

Druce continued to undertake research following his move to Battersea Grammar School. There, working in a temporary research laboratory at the school at St John's Hill, Druce did more work on the chemistry of tin [11, 12] and his first paper from the school appeared in 1921. It reported the formation of the complex salt $K^+_2(EtSnCl_5)^{2-}$ [11] and contains an interesting acknowledgment to Heyrovský, who had directed his attention to the ideas of Professor Brauner on complex salts. Though carried out at Battersea, this work was clearly influenced by Druce's connections in Czechoslovakia and contributed to his doctorate.

This paper also contains a report of ethyltin tribromide, though the substance seems to have very strange properties. Druce claimed that $EtSnBr_3$ was a colourless crystalline solid, which did not melt at 310°C. Yet both $EtSnCl_3$ and $EtSnI_3$ are known and are liquids, boiling respectively at 196-198°C and 181-184°C [13]. Druce's result therefore appears unlikely, though it has never actually been refuted.

In the mid-1920s, Druce turned his attention to elements other than tin. This may have been inspired by his connections with the Charles University in Prague, because initially he revisited some studies of the Czech chemist Jaroslav Janovský. In 1874, Janovský had reported a solid hydride of arsenic, designated As_2H_2 [14]. Working with his colleague Edward Weeks at Battersea, Druce appeared to confirm the existence of this solid [15], and the pair went on to prepare analogous compounds of antimony, Sb_2H_2 [16] and bismuth, Bi_2H_2 [17]. In both cases, the claimed compounds were solids that decomposed on heating to yield hydrogen and the metallic element. For bismuth, Weeks and Druce also found a route to the gas BiH_3, improving on the recently reported synthetic method of Friedrich Paneth, then at the University of Hamburg, who had described the substance for the first time [18]. Weeks and Druce confirmed the properties of BH_3, and from it they were able to prepare the intermetallic compound silver bismuthide [19].

Unfortunately Druce's findings on solid hydrides could not be reproduced. A later study concluded that the existence of As_2H_2, Sb_2H_2 and Bi_2H_2 is questionable [20] and such compounds are not recognised by recent textbooks of inorganic chemistry [21]. However, Weeks and Druce evidently made something, but what? It is difficult to know at this stage.

New Elements

In the mid-1920s Druce became interested in the search for the hitherto undiscovered elements of the Periodic Table (numbers 75, 85, 87 and 93). As a result of some of this work, Druce's name has become associated with the discovery of rhenium. Indeed, some authors have claimed that he was involved in its discovery more or less at the same time as the acknowledged discoverers Noddack, Tacke and Berg [2, 21]. However, on balance the evidence does not support this claim.

This is the story. In about 1925 Druce began to work on undiscovered elements through the influence of a physicist called Frederick Loring. Loring is a shadowy figure who emerged in the 1920s with an interest in these elements [22] and in atomic physics generally [23]. This led to collaboration between Loring and Druce in an attempt to find some of the missing elements. Initially they claimed to have found both eka-iodine and eka-caesium (elements 85 and 87) on the basis of weak lines in X-ray spectra. This was obviously false, as modern science has shown that both elements are highly radioactive with very short half-lives [21]. Loring went on to publish a number of papers on the claimed element 87 [24, 25] and even proposed the name *alkalinium* for it. In retrospect, his persistence in the face of such ambiguous evidence seems most unwise.

After their joint paper on elements 85 and 87, Loring and Druce turned their attention to element 75, and in 1925 appeared to have found it. Their initial claim was to have discovered it in crude manganese salts [26], and later in the manganese ore pyrolusite and crude manganese sulphate [27]. The first of these reports appeared in September 1925 and, as for elements 85 and 87, the evidence was physical: the apparently correct X-ray spectrum. However, as before, the lines were very faint and occurred in a region with numerous interferences.

Loring and Druce were not the first to claim element 75. Just months earlier, in June 1925, the German trio of Noddack, Tacke and Berg [28] made a claim for element 75, having obtained similarly weak X-ray signals, this time from a sample extracted from the mineral columbite. Unfortunately for Loring and Druce, the Germans really were onto something and they were able to concentrate up their sample and to prove they actually had a new element. By 1927, they had begun a research programme investigating its chemical properties.

The English discovery was initially confirmed by Dolejsek and Heyrovský at the Charles University using polarography [29]. Their confirmation rested on a small irregularity in the polarographic signal of pyrolusite. However this also proved to be illusory and in 1937 Heyrovský published a correction [30]. He showed that this irregularity was an artefact of the polarograph and not evidence of a new element. Before that, in 1933 Hurd had published a paper in which he reported the results of the analysis of numerous samples of pyrolusite and showed that none contained more than 0.2 ppm of rhenium and most contained no detectable rhenium at all [31]. This was confirmed in a subsequent, more detailed paper [32].

On balance, therefore, Losing and Druce cannot have discovered rhenium independently, or indeed at all, and it is time that this claim was finally laid to rest. Loring and Druce were unfortunate in that their initial evidence was no worse than that of Noddack *et al*. Both teams had only faint peaks in crowded X-ray spectra by way of evidence but, by lucky chance, the columbite mineral examined by Noddack *et al* actually did contain the new element, as they subsequently demonstrated [33]. In contrast, Loring and Druce's substances contained no detectable rhenium and the peaks in their X-ray spectra were due to other elements.

Loring's institutional affiliation is difficult to establish at this remove, but wherever he was based, he did not have access to his own X-ray spectrometer. Instead, he had to depend on spectra run by the technical staff of the Adam Hilger Company Ltd, and they were operating close to the limits of their spectrometer's capabilities. Despite these problems, Loring continued to work on undiscovered elements, though separately from Druce. In a dismissive comment in their book on false claims for the discovery of elements, Fontana *et al* [34] claimed that Druce's death had the effect of "... removing himself from a trying situation and relieving the scientific community from the embarrassment of having to condemn him for having associated his name with that of Loring...". This is most unfair. Druce lived until 1950, some twenty years after his last paper with Loring, and there is no reasonable way that his partnership with Loring, dissolved so long previously, could or should have been a source of embarrassment. Mistakes are part of science and the mistakes by Loring and Druce seem to have been honest ones.

Druce did not leave the chemistry of rhenium altogether after this episode. Instead he went on to publish solo papers on the technical preparation of metallic rhenium [35], on ammonium perrhenate [36] and on rhenium and manganese ethoxides and isopropoxides [37]. In 1948, he published a book on rhenium chemistry [38], the first specialist monograph on this element.

Later Research

Druce had one last unfortunate episode when working with Loring. In 1930 [39] they claimed that ash from the potato plant fertilized with potassium chloride yielded potassium with the atomic mass of 40.5, compared with the recently agreed accepted mass of 39.10 [40]. Potassium consists of three naturally-occurring isotopes, namely ^{39}K, ^{40}K and ^{41}K, of which ^{40}K is a long-lived radioactive (β-emitting) isotope. Hence, Loring and Druce concluded that their potato plants were concentrating up a heavier isotope of potassium, possibly the radioactive one. This result has never been repeated, and very quickly results were published on various other plants and no similar effect was found [41]. The claim of Loring and Druce was quietly forgotten and they never returned to the topic again. This was the last of their joint papers; sadly, like all the others, it proved to have no lasting value.

After 1930, Druce published very few more research papers. Those he did were mainly on rhenium, and made modest incremental additions to knowledge. He began to concentrate on books about Czechoslovakia, reflecting his love of the country and based on the annual visits he made there throughout the 1920s and 1930s [42, 43]. He learned to speak Czech fluently, and became friendly with many prominent Czech citizens, not only Heyrovský but also figures such as Thomas Masaryk (1850-1937), the first President of independent Czechoslovakia. In 1937, he was admitted to the Bohemian Academy of Science and awarded the Order of the White Lion for cultural and scientific work by the Czechoslovak government.

Druce obviously felt it keenly when the Sudetenland crisis developed during 1938, with Hitler demanding the annexation of land covering large areas of Czechoslovakia that had a substantial German population. Germany eventually invaded Czechoslovakia in March 1939, and the country remained occupied until the end of the war. During this time, Druce found solace in research for a London University MA degree, completed in 1942, entitled "The role of Czech men of science in the national revival movement" [4]. He also published a paper on Czechoslovak contributions to chemistry in the nineteenth century [44] and a short book on two recently deceased Czech chemists, Brauner and Wald [45].

Post-war and Final Years

After the war, Druce was able to resume his links with Czechoslovakia and to return there. In 1948, he attended events associated with the 600th anniversary of the foundation of the Charles University in Prague, which he reported in the journal *Nature* [46]. In this year, too, he published his monograph on the chemistry of rhenium [38].

Early in 1950, Druce became ill, and he proved to have cancer [3, 4]. After some months of painful illness, he died in the Royal Cancer Hospital, Fulham, on 22 June 1950. He was just short of his fifty-sixth birthday.

Obituaries describe Druce as quiet and unassuming, and also that he had a careful laboratory technique [3, 4]. This latter attribute is difficult to reconcile with the number of errors and unrepeatable results in his published papers. However, despite these problems, Druce carved out for himself a high place in contemporary chemistry. It is true that he made mistakes, or perhaps was unlucky. Either way, he had a fascinating life in and around chemistry and for that he deserves to be remembered.

