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# Historical Group

## NEWSLETTER and SUMMARY OF PAPERS

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**No. 81 Winter 2022**

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### From the Editor

Welcome to the winter 2022 RSC Historical Group Newsletter. This issue includes a number of short articles and book reviews and I am most grateful to everyone who has contributed. I am delighted to be able to republish some of Professor Raymond Bonnett's recollections of working with the legendary organic chemist, Robert Burns Woodward, in "My Life with Chlorophyll and Woodward: Recollections at 90". There are also articles by Alan Dronsfield and Pete Ellis "Measuring Glucose Levels during a Century of Insulin Therapy"; Stephen M. Cohen "*Onfang fun Khemye*: The First Chemistry Book in Yiddish"; and Chris Cooksey's biography of the Eastman Kodak chemist Edwin Ernest Jelley (1898–1965). There are book reviews of Dan Kaszeta, *Toxic: A History of Nerve Agents from Nazi Germany to Putin's Russia*; Eric Scerri, *The Periodic Table: Its Story and Its Significance*; François Jarrige and Thomas Le Roux, *The Contamination of the Earth: A History of Pollutions in the Industrial Age*; and Barry J. Oliver, *Ludwig Oertling, Balance-Maker: The Man, His Company and its Products*. As well as summaries of its popular monthly webinars, there is a report on "The Handed World – 150 Years of Molecular Chirality", the group's first in-person meeting since 2019.

The group's first meeting of 2022, on 23 March at Burlington House, will explore the scientific life of Professor Sir Geoffrey Wilkinson (1921-1996) from the perspective of collaborators, friends and family and celebrate three anniversaries, the centenary of his birth (2021), the half-century anniversary of the Nobel Prize (2023) and seventy years since the publication of the seminal article on ferrocene (2022). Further details appear later in the newsletter.

As ever, I am indebted to the newsletter production team of Bill Griffith and Gerry Moss, and the Group's Secretary, John Nicholson, for their assistance in bringing the final version together. Additional thanks go to Peter Morris, Henry Rzepa and Jeff Seeman for their input. If you would like to contribute items such as news items, short articles, book reviews and reports to subsequent issues please contact me. The deadline for the summer 2022 issue will be Friday 10 June 2022. Please send your contributions to [a.simmons@ucl.ac.uk](mailto:a.simmons@ucl.ac.uk) as an attachment in Word.

Group members should receive an email from the RSC informing them when the latest newsletter is available, but for the record the Newsletter appears twice each year – usually in January/February and July/August. It is often available online before official notification is sent out by the

RSC, so please look out for the newsletter on both the RSC and Queen Mary Historical Group websites, the latter which has changed since the last newsletter was published: <http://www.rsc.org/historical> or <https://rschg.qmul.ac.uk>.

Anna Simmons, UCL

## Letter from the Chair

In my message at the beginning of last year, I expressed the hope that the situation would improve once the vaccine programme started. However, with the arrival of the Delta variant and more recently the Omicron variant, things have remained uncertain although the situation is clearly better than it was a year ago. The good continuing health of all of us remains important and I hope that you and your loved ones are keeping well. At long last we have been able to resume our meetings and two meetings have now taken place. The “The Handed World: 150 Years of Molecular Chirality”, organised by Michael Jewess, kicked off our programme on 13 October and the “Life and Work of George Porter, Lord Porter of Luddenham (1920-2002)”, organised by Frank James, took place on 6 December, which would have been Sir George’s 101<sup>st</sup> birthday. Both meetings were at Burlington House, and we are most grateful to the RSC’s events and catering staff for making the meetings possible and helping to make them safe. The Porter meeting broke new ground in being a “hybrid” meeting whereby one could either attend in person or online. The committee will consider the future viability of such meetings at its next meeting in March. The meeting to mark the centenary of Sir Geoffrey Wilkinson, organised by Henry Rzepa, will take place at Burlington House on 23 March 2022 and the “Women in Chemistry” meeting, organised by John Hudson, will be on 13 October at Burlington House. Hence we are now slowly getting back to normal and we can start organising new meetings, all being well. We are thinking of having a “pot pourri” meeting in the spring of 2023 whereby members can present their research on a number of different topics. We aim to keep all our members informed about our meetings by email and on the internet.

We will continue to produce the newsletter and the monthly online talks on Zoom. Please look out for the e-alerts from the RSC, posted out in the first week of every month, which will tell you the topic of the forthcoming talk and a joining link. Recently we have enjoyed talks on “A Century of Global Synthetic Ammonia: 1921-2021” by Tony Travis, “Ordeal Beans: Both Therapy and Poison” by Ann Ferguson, and “Structures: The Key to Chemistry Communication” by Helen Cooke. I

gave a seasonal talk on frankincense and myrrh in December. In 2022 we will have talks by John Hudson on alchemy, by Diana Leitch on the Brunners, by Anna Simmons on the Laboratory at Apothecaries’ Hall, and by Robert Slinn on Roger Altounyan and Intal. Later in the year, we will have talks by our American colleague Mary Virginia Orna, and Aviva Burnstock from the Courtauld Institute. These online talks have been very successful and I would encourage members to continue to log on to the forthcoming talks in 2022.

I must thank Anna Simmons for her continuing excellent work as editor of the newsletter despite increasing commitments elsewhere. We are all greatly in her debt.

Finally I wish all members a much happier and healthier 2022.

Peter Morris

## ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP NEWS

### Secretary’s Annual Report for 2021

Here is my brief report on our year’s activities. Once again, 2021 was a strange year, with the Covid-19 pandemic influencing everything we did. As I write, the way forward is still not clear, and it is uncertain how much disruption there will be to our planned activities in 2022.

As was begun in 2020, our committee meetings during the year have been virtual via Zoom, with one meeting in March and another in October. Business is certainly dealt with rapidly by meeting in this way, but we undoubtedly lose something important by not meeting in person. We hope we will be able to resume meeting in person next year, but at this stage, we cannot be sure of that.

During 2021 our “lockdown webinar” series continued, with a total of ten presentations during the year. This has been one of the successes of the pandemic, and we regularly attract audiences of between fifty and seventy for each webinar. What is also encouraging is that the audience has a wide geographical spread, and we are clearly attracting members who would not feel able to travel to an in-person event at Burlington House. We plan to continue running these webinars on a monthly basis, so why not check when the next one is, and join us?

There was some easing of restrictions on meeting during the year, and this meant that we could hold in-person meetings of the Group. In October the subject was the history of chirality. It attracted some forty-

five attendees, which was down on our usual pre-Covid attendance, but very encouraging under the circumstances. A full report on this meeting appears elsewhere in the Newsletter. We have also arranged a meeting in December, which as I write is still to come. The subject is the “Life and Work of George Porter” and it is to be our first hybrid meeting. Currently, it looks as though we will have a similar attendance to the October meeting, with numbers evenly split between in-person and on-line attendance. A report on this meeting will appear in the summer 2022 newsletter.

Lastly, I am happy to report that we have published two editions of the Group Newsletter during the year. Anna Simmons, our editor, does a remarkable job in attracting a wealth of interesting articles, and to call the resulting publication a newsletter really does not do it justice. So, thank you to her for all her hard work.

John Nicholson

## ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP MEETINGS

### Geoffrey Wilkinson Meeting 23 March 2022

*Royal Society of Chemistry, Burlington House, London*

This meeting is co-organised by the RSC Historical Group and the chemistry department at Imperial College London and will explore the scientific life of Professor Sir Geoffrey Wilkinson (1921-1996), a pioneer in inorganic chemistry and homogenous transition metal catalysis, from the perspective of collaborators, friends and family. It will celebrate three anniversaries, the centenary of his birth (2021), the half-century anniversary of the Nobel Prize (2023) and seventy years since the publication of the seminal article on ferrocene (2022). The meeting will include short talks on topics ranging from the historical aspects of Wilkinson’s legacy to exciting new chemistry evolving from it, given by sixteen speakers and with a packed programme that will run from 9 am to 6 pm.