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John Nicholson

BOOK REVIEWS

John Blackie, *The Dyes: Scotland's Dyestuff Pioneers and a Century of Chemical Manufacturing in Grangemouth* (Perth: Dyes Publishing, 2019). ISBN 978-1-9993700-0-8, Pp. 487, Paperback £12.00. Available from dyespublishing@aol.com or Grangemouth Heritage Trust, 13^A La Porte Precinct, Grangemouth FK3 8AZ.

Most histories of the chemical industry aim to provide a comprehensive overview, or alternatively chart the history of an individual company. This book details the history of an individual site, situated on Earl's Road at Grangemouth. This year marks the site's centenary, for in 1919 James Morton began to build a new factory there to replace his small and overcrowded dye works in Carlisle. Morton's company was initially called Scottish Dyes Ltd., and for many years those who worked there, and those who lived in the locality, referred to the works as "The Dyes". The book charts the many changes that have occurred over the last century as a result of a wide range of factors – economic, political, social, technological, regulatory, etc.

Morton, a manufacturer of textiles, had started making anthraquinone vat dyes in Carlisle during World War I as he was no longer able to import these dyes from Germany. His chemists had not only succeeded in the difficult task of synthesising the anthraquinone dyes he needed (which had never been done in this country before), but by the end of the war had discovered some new ones. Production of dyes at Grangemouth commenced in 1921, and over the next few years increased dramatically. By 1924 the site was producing sixty per cent of all vat dyes made in Britain. Its most famous products were Caledon Jade Green, discovered at Carlisle in 1919, and the pigment Monastral Blue, discovered at Grangemouth in 1928. By 1928 Scottish Dyes had become a major player in the British dyestuffs industry, and in that year was incorporated into the recently formed ICI. From then until the outbreak of World War II there was a steady increase in production.

During the war Grangemouth was called upon to manufacture desperately needed pharmaceuticals, especially anti-malarials and sulpha drugs. Expansion continued after the war. In the late 1960s a plant was built to produce ICI's range of "Procion" reactive dyes, and the manufacture of a range of crop protection products was commenced. This expansion resulted in the total workforce exceeding 2000 by the mid-1970s. But it soon became evident that the UK chemical industry was facing an uncertain future, and it was felt that the emphasis should be switched more towards the manufacture of speciality and performance products. Accordingly Grangemouth became part of ICI's newly formed Fine Chemicals Manufacturing Organisation. During the 1980s the manufacture of further new products was introduced including small scale pharmaceutical products, novel agrochemicals and inks for inkjet printers, but overall the workforce steadily declined. In 1993 ICI was demerged into Zeneca, which comprised the pharmaceutical, agrochemical and specialities products, and the residual ICI was left with the heavy chemicals, paints and explosives businesses. The Grangemouth site thereby became part of Zeneca, but the residual ICI was further dismembered in 2007 with the consequence that ICI itself ceased to exist.

The remainder of the book deals with the most recent period at Grangemouth. The author, John Blackie, is well placed to do this, as he began his career as a chemical engineer in 1983 at ICI Grangemouth. He rapidly progressed into operations management and held a number of senior positions in the UK and abroad before returning to the Earl's Road site in 2004 as a site manager and manufacturing director. He left in 2011 to pursue other business interests. He developed a keen interest in the history of the site, and ten years ago he published a booklet *Ninety Years on the Earl's Road*. The present volume gives a more detailed account and brings the story up to date. There has been much change since the ICI demerger in 1993. A significant moment came in 1996 when Zeneca Specialities sold the remaining textile colours interests to BASF, thus terminating the link with the original business established by James Morton. The site is now under multiple ownership, with a number of companies producing a variety of products.

The book will appeal to a wide readership. Being written by a former insider, it will appeal to many present and former employees at Grangemouth. The social and sporting activities provided for employees are described, and the pension scheme made ICI a good company to work for. The book has much to say on changing work practices, organisation and management, health and safety issues, etc. The impact of computers on chemical manufacturing operations is described. The book will interest historians of the chemical industry, particularly those concerned with the development of the fine chemicals industry. It will be of relevance to those interested in local history and the industrial development of the Forth Valley, although for a complete picture of the chemical activity in the area one needs also to consider the nearby (but separate) oil refinery and associated petrochemical works owned by INEOS, which is of course outside the scope of the present volume.

A couple of minor criticisms are that there is no index and I would have preferred the bibliography to be organised on a chapter-by-chapter basis. But overall this is a most interesting and useful book. An attractive feature is provided by almost fifty photographs, many of which are in colour. At only £12 this book represents astonishing value, and is warmly recommended.

John Hudson

Susannah Gibson, *The Spirit of Enquiry*: *How One Extraordinary Society Shaped Modern Science* (Oxford: Oxford University Press 2019), ISBN 978-0-19883337-6, Pp. 398, Hardback: RRP £25, $US 34.95.

2019 marks the bicentenary of the Cambridge Philosophical Society, and hence an account of its origins and history is most timely. I received Susannah Gibson's book just a few days after finishing Malcolm Longair's *Maxwell's Enduring Legacy: A Scientific History of the Cavendish Laboratory* [1]. The Cavendish was founded in 1874, some fifty-five years after the Cambridge Philosophical Society. *The Spirit of Enquiry* is concerned in the main with that period, the first half-century of the CPS, when it was active as a pressure group for change in the University. Not that there was consensus about the need to reform and broaden the undergraduate curriculum even amongst the enthusiastic 'scientists' [2] who comprised the CPS. On the contrary, several very senior members, including the polymath and Master of Trinity College, William Whewell, were very much against it, for one reason or another. In Whewell's case this was in part because he thought the sciences better studied at the post-graduate level, on top of a common foundation, as he argued at length in his own monograph on University teaching [3].

The CPS was the brainchild of two keen young geologists, John S. Henslow and Adam Sedgewick, who came up with the idea while on a field trip to Alum Bay on the Isle of Wight. Cambridge lacked a forum for the discussion of natural philosophy etc. and so, with others of like mind, they established one; albeit for M.A.s only. In that regard the Society was exclusive, even if many of the other philosophical societies and institutions founded in towns and cities throughout Britain in the first half of the nineteenth century were not, in that way at least. The Society met at first in borrowed rooms in the Botanical Gardens, although within a very few years it had built a splendid house of its own in All Saints Passage. A house, no longer in existence, and one which it did not own and occupy for all that long, as a result of the dishonesty of the housekeeper, one Mr Crouch, whose cynical abuse of his well-paid position put the Society in grave peril of foundering, although it survived, even if in reduced circumstances.

The first meeting of the Society in February 1819 entailed the reading of three papers, one of which was on the discovery of cadmium in English ores by Edward Clarke. The other two were to do with machines and with soundings at sea, respectively. The finding of cadmium in Britain is one of rather few mentions of chemistry and chemists in the book. Most of the early members of the society were more inclined towards either geology or natural history, or, to the mathematical sciences. Gibson argues the latter inclination was a result of the extant Cambridge degree, wherein mathematics, albeit of a rather old-fashioned kind, was a compulsory component (would that it was now!). Chemists might like to note, though, that Lawrence Bragg's account of X-ray diffraction was first presented to the CPS, where it caused a sensation, its potential being immediately evident. Bragg did not however read the paper himself, as he was deemed too young, and it was delivered by his advisor, one J.J. Thompson, (he may well have not yet graduated M.A.).

The long-term influence of the Society upon the world, let alone the world of science, would be hard over-estimate, as can be judged from listing just a few of its nineteenth-century members, who included Lyell, Herschel, Babbage, Maxwell, Stokes, Darwin, Huxley and Rayleigh, amongst many others. The CPS is not the pre-eminent forum it once was, but it continues to offer talks and provide bursaries to this day. These days, the longstanding Monday evening meetings are normally held in a lecture theatre in the Department of Chemistry [4]. Membership of the Society remains exclusive, although the lectures are now open to the public at large, a change instigated long ago by Rutherford.

I found Susannah Gibson's account of the CPS and its members to be as enjoyable as it was informative. It is an attractively produced book and looks to be aimed at a wide audience, judging by its price, which is reasonable for a quality hardback. It is not over-long at 377 pages, including notes, etc., given that it is double line-spaced, making it easy to read. It is illustrated by means of a selection of contemporary photographs, paintings and drawings.

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Richard Buscall

Isabel Malaquias and Peter J. T. Morris, eds., *Perspectives on Chemical Biography in the 21st Century* (Newcastle-upon-Tyne: Cambridge Scholars Publishing, 2019), ISBN (10): 1-5275-2275-X, Pp. 269, hardback £61.99 (Amazon and direct from publisher's website, https://www.cambridgescholars.com/perspectives-on-chemical-biography-in-the-21st-century).

I started my chemical career at the age of eight when I was given a Lott's Chemistry Set as a birthday present. My interest was supported by somewhat bewildered parents and enthusiastic (secondary) school teachers. In my early teenage years, I discovered the history of my subject through books which remain on my shelves, sixty years on. As I write this review, I see among them James Kendall's *Great Discoveries by Young Chemists* [1], William Tilden's *Famous Chemists, The Men and their Work* [2] and James Partington's *A Short History of Chemistry* [3]. The first two are obviously accounts of the individuals who shaped our subject and Partington, in his many books, favoured a biographical approach, too.