The meeting is free of charge and registration will be essential. Lunch will be provided free, but attendance at the evening dinner at Burlington House (3 courses plus wine) must be booked via the registration form and will be chargeable. For further information, including a list of speakers, and booking details please visit:

<https://www.rsc.org/events/detail/47050/sir-geoffrey-wilkinson-an-anniversary-celebration>

## MEMBERS’ PUBLICATIONS

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

William H. Brock and Michael Jewess, “Unwise Relationships and an Unsound Valence Theory: The Chemical Career of Robert Fergus Hunter (1904-1963)”, *Ambix*, vol. **68**, issue 4, November 2021, 403-430.

The life of the Imperial College-trained Robert Fergus Hunter was a Bildungsroman of a gifted chemist who appeared destined for a prominent academic career in organic chemistry. Two circumstances spoiled his chances. In the first place he became associated with the declining fortunes of the weekly *Chemical News*. More seriously as professor at the Aligarh Muslim University in British India (1930-1936), he published papers on valence theory with the German-Jewish physicist Rudolf Samuel that fatally destroyed his chance of further academic preferment. Instead he became a research chemist in the food and plastics industries. The paper critically assesses Hunter’s work on valence and also provides new light on science in India during the 1930s.

Frank A.J.L. James, “A Chemical Satire on the 1809 Change of Government in Britain”, *Ambix*, vol. **68**, issue 4, November 2021, 442-446.

This note provides the context and transcription of a short satiric article published in the *Bristol Mirror* on the political events of 1809. The piece used chemical metaphors to provide an understanding of the circumstances surrounding the change of ministry in Britain in the autumn of that year. The article bears a strong relationship to early twenty-first century political satire, including its relationship, or lack thereof, to reality.

Peter Reed, “Alfred Fletcher’s campaign for black smoke abatement, 1864–96: Anticipating the 1956 Clean Air Act”, *The International Journal for the History of Engineering and Technology*, 1-22.

<https://doi.org/10.1080/17581206.2021.1985388>.

Many smog episodes occurred during the nineteenth century due to the burning of coal but the few legislative efforts proved ineffectual. It was only in 1956 with the Clean Air Act that government and parliament took action, following the major London smog episode in 1952. Two elements underpinning the 1956 legislation had formed part of an earlier

campaign conducted by Alfred Fletcher while working for the Alkali Inspectorate between 1864 and 1896 as his personal diaries reveal. Fletcher promoted town gas as a fuel and the adoption of a hot-air stove that he patented; both were used for heating his own house. He also oversaw a technical committee in Manchester charged with testing smoke-preventing appliances.

## PUBLICATIONS OF INTEREST AND NEWS

The following journal issues have been published since the summer 2021 *Newsletter* was completed.

### ***Ambix, The Journal of the Society for the History of Alchemy and Chemistry, vol. 68, issue 4, November 2021***

Sean O'Neil, "Good Names but Better Symbols: The Establishment of Chemical Notation as a Nomenclatural Corrective at the Turn of the Nineteenth Century".

Arnaud Page and Maxime Guesnon, "Glutenophilia: Chemistry and Flour Quality in Nineteenth-Century France and Great Britain".

Marcin Krasnodebski, "The Meandering Life of a Research Trajectory: Rare Earths in the Aubervilliers Research Centre (1953-2020)".

William H. Brock and Michael Jewess, "Unwise Relationships and an Unsound Valence Theory: The Chemical Career of Robert Fergus Hunter (1904-1963)".

#### *Text and Commentary*

Guillaume Delmeulle, "At the Origins of the De Perfecto Magisterio: A Translation from Arabic or a Latin Composition".

#### *Notes and Communications*

Frank A.J.L. James, "A Chemical Satire on the 1809 Change of Government in Britain".

### ***Bulletin for the History of Chemistry, vol. 46, number 1, 2021***

Carmen J. Giunta, "Editorial: Promoting Diversity".

Comment and Response: "The Toxicity of Mercury".

Krešimir Molčanov, "Atomism of Lucretius Seen Through the Eyes of a Modern Physical Chemist".

Henk Kubbinga, "The Fourth Centenary of the Molecular Theory, 1620-2020".

Pier Remigio Salvi, "Discovering Oxygen: Experimental Techniques and Logic of a

Great Chemist, Carl Wilhelm Scheele".

Roberto A. Ferrari, "An Unrecorded Early Lavoisieriana".

G.J. Leigh, "The Early Lives and Courtship of Jane and Alexander Marcet".

Marcello S. Rigutto and J.A. Rob van Veen, "On Sabatier's Misrepresentation of Berthelot's Hydrogenation of Benzene with Concentrated Hydroiodic Acid".

Marelene Rayner-Canham and Geoff Rayner-Canham, "Mary 'Polly' Porter (1886-1980): Pioneer Woman Crystallographer".

Dean F. Martin, Vera V. Mainz and Gregory S. Girolami, "St. Elmo Brady (1884-1966). The First African American Chemistry Doctorate Recipient".

Kathleen L. Neeley and James D. Neeley, "A Wave of Women Chemists: Mary Elvira Weeks and Her University of Kansas Colleagues".

W. Christopher Boyd, Review of *What Is a Chemical Element? A Collection of Essays by Chemists, Philosophers, Historians, and Educators*, Eric Scerri and Elena Ghibaudi, eds., 2020.

E. Thomas Strom, Review of *Robert Le Rossignol: Engineer of the Haber Process*, by Deri Sheppard, 2020.

Jeffrey I. Seeman, "The Back Story, Eugene Garfield (16 September 1925 - 26 February 2017), Information Scientist and Businessman".

### **Chemical Space (1800-1869) and the Evolution of the Periodic System**

The periodic system arose from knowledge about substances, which constitute the chemical space. Despite the importance of this interplay, little is known about how the expanding space affected the system. Here we show, by analysing the space between 1800 and 1869, how the periodic system evolved until its formulation. We found that after an unstable period culminating around 1826, the system began to converge to a backbone structure, unveiled in the 1860s, which was clearly evident in the 1840s. Hence, contrary to the belief that the "ripe moment" to formulate the system was in the 1860s, it was in the 1840s. The evolution of the system is marked by the rise of organic chemistry in the first quarter of the nineteenth-century. This prompted the



recognition of relationships among main group elements and obscured some of the transition metals, which explains why the formulators of the periodic system struggled accommodating them. See:

<https://chemrxiv.org/engage/chemrxiv/article-details/61631eb18b620d34bd4ad785>

The article is accompanied by interactive information, where one can visualise the effect of the chemical space data upon the periodic system:

<https://mchem.bioinf.uni-leipzig.de/1868/main.html>

Guillermo Restrepo

Max Planck Institute for Mathematics in the Sciences Leipzig, Germany

### **Papers on Humphry Davy (1778-1829): Chemistry, Culture and Society in Early Nineteenth Century England**

In the early nineteenth century, Humphry Davy was almost certainly the best-known English chemist in Europe. The son of a bankrupt yeoman farmer in Cornwall, he served part of an apprenticeship as an apothecary before moving to Bristol where he discovered the extraordinary physiological properties of nitrous oxide (laughing gas). In Bristol he formed close friendships with Robert Southey and Samuel Taylor Coleridge who both greatly admired his poetry. In 1801 Davy moved to the Royal Institution where for a decade he was the most popular lecturer in London and initiated the institution's reputation for research by, for example, electro-chemically isolating and naming chemical elements such as sodium and potassium. He was Professor of Chemistry to the Board of Agriculture and there, and at the Royal Institution, he formed links with members of the aristocracy. His rise continued in 1812 by being knighted by the Prince Regent and marrying a wealthy widow (whose money came from her father, an Antigua merchant and corrupt prize agent). He and Lady Davy toured the Continent between 1813 and 1815, meeting ex-Empress Josephine and the Queen of Naples. Shortly after his return, in the closing months of 1815 Davy invented a form of the miners' safety lamp. This crucial device allowed industrialisation to continue, and, possibly more than anything else, is what he is remembered for today. In 1820 he became President of the Royal Society of London, succeeding Joseph Banks who had occupied that role for forty-two years. In the circumstances, any successor to Banks would have had a difficult time and Davy's temperament meant he was unsuited to the role. After a stroke he resigned in 1827 and spent most of the rest of his life on the Continent, dying in Geneva in 1829.