However, fashions change even in the history of chemistry, and the editors of this book tell us by way of introduction that the biographical approach has "been overlooked and even despised for many years… (with) uncritical, almost hagiographic lives of chemists written in the earlier part of the 20th century". Harsh words, perhaps, but essentially true at least in some quarters. But a renaissance might be coming along as the editors write further "…the genre of biography has enjoyed a revival since the beginning of this century". In anticipating and contextualising this revival, the Working Party on History of Chemistry of the European Association for Chemical and Molecular Sciences (known since summer 2018 as EuChemS, the European Chemical Society) held an international conference based at the University of Aveiro, Portugal, in September 2015. The present book is a collection of twenty-four papers presented over the three days. The editors have grouped them into five broad areas:

- The sources of biographical information with a stress on the pitfalls inherent in acquiring oral histories
- Some aspects of physical, theoretical and inorganic chemistry. This is a mixed section ranging from reflective musings (such as 'Why has there never been a biography of Charles A. Coulson, and if there is to be a biography, which particular slants should it take?') to the straightforward traditional (The life and work of Henry Moseley, written by Historical Group member Gordon Woods). This is factual, clear in its exposition, and maybe a throwback to an earlier time of biographical writing, but in my view, not the worse for this. Also we have a "good read" from Jay Labinger who recounts the antipathy between Linus Pauling and Don Yost during their years at Caltech, and how it might have delayed the first appearance of a noble gas compound by several decades.
- Aspects of biography. This section concerns itself, in part, with how the fruits of biographical researches might best be disseminated. Again we have some reflective considerations and then a couple of examples: Birute Railiene writes about the Polish/Lithuanian chemist Jędrzej Śniadecki (1768-1838), probably unknown to most readers of this newsletter, and how she has raised his profile in a series of conferences dedicated to his honour in Lithuania. Perhaps sitting less comfortably in this section is a partial biography of the artist Albrecht Dürer with an emphasis on the pigments that he employed. In the light of what we have here, it would be hard to justify him as a chemist.
- Moving on, we have "Facets of 19th century chemistry", a section of miscellaneous papers that do not fit comfortably in any of the preceding sections. Our Chairman, Peter Morris, with an eye on his excellent book on the history of the chemical laboratory [4], gives an account of Wilhelm Hofmann and the laboratories associated with him, and how they influenced the design of chemical accommodation well into the later part of the last century. In another section we have brief pen-portraits of seven glass-blowers whose apparatus helped better-known chemists to advance their studies, together with seven prominent chemists who were themselves competent and innovative glass-blowers. If I might be permitted another personal intrusion, the chapter authors, Joãdo Oliveiro and António Morais devote some space to the borohydride chemist, Alfred Stock (1876-1946), whose complicated glass vacuum lines permitted the safe handling of his pyrophoric compounds. I used derivatives of his apparatus to handle a host of air-sensitive phosphorus compounds in the 1960s. They did their job, but you had to watch out. A tap, inadvertently left open would permit liquid air to condense into a receiver being cooled with liquid nitrogen. Then, if you closed the taps and left it, it would warm up and the resultant pressure would blow the line-up, with a deal of embarrassment, or more!
- The final section, with a nod to the location of the conference, consists of biographical papers with a Portuguese and Spanish connection. They consider the work of Sebastião Betâmio de Almeida (1817-64), a pioneer of Portuguese industrial chemistry, Joaquim de Santa Clara Sousa Pinto (1803-76), associated with the introduction of gas-lighting

(especially using illuminant derived from the destructive distillation of vegetable materials) and Mariano Santisteban (1821-86), an educationalist with an interest in reforming the teaching of chemistry.

Unfortunately this book is expensive and this will engender a limited appeal. Notwithstanding Woods' account of Henry Moseley and a later, more reflective one on the composer/musician Alexander Borodin, I doubt if many chemistry history hobbyists will discern enough here to make them reach into their pockets. However, professional historians of chemistry will value this text which in the words of the editors "which will lead the reader through emerging questions round sources, and the generic problems faced by authors of biographies". For those uncertain as to possible purchase, I recommend them to visit the publisher's site at:

https://www.cambridgescholars.com/download/sample/65105. Here they will find a full account of the contents, chapter by chapter, together with a twenty-two page section of text from the start of the book. Other 'tasters' of the beginning of the book are also available elsewhere online.

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Alan Dronsfield

Eric Scerri, *A Tale of Seven Scientists and a New Philosophy of Science* (Oxford: The University Press, 2016), ISBN: 9780190232993, Pp. 264, Hardback: £23.49.

Eric Scerri is a well-known philosopher of chemistry with a strong interest in the history of the subject, notably the emergence of the Periodic Table. In his latest book he writes about his current thinking on the philosophy of science. He illustrates his ideas by considering the contributions of seven key individuals that he describes as "little people". All seven provided key ideas towards our current understanding of the electronic configurations of atoms, and also helped to explain the relationship with chemical properties. Yet all have been largely forgotten.

This is consistent with the model of science that Scerri advocates in this book; that science is a process of evolution rather than revolution. Scerri likens the small steps that individual scientists contribute to random mutations in biology. These steps are under pressure to survive, the main criterion of survival being usefulness rather than any sort of absolute truth. Incremental steps occur almost imperceptibly and are usually made by individuals who are quickly forgotten. This view contrasts with the picture usually given in textbooks, where science is presented as a series of revolutions created by a few famous intellectual giants. In Scerri's model of science, there is no such thing as right or wrong when it comes to evaluating a theory. Rather, the question is one of usefulness. Does a theory have any use and does it lead to the evolution of the subject? If it does, the theory has validity, even if some of its features need to be corrected later. I must say I find this argument persuasive.

Ironically from this reviewer's perspective, the first of Scerri's "little people" is John William Nicholson. Nicholson was a mathematical physicist, professor at King's College London then Fellow at Balliol College Oxford, who died in the year that this John William Nicholson was born. His particular contribution was to propose the quantization of angular momentum of electrons in atoms, a concept soon taken up by Neils Bohr. Other people covered in the book (van den Broek, Abegg, Main Smith, Stoner and Janet) all contributed ideas that were similarly helpful as steps along the path to the modern view of the atom. For example, it was van den Broek, an economist by training, who first recognised the fundamental nature of the atomic number and used it to predict the existence of missing elements. Moseley now receives all the credit for this step, whereas in fact he undertook his experiments with a view to testing van den Broek's hypothesis. Moseley explicitly acknowledges this at the beginning of one of his classic papers.

Overall Scerri has produced a fascinating book. As ever, he has written well and has used his insights from the history of science to inform the development of a convincing philosophy of the subject. Personally I would have liked a little more biographical detail on the seven "little people" but that is a minor quibble. Even without the extra detail, the book is a tour de force and I cannot recommend it too highly.

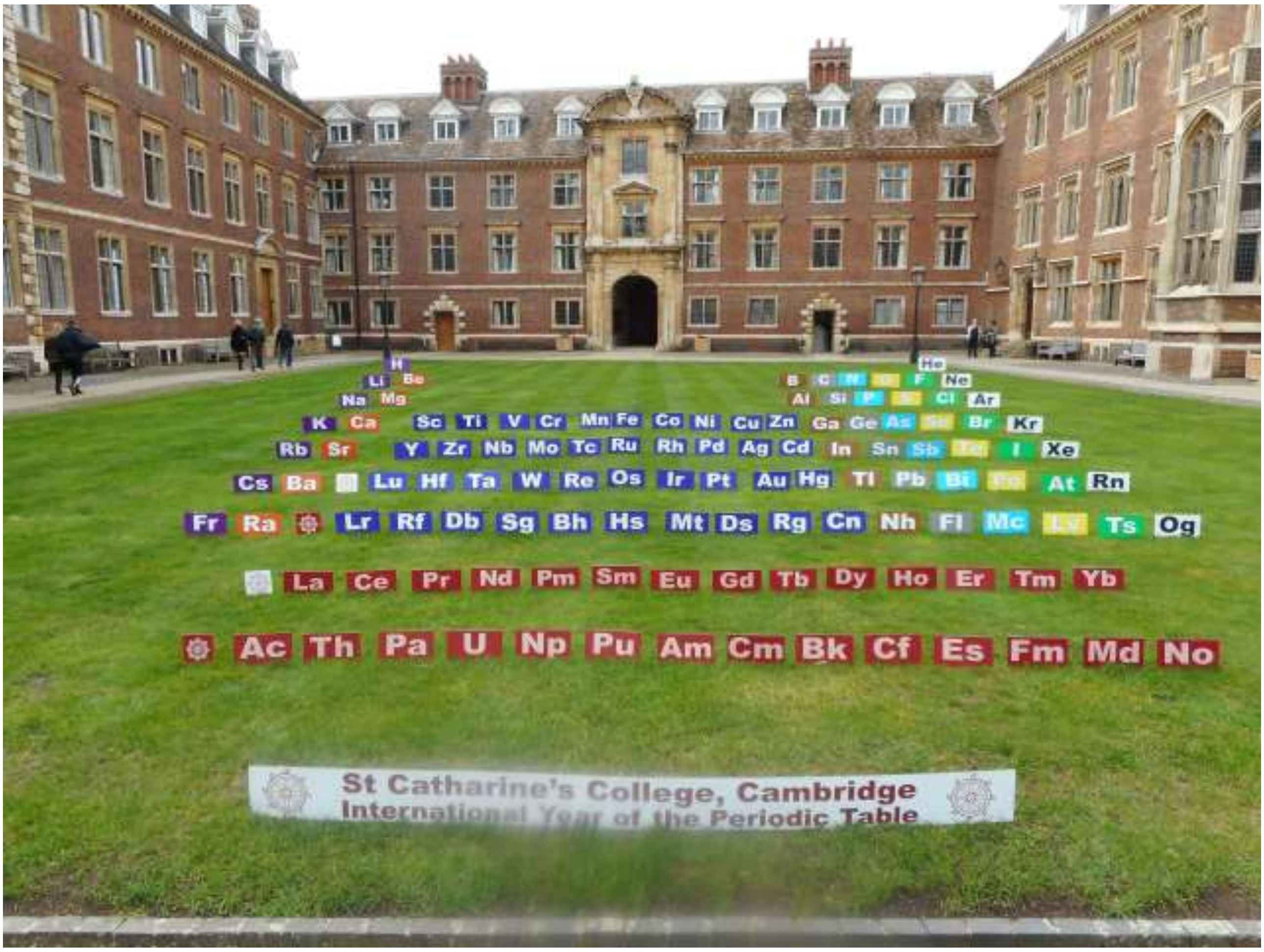
John Nicholson

EXHIBITION REVIEWS

International Year of the Periodic Table Exhibition, St. Catherine's College Cambridge, 12 March – 5 April 2019

This exhibition, curated by Historical Group member Peter Wothers, was part of the Cambridge Science Festival. Happily the first week of the exhibition coincided almost exactly with the 150th anniversary of Mendeleev's publication of his first version of the periodic table. The venue, St. Catherine's College, is where Peter is a Fellow and Director of Studies in Chemistry.

Before entering the exhibition, the visitor walked past a giant representation of the periodic table in the form of a series of coloured plaques, one for each element, arranged in periodic sequence on the front lawn. Once in the exhibition itself, the visitor was treated to a wonderful display of artefacts and documents relevant to the elements and the periodicity of their properties. Some of the earliest material originated from the era before the modern concept of an element evolved, examples being Agricola's *Vom Bergkwerck*, 1557, the first vernacular edition of his famous *De Re Metallica* published the year before, and a charming early illustrated pocket book on alchemy, the *Viridarium Chymicum* from 1624 by Daniel Stolcius. Our modern concept of an element was developed by Lavoisier, and exhibited was a first edition on his *Traité*, open at the page of his table of elements. Three copies of Mrs Marcet's highly influential *Conversations on Chemistry* were displayed, one American (1806), one Swiss (1809), and one English (1819). The 1819 edition was open at Marcet's classification of the elements in terms of the nature of the products formed when they reacted with oxygen.



The periodic table on display on the lawn of St Catherine's College, Cambridge

The first attempt to link elemental properties with atomic weights was made by Döbereiner with his triads of similar elements, and a copy of his paper was on show. Also displayed was a copy of J.H. Gladstone's paper of 1853 in which he was looking for relations between atomic weight of analogous elements, but in this pre-Cannizzaro era many of the atomic weights he was using were in error. One of the star exhibits concerned the 1862 helical arrangement of A.E. Béguyer de Chancourtois in which he plotted the atomic weights of the elements on a sloping line on the surface of a cylinder, demonstrating that similar elements fell on or near vertical lines connecting neighbouring turns of the helix. The helical line was generated by pasting eight pre-printed sheets on to the surface of a cylinder. Unfortunately the chart was not included with Béguyer's paper, but Béguyer subsequently distributed offprints containing the long chart, printed in three colours. An example of this exceedingly rare publication was on display. Also on show was a cylinder, approximately 1.5m in length, created from a reproduction and following the instructions on the chart. This exhibit demonstrated that Béguyer is perhaps a more significant forerunner of Mendeleev than is generally appreciated.

Other pre-Mendeleev publications on show were concerned with Newlands' law of octaves of 1863 (including its dismissive reception), and Odling's table of 1864. Odling subsequently published a revised version of his table in a textbook, which was translated into Russian in 1867, but Mendeleev stated that he was unaware of Odling's suggestions.

Immediate post-Mendeleev material was concerned with Lothar Meyer's atomic volume curves of 1870 and H.A. Baumhauer's spiral table of 1870 – the first to appear in that form.

Mendeleev himself of course occupied centre stage. Under his photograph was a case containing the first edition of his *Principles of Chemistry*. The idea of the periodic law came to Mendeleev after volume one of the book had been printed, so he had his first version of the table, in which the groups are arranged horizontally, produced separately and inserted before the book was distributed. At the same time he wrote an account outlining the system in detail which was read to the newly formed Russian Chemical Society. It appeared in volume one of the Society's *Journal*, but only eighty copies were printed. The copy on display, owned by St. Catharine's College, is the only complete copy in the UK. Also exhibited was volume two of Mendeleev's *Principles* which appeared a little later. This contained a more modern looking table with the groups arranged vertically. One of the most celebrated aspects of Mendeleev's work was his accurate prediction of the properties of elements yet to be discovered. On display was an article from *Chemical News* in which he pointed out that the properties of the newly discovered gallium were very close to those he had predicted for *eka*-aluminium.

The symbols of the elements in each of the eight main groups were displayed vertically on the panes of the windows surrounding the room. Under each window was a display with (in most cases) samples of the elements in the group and various items of information about them. For example for group 2 we learn that beryllium is used in the windows of X-ray tubes, magnesium is used in lightweight alloys, calcium occurs in chalk and marble, strontium is the only element named after a British location (Strontian in Scotland where the parent mineral was discovered as an impurity in lead ore), barium is used as barium sulfate in barium meals for X-ray investigations, and radium was once used to make the hands of clocks and watches luminous. This part of the exhibition would have been of considerable interest to school students.

In contrast to the historic material on display, there were two stunning modern items. One was a periodic table beautifully crafted in macramé by Jane Stewart. The other was a three-dimensional form of the table based on the 1920 design by Georges Schaltenbrand, with the symbols of the elements engraved on silver tiles, with each tile attached to a silver ribbon which was wound in a descending spiral around a central silver rod. The resulting helix was of varying diameter such that each element was aligned vertically with others in the same group, the distance from the central rod being proportional to the number of valence electrons. All 118 elements were represented. The sculpture, if that is the right word, was about 1m tall. One assumed the exhibition venue had an effective burglar alarm!

This was a most memorable exhibition. It was instructive, enjoyable, and it was a privilege to view a variety of rare and valuable documents of relevance to the history of chemistry. Peter Wothers is to be congratulated on putting together an exhibition which made a significant contribution to the celebrations surrounding the International Year of the Periodic Table.

This exhibition will be on display at the Royal Society of Chemistry, Burlington House, London, from 13-30 August 2019. All are strongly encouraged to visit.

John Hudson

200th Anniversary of the Birth of Carl Remigius Fresenius, Wiesbaden Museum

Although there are a few universities named after distinguished chemists (notably the Justus Liebig Universität in Giessen), there is only one chemist who actually founded a university. In December 2018 the Hochschule Fresenius in Idstein (until 1995 in Wiesbaden) celebrated the 200th anniversary of the birth of Carl Remigius Fresenius (1818-97) with an exhibition in the city's museum curated by Professor Leo Gros. "Remi", as he was familiarly known, was born in Frankfurt and trained as an apothecary before attending courses in history and philosophy at the University of Bonn while also using the laboratory facilities of the private pharmaceutical school that Ludwig Clemor Marquart (1804-81) had founded in Bonn in 1837. It was there that Fresenius developed methods of systematic qualitative analysis. Remi's analytical investigations culminated in the book *Anleitung zur qualitativen chemischen Analyse* in 1841. This was just the sort of textbook of group separations that Liebig needed at Giessen to train his students in analytical separations. Fresenius was invited to Giessen to become Liebig's personal assistant and was awarded his doctorate for the second edition of his textbook in 1842. A year later he was placed in charge of Liebig's laboratory when Liebig's other assistant, Heinrich Will (1812-90), a pioneer of volumetric analysis, was given charge of an elementary teaching laboratory built in the garden of Liebig's newly-erected house a short distance from the main laboratory. By 1846, Fresenius's text was in its fourth edition, and during his lifetime, there were seventeen German editions in total as well as translations in virtually every European language. It remained the model for generations of textbooks on qualitative analysis until the 1950s. Little surprise, then, that Fresenius is commonly known as "the father of analytical chemistry", or that he was one of the three candidates considered for the post of Director of the Royal College of Chemistry in London in 1845.