Until the end of March 2022 a curated collection of papers on Humphry Davy from authors including Noel Coley, Peter Collins, Jan Golinski, Frank James, David Knight, Hattie Lloyd Edmondson, Colin Russell and Sharon Ruston, and published in journals including *Ambix*, *Annals of Science*, *Interdisciplinary Science Reviews*, *The Mariner's Mirror* and *Transactions of the Newcomen Society* is available free access via:

<https://www.tandfonline.com/journals/yamb20/collections/Papers-on-Humphry-Davy>

### **EuChemS News**

The 2020 EuChemS Historical Landmarks Award (European level) goes to the Justus Liebig Laboratory in Giessen (Germany) in recognition of the role it played in the history of chemistry and the European sense of belonging between people and ideas. Located in Giessen (State of Hesse) in Germany, the chemist Justus von Liebig worked in this laboratory from 1824 to 1852. Justus von Liebig is considered as one of the main founders of organic chemistry and is well-known for his major contributions to agricultural and biological chemistry. Liebig is also recognised for transforming chemistry education and as a truly European figure. Justus Liebig's Laboratory building was turned into a museum in 1920. Rich collections of historical documents, including hundreds of letters, chemistry books, pictures, chemical apparatus, scientific instruments, and personal memorabilia make the Liebig Museum one of the most impressive chemistry museums worldwide.

### **History of Science Society News**

Bernadette Bensaude-Vincent, the historian and philosopher of chemistry and materials science, is the recipient of the History of Science Society's 2021 Sarton Medal. This prize is awarded annually to an outstanding historian of science, selected from the international scholarly community.

### **The Davy Notebooks Project**

A public-facing project set to uncover previously unpublished material from the early nineteenth century's "foremost man of science" has launched online. Sir Humphry Davy (1778-1829) discovered more chemical elements than any individual has before or since. His achievements saw him rise up through society's ranks from relatively modest origins to become, just over 200 years ago, the President of the Royal Society of London. In 1815, he invented a miners' safety lamp that came to be known as the Davy Lamp, saving countless lives in

Britain and Europe, and vastly improving the nation's industrial capability.

The £1 million project, funded by the Arts and Humanities Research Council (AHRC) and led by Lancaster University with the University of Manchester and UCL, will use the people-powered research platform Zooniverse to bring to light Davy's notebooks – the documents he used to work out scientific ideas alongside lines of poetry, philosophical musings, geological drawings, and accounts of his life. Davy kept notebooks throughout his life, but most of the pages of these notebooks have never been transcribed before. Most entries have yet to be dated or considered in the light of what they tell us about Davy, his scientific discoveries, and the relationship between poetry and science.

In 2019, AHRC funding enabled Professor Sharon Ruston and Dr Andrew Lacey, both of the Department of English Literature and Creative Writing at Lancaster University, to crowdsource transcriptions of five of Davy's notebooks, dating from between 1795 and 1805, using Zooniverse. Following on from this successful pilot project, during which more than 500 participants from around the world transcribed 626 notebook pages in under twenty days, the project team will now crowdsource transcriptions of Davy's entire seventy-five-strong notebook collection. Some seventy notebooks are held at the Royal Institution of Great Britain in London and five are held in Kresen Kernow in Redruth, Cornwall.

Crowdsourcing is now underway. It's free to take part, and you can transcribe as much or as little as you like. The edited transcriptions will later be published online, alongside images of the notebooks, on a free-to-access website, as part of Lancaster Digital Collections. For more information please visit

<https://www.zooniverse.org/projects/humphrydavy/davy-notebooks-project>

## SHORT ESSAYS

### **My Life with Chlorophyll and Woodward: Recollections at 90**

*Editorial note;* A few years ago Professor Raymond Bonnett was invited to publish in the *Russian Chemical Journal* [1] his recollections of working with the legendary organic chemist Robert Burns Woodward. Professor Bonnett has kindly agreed to republish part of this account, which deals with his time at Harvard, in the RSC Historical Group

Newsletter. Professor Oscar Koifman, editor of the *Russian Chemical Journal*, has generously given permission for the use of the original article in this way.