Fresenius was, however, not interested in a British career (unlike his friend Wilhelm Hofmann, who took the job), since he had other ideas for advancing his career. In 1845, when he published the complementary *Anleitung zur quantitativen chemischen Analyse,* he left Giessen to become professor of chemistry at an agricultural college (Herzoglich-Nassauische Landwirtschaft-Institut) in the spa of Wiesbaden, some twenty-four miles to the west of Frankfurt. Since the college had no laboratory, Fresenius built his own private facility with the aid of a subsidy from the Duchy of Nassau. Here he taught the art of wet analysis and engaged in research projects on the analyses of water, wines, foodstuffs and developing toxicological tests. He later added departments training in pharmacy and agricultural chemistry. By the

1860s the Wiesbaden College had become renowned for analytical chemistry and this was sustained by Fresenius's creation of the journal *Zeitschrift fűr analytische Chemie* in 1862 (since 2002, *Journal of Analytical and Bioanalytical Chemistry*, with all articles in English). The journal effectively established analytical chemistry as a specialised discipline within chemistry.

Fresenius, who also wrote morale-boosting poetry, was twice married. Two of his sons, Heinrich (1847-1920) and Wilhelm (1856-1936) and grandson Wilhelm (1913-2004) trained as chemists and continued the Fresenius Institute and the *Zeitschrift* into the twentieth century. In 1971 the private Fresenius Institute was recognised as worthy of state funding for higher education. It then became the Fresenius University of Applied Sciences, or Hochschule Fresenius, with a new campus at Idstein, some fifteen miles to the north of Wiesbaden. The December 2018-January 2019 commemorative exhibition at the Wiesbaden Museum was accompanied by an attractive bilingual catalogue compiled and curated by the chemist Leo Gros. Leo Gros, *Carl Remigius Fresenius – Vater der Analytischen Chemie* (Wiesbaden: Wiesbaden Museum, 2018), ISBN: 978-3-89258-120-8, Pp. 128. Pbk 10.70 Euro (including postage within Europe).

My thanks to Dagmar Klein (Giessen city guide), for alerting me to the exhibition.

W.H. Brock

RSCHG MEETING REPORTS

Celebrating the Centenary of IUPAC

Royal Society of Chemistry, Burlington House, London Wednesday 14 March 2019

The International Union of Pure and Applied Chemistry (IUPAC) is celebrating the centenary of it first meeting when the old International Association of Chemical Societies was dissolved and IUPAC formed. The Royal Society of Chemistry has an important role as an English-speaking country and all IUPAC recommendations are published in English. Speakers covered the background to the formation of IUPAC and most of the main areas of activity. Most of the speakers have been involved with IUPAC for many years and contributed to many recommendations in *Pure and Applied Chemistry* and the colour books on chemical nomenclature [physical chemistry (green), inorganic (red), organic (blue), macromolecular chemistry (purple), analytical chemistry (orange), etc].

Gerry Moss

IUPAC 100: How it all began

Fred Parrett, Parrett Technical Developments, SCI London Group Treasurer

IUPAC, was established in 1919 to improve international cooperation among chemists, to agree on setting standardisation of nomenclature, terminology, measurement, atomic weights and much other critical data. These issues did not suddenly appear in 1919, but had been a problem for decades before. The first organised attempt to address the topic is considered to be a conference in 1860 in Karlsruhe, organised by Auguste Kekulé. Although not an immediate success, it was the forerunner of a number of conferences in the next fifty years throughout Europe, where chemists gathered to seek agreement, solutions and cooperation. The most significant of these was the 1911 meeting in Paris proposed by the Société Chimique de France, with representatives from the Chemical Societies of Great Britain and Germany. This led to the formation of the International Association of Chemical Societies (IACS), with goals similar to those adopted by IUPAC. Further meetings were held and substantial financial support for ICAS was provided by the Solvay Chemical Company. Then in 1914 World War I began, and things came to a halt. No progress was made for almost four years, but as the war came to an end, the trauma of a war that questioned trust in chemistry and science perhaps focused minds on the need to improve cooperation. Thus, plans evolved to re-establish the work of ICAS. These meetings from late 1917 involved only the Allied Powers, since Germany, the Central Powers were excluded. The driving force as 1919 approached was the increased involvement of industrial chemists from France and Great Britain. Final meetings in Paris and London in July 1919 saw IACS formally dissolved, and replaced by the International Union of Pure and Applied Chemistry

Internationalism on Trial: IUPAC and the International Research Council, 1919–1931

Robert Fox, University of Oxford

IUPAC was one of four scientific unions established at the first meeting of the new International Research Council in Brussels in July 1919. Like the other unions that functioned under the aegis of the IRC (until the IRC's replacement by the International Council of Scientific Unions in 1931), it was marked by its roots in the immediate aftermath of the Great War. The IRC had been founded as a body from which Germany and the other Central powers were to be excluded, and in which even the use of the German language would be prohibited; the unions too were bound by the same exclusionist policy. From an initial group of representatives of the national scientific academies of France, Britain, the USA, Belgium, and Italy, the IRC cautiously expanded to embrace countries that had been neutral during the war. But with growth came tensions, in particular between the "hard line" positions of France and Belgium, both committed to the maintenance of the boycott, and the calls for a more conciliatory approach, voiced initially by the "neutrals" but soon taken up by many in the USA and even in Britain. In the face of pressure from leading figures in a number of unions for scientists from the former Central powers to be admitted, the IRC found its authority weakened. Minor concessions in 1926 did no more than paper over widening cracks, and the later 1920s were marked by the unions' growing assertion of their will to act independently of the council. The arrival, to a standing ovation, of a distinguished delegation of German chemists at the IUPAC General Assembly of 1930 in Liège conveyed vividly the shift in the balance of power that had come about by then. The transition to ICSU in 1931 has therefore to be seen as an acknowledgement that the way forward in international science lay not in the IRC's increasingly contested aspiration to centralized control but in a federation of essentially autonomous disciplinary bodies.

Physical Chemistry and IUPAC: The Chemistry of Data

Jeremy Frey, University of Southampton

Even before the foundation of IUPAC, physical chemistry was being increasingly underpinned by physics. IUPAC accordingly depends on physical standards set by the Bureau International des Poids et Mesures (BIPM). At the same time IUPAC gives important input to BIPM, as recently when, of the seven SI base units, four (kg, A, K, mol) were redefined.

A core function of IUPAC has long been collecting and validating data: atomic weights and thermodynamic, kinetic, and photochemical data, including data relevant to atmospheric chemistry and climate modelling. However, in the latter part of the twentieth century, IUPAC devoted substantial effort to facilitating accurate and effective international communication of chemical findings. The resulting flagship IUPAC publication is the "Green Book", *Quantities, Units and Symbols in Physical Chemistry* (1st edition, 1988; 2nd edition 1993; 3rd edition 2007 published by RSC Publishing; 4th edition in preparation accommodating the new base unit definitions). The Green Book is not simply prescriptive. Rather, it explains its recommendations, seeking to convince a global audience of the need for clarity and consistency. It deals with physical chemistry as a whole, drawing on the whole range of IUPAC's activities. The Green Book is prepared by Commission I.1 Physicochemical Symbols, Terminology and Units (retained in 2000 when IUPAC reorganised itself, abolishing many other Commissions).

The increased use in the past century of commercial laboratory equipment has not only transformed chemical practice but also strengthened the basis of many IUPAC recommendations on measurement techniques, including those of relevance to industry. However, computer software, while likewise now key to much physical chemistry, has led to a new anarchy. In the personal view of the speaker, the most urgent task facing IUPAC as it starts its second century is to provide the standardisation of software that the international community needs.

IUPAC, its Commission for the Nomenclature of Inorganic Chemistry and the Periodic Table

Jeff Leigh, University of Sussex

Although the Mendeleev Periodic Table is 150 years old, English-speaking chemists rather overlooked it until relatively recently, unlike in German-speaking circles. IUPAC recognised the need for promoting the Table and its contents early on, and after 1919 it gradually became responsible for encouraging the use of long-forms of the Table, the updating of reliable atomic weight data via the Atomic Weight Commission and later the Commission on Isotope Abundance and Atomic Weights (CIAWW). In 1919 IUPAC also adopted some already extant nomenclature committees, and particularly what became the Commission for the Nomenclature of Inorganic Chemistry (CNIC). Until its abolition in the structural reform of IUPAC at the end of the twentieth century, CNIC was deeply involved in codifying the nomenclature of the rapidly developing inorganic chemistry, principally *via* its Red Books, and in the assessment of claims to have synthesised new elements of atomic numbers up to element of atomic number 118, and in providing names and symbols suggested by the discoverers which would also be acceptable to the international chemistry community.

Analytical Chemistry, born in 1934

Duncan Thorburn-Burns, Queen's University, Belfast

The Analytical Division was born in 1934 as the "Commission on New Analytical Reactions and Reagents". In 1949 when Commissions were allocated to Sections, "New Reagents and Reactions" was the sole one in the Section of Analytical Chemistry. By 1953 the Section had expanded to four Commissions and six Sub-commissions. Over the years Commission V.1 morphed by addition of separations finally into "General Aspects of Analytical Chemistry".

When the Royal Society was the UK National adhering body to IUPAC its National Committee for Chemistry had an Analytical Chemistry Sub-Committee. The adverse effects of the loss of this association and structure were discussed in the paper. The experiences of members of Division V during the Cold War period and since then and their contributions to The Working Party on Analytical Chemistry of the Federation of European Chemical Societies, which became the Division of Analytical Chemistry of EuChemS, were also outlined, along with some IUPAC and closely related publications.