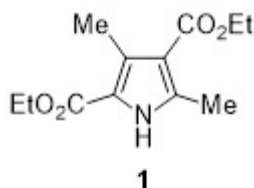
On April 29th 1958 Robert Burns Woodward sent me a letter offering me a position in his postdoctoral research group for one year from September 1st 1958 at an annual stipend of \$4,000. On August 21st, armed with a Fulbright travel grant, my wife and I set sail on the *Queen Elizabeth* for New York, arriving at Harvard a few days later. Settling in went pretty smoothly: through the good offices of our friend Bob Sheppard (who later worked at the LMB at Cambridge), we inherited the apartment held the previous year by John Hannah (who was just finishing his stint on the chlorophyll problem). We also inherited John Hannah's car, which I believe he had originally got from Professor K. E. Bloch. (It was a huge beast compared with the 1935 Austin 10 we previously had in Cambridge, but it served us well). Since payday was not till the end of the month, I had to borrow \$400 from Woodward to tide us over till then.

It was only when I got to see Woodward that I learnt that I was going to be working on the synthesis of chlorophyll *a*. Woodward sat me down comfortably in his office, and gave me a 90 minute personal lecture on what had happened so far. It was clear to me that this work was engaging his attention most closely. The chlorophyll synthesis took about three and a half years, and seventeen postdoctoral researchers were directly involved. In 1956/57 John M. Beaton, Gerhard Closs, Albert Langemann and Zdenek Valenta started the work, followed in 1957/58 by William A. Ayer, John Hannah and Fred P. Hauck. I joined in for the year 1958/59 with Hans Dutler, Shô Itô, Jürgen Sauer, and Heinrich Volz. Hans Dutler carried on into the fourth year with Paul Buchschacher, Friedrich Bickelhaupt, Eugene Le Goff, Willy Leimgruber and Walter Lwowski, which saw the job done, and the appearance of the preliminary communication [2].

This was a very international group of researchers, but under Woodward's guidance they seem to have worked together with uncanny understanding. Although I communicated with most of my sixteen co-workers, I did not meet them all personally, and the present personal recollection has to refer principally to activity during 1958/59. The chlorophyll group was located in laboratories directly opposite Woodward's office. It was always possible for us to see him, but we had to go through his secretary, Dolores (Dodie) Dyer, who kept guard very effectively, and in addition to her secretarial duties, attended to things like sending off samples for elemental analysis, and collecting record

books. On the other hand, Woodward had only to cross the corridor to be in our labs – and this he frequently did. He would come with enquiries and suggestions for fresh approaches, which he inscribed on small notepads left about for that purpose. In the hot summer of 1959, to our amazement air conditioning was installed in our labs, no doubt to enhance productivity!

As the reader will well know, porphyrin/pyrrole chemistry is a rather specialised aspect of organic chemistry. It has a number of faithful devotees, but I think that Woodward had had no previous experience of its intricacies. My understanding is that he prepared himself for the task by digesting the monumental summary by Hans Fischer (Fischer-Orth-Stern [3]), and coming to a view on the correctness (or otherwise) of the Fischer formulation of chlorophyll *a*. At first he seems to have had doubts, and considered other structures (including some with a 6-membered ring, as I recall). But in the end he evidently concluded that the general structure which Fischer and Linstead [4] had arrived at was indeed correct. He then used a considerable amount of Fischer's pyrrole chemistry in the early stages of the synthesis, improving it and adding to it as he went along. Each of the four rings of the porphyrin precursor (#35 in the full paper [5]) was elaborated from Knorr's pyrrole (#1), which had to be prepared on a large scale (several kilograms).