Organic Chemical Nomenclature and IUPAC

Gerry Moss, Queen Mary University of London

Before the structures of organic compounds were recognised, compounds could be characterised but only given a trivial name, perhaps just indicating a property such as acid. After the atomic weights and hence valency was sorted out it was possible to suggest structures. The first attempt to generate names arose from the 1892 Geneva conference but this only covered some simple hydrocarbons and heterocyclic systems and only one functional group. Today these rules are still used in, for example, the name α,β-unsaturated ketones and, now for only a few cases, the use of primed numbers.

In 1923 IUPAC formed a Commission for the Reform of the Nomenclature of Organic Chemistry. They prepared the 1930 Liège Rules. A key development was to list suffixes and prefixes for many functional groups. Modern nomenclature dates from 1957 when Section A (hydrocarbons) and section B (fundamental heterocycles) were published. This was followed in 1965 by section C (compounds containing C, H, O, N, halogen, S, Se and Te). From 1973 to 1978 Sections D, E, F and H followed. All these sections were combined in the 1979 Blue Book.

Between 1982 and 2005 a series of recommendations on special classes of compounds were published. A guide was published in 1993 that made a number of selections between alternative names. It formed a basis for the very much fuller Nomenclature of Organic Chemistry (IUPAC recommendations and preferred names 2013). Following the abolition of Commissions, Division VIII Chemical Nomenclature and Structure Representation was formed in 2002 to oversee chemical nomenclature.

In parallel with the pure organic chemical nomenclature there was much activity with biochemical nomenclature by the IUB-IUPAC Commission on Biochemical Nomenclature. Major documents include those on steroids, carbohydrates, amino acids, carotenoids, tetrapyrroles and flavonoids.

Polymers and IUPAC

Phil Hodge, University of Manchester

It was not until the late 1930s, some twenty years after IUPAC began, that it was widely accepted that polymers are actually very long chain molecules. This was mainly the result of the X-ray studies by Hermann Staudinger in Germany and for this he received the Nobel Prize in 1953.

After the Second World War polymer scientists felt the need for an international platform where the general problems of polymer science could be discussed freely and where nomenclature, terminology and symbols could be standardized. They turned to IUPAC. After various organizational arrangements over approximately thirty years this eventually led in 1967 to the creation of IUPAC Division IV, a division we still have today. To handle the steady creation and discussion of projects a Sub-committee for Polymer Terminology (SPT) was set up and this now deals with all projects.

A compendium of *Polymer Terminology and Nomenclature* (“the Purple Book”) was published by RSC in 2009. To help in the application of the SPT conclusions a series of “Brief Guides” (typically limited to 4 sides of A4 paper) has been published from 2012 onwards. These have proved to be very popular and the general idea has spread well beyond polymer science. They are widely quoted in the literature.

New types of macromolecule continue to become accessible, such as cyclic polymers, polyrotaxanes, and dendrimers. New types of polymerization are developed such as living free radical polymerization, and ring-expanding polymerization. Spectroscopic methods, especially ^{13}C NMR spectroscopy, become ever more powerful at deducing the detailed structures of macromolecules. These advances require structure-based nomenclature to handle increasingly complex issues. New areas of polymer application are developed, such as those used in mobile phones and in drug delivery systems. This requires new terminology and symbols. Taken together these types of development mean IUPAC Division IV and the SPT will have plenty of work to do well into the foreseeable future.

20 years of InChI – Where Next?

Richard Kidd, RSC, InChI Trust Treasurer

The IUPAC InChI (International Chemical Identifier) standard for chemical structure representation originally stemmed from a proposal twenty years ago. The need for the identifier was initially proposed by Steve Heller and Steve Stein of the National Institute of Standards and Technology (NIST) in 1999, driven by the needs of the mass spectral database, which dovetailed with IUPAC support for digital standards development (Ted Becker of the National Institutes of Health (NIH) and Alan McNaught of the RSC). An updated proposal was adopted, and NIST provided the staff to program the identifier, which was first released in 2005. The resulting text string that forms an InChI consists of several layers denoting the formula, connectivity, isotopes, stereochemistry, tautomers and charge – with a normalized ‘standard’ InChI and a shorter hashed form with a fixed length called the InChIKey which was introduced in 2009 to be search-engine friendly.

Since its introduction, the InChI has grown in application – it is ubiquitous in large compound databases – and especially for disambiguation and linking purposes, but at a trade-off of standardization (it is best used as an identifier rather than a structural representation).

The InChI Trust was formed in 2009, and works alongside the IUPAC Div VIII InChI Subcommittee to promote and further develop the software standard. This relationship continues to evolve, with the InChI Subcommittee acting as a scientific advisory board to prioritize possible future developments, as well as sponsoring new projects. The Trusts three strategic aims are to increase engagement with the scientific community, to maintain and extend the InChI and its application, and to provide an organizational framework to ensure the sustainability of the standard.

The key future decisions for IUPAC and the Trust cover how to prioritise and support the extension of the standard to new areas of chemical structures (for organometallics, tautomerism, and for areas of uncertainty and variability), and the further application of existing InChI principles (such as using InChI to encode reactions and mixtures, and how to provide educational resources). To support these discussions the InChI Trust organizes a rolling series of workshops to bring its scientific network together.

The Centenary of Transmutation

Joint meeting of the Institute of Physics History Group, and the RSC Historical Group

Manchester University, 8 June 2019

The meeting celebrated the centenary of the publication of Rutherford's sequence of four papers entitled "Collision of α-Particles with Light Atoms". These ground-breaking papers were the last that Rutherford published based on work conducted at Manchester before he moved to Cambridge. Rutherford had left Montreal in 1907 to take up the Langworthy Chair of Physics at Manchester, where his predecessor as professor, Arthur Schuster, had built a new physics laboratory. Schuster had resigned his professorship on the condition that the post be offered to Rutherford. The ensuing twelve years were to see momentous developments. Rutherford's final Manchester papers, celebrated at this meeting, were epochal in the development of nuclear physics.

After a welcome from Professor Sean Freeman, current holder of the Chair of Nuclear Physics, the meeting heard five presentations relating to Rutherford's four 1919 papers and their significance and impact.

The Physical Laboratories of the University of Manchester: A Radio-Archaeological and Historical Account

Neil Todd, University of Exeter

This meeting to celebrate the centenary of Rutherford's 1919 discovery of artificial transmutation was held within the buildings in which that discovery took place. Although designed at the end of the nineteenth century by Arthur Schuster and architect J.W. Beaumont for the purpose of research in and teaching of topics of classical physics, the erection of the Physical Laboratories of the University of Manchester coincided with an earlier series of discoveries: X-rays 1895; radioactivity 1896; the electron 1897; and radium in 1898, the same year as the foundation stone of the Laboratories. These discoveries were to spark off the remarkable transformation in physical science referred to by some historians as the second scientific revolution. By the time Rutherford arrived in 1907 the revolution was well underway, not least thanks to Rutherford and Soddy's 1902 theory of successive transformations (spontaneous transmutations) to explain radioactivity. However, it was surely the further series of discoveries which occurred here between 1907 and 1919: the atomic nucleus in 1911, and the Bohr-Rutherford quantum atom and the firm establishment by Moseley of the concept of atomic number in 1913, to name only the most outstanding, culminating in the 1919 nuclear reaction, which justifies the epithet of the birthplace of modern physics for the Manchester Physical Laboratories.

These discoveries, almost without exception, could not have taken place without the element radium which, along with its daughter elements, provided sources of energetic particles. Radium, perhaps unique among the radioactive elements for its potency and half-life, also has a very high propensity to give rise to the contamination of everything it comes into contact with, and this was a problem which was to plague Rutherford throughout most of his career (until radium was made redundant by the invention of machines which could do the same). Manchester was not spared the contamination problem and traces of it were to remain until recently only after several cycles of remediation. Although potentially a health issue, the contamination is also a unique kind of archaeological data which can provide information about the human activities which caused it. An account was given based on a study of the patterns of contamination, in conjunction with historical data, which has allowed a reconstruction of how Rutherford moulded the Physical Laboratories for his own purposes. This reconstruction also formed the basis for a tour during the meeting of the old buildings, including the room in which Rutherford conducted the experiments leading to the 1919 publication.

Rutherford's Road to Splitting the Atom

John Campbell, University of Christchurch, New Zealand

2019 is the centennial of the publication in which Ernest Rutherford bombarded nitrogen with naturally occurring alpha particles and produced hydrogen. In doing so he became the first person to split the atom, the world's first successful alchemist, and the first person to demonstrate that the hydrogen nucleus was a constituent of a heavier nucleus. His earlier discovery, the nuclear model of the atom, was published in 1911, later confirmed by accurate measurements of large angle scattering of alphas from heavy atoms. By 1913 he turned to bombarding lighter atoms with alphas because one could get closer to a lighter nucleus than the heavily charged heavy nucleus. He and Ernest Marsden were quite used to observing hydrogen nuclei recoiling when struck head-on by an alpha particle. The lighter H recoiled with a speed 1.6 the speed of the incoming alpha and a range in air four times that of the doubly charged alpha. The partnership ceased temporarily in 1914 when Marsden accepted a job in New Zealand and World War I broke out. For the next two years Rutherford was engaged in war work. By late 1917 he was free to return to his scientific research. He delayed the announcement of alchemy until World War I had meat-ground its way to a weary conclusion and he was leaving Manchester for Cambridge. Acclaimed as an alchemist, within two years of his paper fanciful headlines such as "Making Gold from Feathers" further caught the public imagination and induced more erroneous claims (they had started in

1906) of what we now call cold fusion. In this talk the background to Rutherford's path to splitting the atom was detailed, especially those origins whilst he was previously in Canada.

Transmutation and the History of the Nuclear Force

Robin Marshall, Department of Physics, University of Manchester.

The sequence of experiments carried out in Manchester during the period 1907 to 1919 heralded the beginning of the much-needed acceptance of the existence of a "new" force of nature, "new" in the sense that hitherto, no human knew it existed. This talk began with a brief and simple summary of the current understanding of the strong nuclear force and especially the way that the force between quarks, mediated by gluons, also manifests itself as a force between nucleons, mediated by meson quanta. Early nineteenth-century portents of the existence of a new force, in addition to gravity and electromagnetism, were mentioned and also why phenomena such as solar flares and the understanding of the age of the sun and earth made such a new force obligatory. Then the various Manchester experiments are considered in turn, in the context of the answers to two basic questions: 1. Could this experiment have observed the effects of the strong nuclear force? 2. Did this experiment observe the effects of the strong nuclear force and if so, how? As well as the contributions from the usual Manchester heroes, Rutherford, Geiger, Marsden and Chadwick, the contributions from the formidable French physicist, Jean Baptiste Perrin and the often overlooked, Étienne Biéler will also be honoured.

"Splitting Atoms": The News Media and Public Perception of Transmutation

Brian Cathcart, Kingston University, London

Although Rutherford announced his 1919 breakthrough at a well-advertised meeting in the Royal Institution, the press coverage that followed (and the press was the only news medium at the time) was thin and often poor. Science journalism did not really exist in 1919; the public tended to learn of scientific developments very slowly, mainly through books and the education system. It is instructive, however, to compare what happened in 1919 with the media treatment of Rutherford's announcement of the nuclear atom in 1911 (there was none at all), and of the achievement of artificial disintegration under Rutherford's auspices at Cambridge by Cockcroft and Walton in 1932 (which prompted what would now be called a media frenzy). A kind of progress may be detected over these twenty-one years, of which the 1919 reports offer intriguing evidence. Over the whole period, of course, much else changed, not least the attitudes and personal standing of Rutherford himself, while the public and the context of human affairs were also different. And journalism was also changing – though strikingly the progression shown reveals limitations to science journalism of which we are uncomfortably conscious today.

Chemical Implications of Induced Transmutation

Michael Jewess, Harwell, Oxfordshire.

Rutherford in 1919 bombarded target N-14 nuclei with spontaneously-emitted α-particles thereby effecting transmutation, the precise reaction being later elucidated by Blackett. Bombardment with electrostatically accelerated nuclei (protons, deuterons, and others) and with neutrons extended the range of transmutations possible. Rutherford's 1919 experiment with N-14 generated only nuclides that occur naturally on earth (H-1 and O-17), but later transmutations created nuclides that do not occur naturally – or else occur naturally only in very small quantities (*eg* C-14, H-3, and He-3 formed by β-decay of H-3). Induced transmutation (or the spontaneous decay of the direct products of induced transmutation) –

(i) has satisfyingly filled *gaps in the periodic table below element 92* (U);

(ii) has created elements 93 (Pu) to 103 (Lr) completing the *second, actinoid f block of elements* which as a whole has distinctive chemistry compared with the first *f* block, the lanthanoids;

(iii) underlies nuclear power and nuclear weapons which have required chemists to develop *new separation processes* (*eg* for separating Pu from U*)*;

(iv) has provided isotopes of known elements enabling *chemical investigations* ranging from low solubilities to reaction mechanisms; and

(v) has created radioisotopes for *medical use requiring chemical delivery mechanisms* (*eg* Tc-99*m* to the heart, F-18 to cancers).

At lunchtime Neil Todd conducted attendees round the laboratories where Rutherford and his co-workers conducted their research. Rutherford's work was of enormous significance for chemistry, and it was pleasing to see an RSC Landmark plaque in the physics building commemorating Rutherford's 1911 discovery of the nuclear atom. The RSC Historical Group was a joint sponsor of this meeting with the Institute of Physics History Group, and as with previous jointly sponsored meetings the content was accessible to the average physicist and the average chemist alike.

John Hudson and Michael Jewess

OTHER MEETING REPORTS

Chemistry in Albertopolis

A one-day conference held in the Science Museum, 11 April 2019

The Great Exhibition (of the Works of Industry of All Nations) was an international exhibition that took place in a huge temporary glass-house (nicknamed “the Crystal Palace”) in Hyde Park, London, from 1 May to 15 October 1851. It was the first in a series of World’s Fairs, exhibitions of culture and industry that became popular in the nineteenth century. The Great Exhibition was organized by civil servant Henry Cole, chemist Lyon Playfair and Prince Albert. Six million people - equivalent to a third of the entire population of Britain at the time - visited the Great Exhibition. The average daily attendance was 42,831 with a peak attendance of 109,915 on 7 October. The event made a surplus of £186,000 (£18,370,000 in 2015), which was used to found the Victoria and Albert Museum, the Science Museum, Imperial College and the Natural History Museum [1]. They were all accommodated in the area to the south of the exhibition, otherwise known as “Albertopolis”, alongside the Imperial Institute, an organisation set up to promote trade within the British Empire. This last was housed in a huge building and was demolished piecemeal in the 1960s and 1970s to allow for the expansion of Imperial College. The remaining surplus from the Great Exhibition was used to set up an educational trust to provide grants and scholarships for industrial research and continues to do so today.

Dame Mary Archer, Chair of the Science Museum Group, welcomed conference participants to “*Chemistry in Albertopolis*, a day of exploration to look at how chemistry took root and flowered in the educational and cultural organisations of Albertopolis”. The conference, organised by the Science Museum’s *Research and Public History Department*, focused on developments from the mid-nineteenth century to the present day.

Several Historical Group members and friends of the RSCHG contributed to the conference, among them: Robert Anderson on Prince Albert and the origins of the scientific and cultural quarter; Hasok Chang on William Tilden on the history and pedagogy of chemistry; Bill Brock on the ‘central’ role of Henry Armstrong in British Chemistry, 1879-1910.

The conference then broke for lunch and a tour of Imperial College’s former chemistry laboratories and lecture rooms, and the Queen’s Tower, the only surviving relic of the Imperial Institute. We then resumed to consider some of the College’s more famous chemists. Anne Barrett spoke on Frances Micklethwait, honoured (MBE) for her WW1 work on antidotes to mustard gas and Martha Annie Whiteley, who researched alongside Frances, and was also honoured (OBE) for her WW1 work (on tear gases). Bill Griffith and William Motherwell listed several Imperial College-connected chemists who won Nobel Prizes, but chose to concentrate on two with whom they had worked personally: Bill on Geoff Wilkinson [2] and Willie on Derek Barton [3].

A later afternoon session considered how chemistry had been displayed in the Science Museum. The Historical Group’s Chairman, Peter Morris, surveyed the evolving displays with the eye of a professional historian, Rupert Cole (Associate Curator) shared his thoughts with us about possible emphases for current displays and finally Hattie Lloyd (Assistant Curator) showed us slides of examples of azo dyes prepared by Imperial’s Frances Micklethwait. She had discovered these in the museum’s collection and discussed with the audience possible storage problems and their archiving.

The conference closed with a lecture given by Sir Ian Blatchford, Director of the Science Museum, on Lyon Playfair (1818-1898). In 1845 Playfair was appointed to a professorship in the Royal School of Mines (one of the antecedents to Imperial College). Through this position, he bonded intellectually with the scientifically-minded Prince Albert, and joined him and Henry Cole to oversee the administration involved in the establishment of the Great Exhibition. He became President of the Chemical Society in 1857 and a year later moved to Edinburgh as professor of chemistry. From hereon he increasingly pursued a political career, becoming a member of parliament and later (1873) Postmaster General.

The Science Museum and Imperial College were generous hosts throughout the day and must be thanked for putting on such an attractive event.

Notes

1. Adapted from the Wikipedia article https://en.wikipedia.org/wiki/Great_Exhibition
2. Geoff Wilkinson (1921-1996, Nobel Prize 1973) obtained both his BSc and PhD at Imperial College, undertook research in the USA, returning to Imperial in 1955. His research interests here focused on ferrocene and its structure, and complexes of transition metals. With his doctoral student, F. Albert Cotton, he wrote the textbook *Advanced Inorganic Chemistry* (1963) which changed the approach to the teaching of the subject across the world.
3. Derek Barton (1918-1998, Nobel Prize 1969) like Wilkinson obtained both his BSc and PhD degrees at Imperial College He held a variety of industrial and academic appointments, returning to Imperial in 1957 as professor of organic chemistry. He is remembered for his ground-breaking studies in conformational analysis and the keenness of his mind that he applied to solve problems in natural product synthesis.

Alan Dronsfield

The life and work of Fritz Haber revisited on the 150th anniversary of his birth, in Berlin, Jerusalem, and Karlsruhe

Three recent symposia marked the hundred and fiftieth anniversary of the birth of the German physical chemist and Nobel laureate Fritz Haber (1868-1934). Among his most significant – and practical – achievements was the fixation of atmospheric nitrogen. However, and not lost on the audiences at the three events, was the fact that the life and times of Haber straddled some of the most turbulent periods in modern times. Because he has become so closely associated with the introduction of gas warfare, highly selective portraits of his career and invariably glib judgements on his work abound in the public domain. To counter this trend, some of the presentations addressed the striking persistence of negative and stubborn attitudes, and presumptions, with respect to Haber, drawing attention to the problem of how moral judgements on men – and women – of great achievement of past times are uttered in more recent, and very different times. The three symposia commemorating the sesquicentenary of Haber's birth on 9 December 1868 provided an opportunity to re-examine aspects of his life and work.

The first symposium (organised by Bretislav Friedrich and Gerard Meijer), was held on 10 December 2018 by the Fritz Haber Institute of the Max Planck Society, at Harnack House in Berlin-Dahlem, close to the site of Haber's former residence. At Dahlem in 1911, Haber – just two years after his invention of the nitrogen fixation process – became the founding director of the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry, which in 1952 was renamed in his honour. The first speaker, Bretislav Friedrich, in *Who was Fritz Haber?*, began with a description of Haber's early life, prior to his receiving a research post in 1894 at the Technische Hochschule Karlsruhe, where he would become full professor at age thirty-seven. At Karlsruhe, he brought about the highly challenging synthesis of ammonia from its elements under a pressure of 200 atmospheres (402 kPa) at an elevated temperature of over 500 ˚C in the presence of an osmium catalyst. Since the thermodynamically-limited yield was low, it was necessary to recirculate the unreacted gases in a continuous, closed loop.

Next, Deri Sheppard (University of South Wales) in *"An ideal partnership": Haber, Le Rosssignol and the Ammonia Synthesis*, emphasized the critical role played by Haber's English assistant Robert Le Rossignol (1884-1976) in the design and construction of a complex steel laboratory apparatus for the ammonia synthesis. Le Rossignol had previously developed his skills in both engineering and chemistry at University College London.

Margit Szöllösi-Janze (Luwig-Maximilans-Universität), in *Science at War: Fritz Haber and the Chemical Industry, 1914-1918*, recounted Haber's role as a wartime administrator and mediator between science, chemical industry, and the military. It was through this work that he became associated with the first large-scale wartime gas attack, on 22 April 1915 at Ypres, against French, Algerian, and Moroccan troops. This has left a lasting legacy concerning the use of toxic gases in war, including, later on, against civilian populations. During World War I, the BASF Haber-Bosch synthetic ammonia process was increasingly applied in the manufacture of munitions.

Stefan L. Wolff (Forschungsinstitut, Deutsches Museum) in *Haber as a Jewish German Patriot: From Baptism to Zionism*, examined Haber's conversion as a young man to the Christian faith. In 1933, Haber's situation in Germany changed soon after the National Socialist's assumed power. The Law for the Restoration of the Civil Service, of 7 April 1933, required that Haber dismiss co-workers of Jewish descent. Haber stepped down in protest and through his resignation letter rejected the racist Nazi policy. He received offers of support outside Germany, including from former institute assistant Setsuro Tamaru, in Tokyo. In the autumn of 1933, Haber joined William Pope at Cambridge. Chaim Weizmann, the chemist and Zionist leader, invited Haber to join the Daniel Sieff Research Institute, at Rehovot, in mandate Palestine. Haber's heart problems precluded his travel there. He died in Basel, Switzerland, on 29 January 1934.

Jan Willem Erisman (Vrije Universiteit Amsterdam), in *How 110 Years of Ammonia Synthesis Changed the World Food Production and Environment*, pointed out that while Haber's method for nitrogen fixation enables the feeding of about half of the world population, this has contributed to widespread obesity and other health issues in the developed world. Moreover, release of reactive nitrogen from fertilizer use contributes to environmental degradation.

At Harnack House the Belgian artist David Vandermeulen exhibited images from his pictorial biography of the life and times of Fritz Haber. So far, four volumes of the lavish six-volume *Fritz Haber*, have been published. Hanoch Gutfreund (The Hebrew University of Jerusalem) presented a display of correspondence between Haber and Albert Einstein, from The Hebrew University's Albert Einstein Archives. The letters demonstrate a strong and warm friendship, though the two men disagreed on key issues, ideological and otherwise.

The second Haber symposium (organized by Roi Baer and Igor Shapiro) was held at the Fritz Haber Center for Molecular Dynamics, the Institute of Chemistry, The Hebrew University of Jerusalem, Israel, on 17-18 December 2018. Tony Travis (Edelstein Center for the History and Philosophy of Science, Technology and Medicine, The Hebrew University) in *Fritz Haber and the Pursuit of Nitrogen* described the research in chemistry and engineering that brought about the Haber-Bosch process. By 1930, synthetic ammonia had become a global industry, its several novel high-pressure processes all based on Haber's 1909 method as devised at Karlsruhe.

The third Haber symposium was held at the The Karlsruhe Institute of Technology (KIT) on 15 January 2019 (organized by Marcus Popplow, Caroline Robertson-von Trotha, and Doris Wedlich). Alexander Wanner, KIT's vice president for Higher Education and Academic Affairs emphasized Haber's role as "one of the most outstanding scientists who ever worked in Karlsruhe" without, significantly, ignoring the fact that Haber has been labelled "the Father of Chemical Warfare". In the light of often clouded and unsettling ambiguities concerning Haber, Wanner highlighted the aim of the colloquium to provide "a solid basis of information as well as a discussion from different perspectives and perceptions". After a brief address by Caroline Robertson-von Trotha, the chair of KIT's Centre for

Cultural and General Studies, Bretislav Friedrich, in *Fritz Haber at 150: The Unfolding Views of and on a German Jewish Patriot*, continued with these themes in his keynote talk. Bretislav emphasized the need to fully understand the context of Haber's life and times in order to arrive at a balanced perspective on his activities. There followed a discussion among a panel, and subsequently involving the audience, that raised issues as diverse as the relationship between Haber and Einstein, forms of commemorating Haber on KIT's campus, and initiatives for an extended integration of ethical issues into curricula.

Bretislav Friedrich and Anthony S. Travis

FORTHCOMING RSC HISTORICAL GROUP MEETINGS

The Handed World: 150 Years of Chiral Molecules

Thursday 19 March 2020, Burlington House, Piccadilly, London

From Dalton early in the century to Cannizzaro in 1860, chemists developed a picture of molecules comprising known atoms in known numbers bound closely together. From Pasteur in 1860 to van't Hoff and Le Bel in 1874, this became a picture of molecules in 3-dimensional space with specific geometrical arrangement of the atoms, often such that the molecules were "chiral", existing in two non-superimposable mirror-image forms and therefore "optically active". This picture was arrived at primarily by induction from macroscopic evidence, but it was confirmed in the twentieth century (with refinements) by investigation at the atomic level, such as by diffraction. Also, chirality has proved important in biology and pharmacology, justifying Alice's cautionary statement, "Perhaps looking-glass milk is not good to drink." Speakers will include Alan Dronsfield, Henry Rzepa and Giuliano Siligardi.

The meeting programme and details on how to register will appear in the winter 2020 *Newsletter*. Further information can be found on the RSC Events page.

http://www.rsc.org/events/detail/40046/the-handed-world-150-years-of-chiral-molecules

FORTHCOMING CONFERENCES

38th International Conference for Dyes in History and Archaeology (DHA38)

The 38th annual meeting of Dyes in History and Archaeology will take place in Amsterdam on 7 and 8 November 2019 in the Theatre of the University of Amsterdam (Nieuwe Doelenstraat 16, 1012 CP Amsterdam). The traditional format will be followed: the welcome reception on Wednesday 6, the conference dinner on Thursday 7, and the visits to the Volkenkunde and the Lakenhal museums in Leiden on Saturday 9 November.

Enquiries should be sent to dha38@cultureelerfgoed.nl. Registration for the meeting closes on 15 October 2019.

For further information, see https://www.dha38.nl/

Celebrating D.I. Mendeleev's Periodic System. A Historical Perspective

10-13 September 2019, Saint Petersburg State University

The symposium is a satellite event of the XXI Mendeleev Congress on General and Applied Chemistry, the largest Russian scientific event focusing on all aspects of fundamental and applied chemical research. In the International Year of the Periodic Table, it is only fitting to have a satellite symposium celebrating the 150th anniversary of the first publication of the D.I. Mendeleev's Periodic System of the elements. Keynote speakers include Bernadette Bensaude-Vincent, Helge Kragh, David E. Lewis and Martyn Poliakoff.

Registration and conference fees: Anyone wishing to participate in the satellite meeting should register at the Mendeleev Congress, see http://mendeleev2019.ru/index.php/en/.