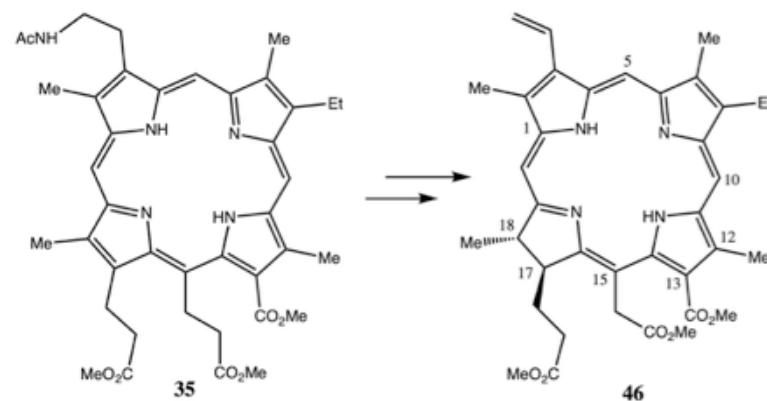


But from then on it was very different. Fischer's porphyrin syntheses were largely based on 2+2 couplings of dipyrromethane derivatives under forcing thermal conditions (molten acids), and for porphyrins with an 'unsymmetrical pattern' of  $\beta$ -substituents this generally led to low yields of mixtures which had to be separated. (Indeed, the Munich group developed a route to chlorophyll *a*, and an outline comparison [6] has been made with the Woodward route).

Woodward himself developed a much superior route to such 'unsymmetrically substituted' porphyrins using dipyrromethane derivatives (this approach was discovered independently by MacDonald [7] at about the same time) which worked under mild conditions, and which lent itself to regiospecific 2+2 coupling in high yield (~50 %).

Several aspects of porphyrin/phlorin/chlorin chemistry were illuminated along the way. One of the most striking developments, which as it turned out fell to the lot of the 1958/59 team to carry out, was this stepwise regiospecific coupling of dipyrromethanes using a thioaldehyde intermediate to give the aforementioned porphyrin #35.

The group of five of us worked very well together, but there was some alarm that compound #35 had a propionic acid substituent at C-15, rather than the acetic acid substituent required for the target molecule, chlorin *e6* trimethyl ester (#46 in the full paper [5]).



How would a carbon atom be removed? As I recall, Woodward would not be drawn on this, but I believe that he had already thought it through and, with a mixture of genius and good luck, peripheral overcrowding played a part – and it worked out!

I found Woodward a charming and sociable person, rather gentlemanly, and a good but demanding boss. The team worked hard, and because he was so keen on the project, as I have said we saw a lot of him, and learnt a lot from him. He seemed to me to have a subtle mixture of shyness and pomposity. I recall on one occasion he brought some cuttings from a spectrum he had traced, wanting to know the relative areas. Anyone else would have asked me to weigh them – but not RBW – he asked me to find the effect of gravity on them. So I dropped them. He looked surprised for a moment – and then laughed, as I picked up the slips and made for the microbalance.

He was indisputably a great organic chemist, one of the greatest, a perfectionist, brimming over with novel ideas. His lectures were performances of the first order (he must have spent hours perfecting



each one) and the weekly seminars he ran on Thursday evenings (often till very late) were crowded, stimulating and delightful.

And we did things besides chemistry. There was an introductory party in the lab (RBW's favourite tippie at that time was VAT 69 whisky, and he was a very heavy smoker) and an elaborate departmental Christmas party, with a fully scripted comedy performance by the students on the academic staff featuring characters such as Dr Wormwood and Doll. Woodward's wife, Eudoxia, invited the wives of her husband's entire research group to a party at their house in Belmont (a western suburb of Cambridge). And when our group had done something particularly notable, Woodward would take us out to Joseph's (which I see still exists) for a lobster lunch. The photograph shows the 1958/59 group with RBW in Harvard Yard after such an outing. I don't recall who snapped the laurel(?) branch from the tree – probably RBW himself. I remained in contact with him until shortly before his death. In November 1976 he came to London to receive the Honorary DSc of the University of London, and I had the pleasure of entertaining him at Queen Mary College. He gave me a photograph of crystalline synthetic vitamin B<sub>12</sub> which I much appreciated because it reminded me of my PhD work with Jack Cannon, Ian Sutherland, Alan Johnson and Alex Todd at Cambridge some twenty years earlier.



Photograph of the 1958-59 Chlorophyll Group taken in July 1959

From left to right: Sho Itô, Hans Dutler, R.B. Woodward, Raymond Bonnett, Jürgen Sauer, and Heinrich Volz. (Copyright R. Bonnett)

And he was a great correspondent. During the chlorophyll synthesis an isomer of the chlorin system (5,22-dihydroporphyrin) had been encountered for the first time, and Woodward had named it 'phlorin' (The protonated form had a broad absorption at ~700 nm, quite unlike a chlorin). I was intrigued, and wrote to Woodward to ask how he had arrived at the new name. This was his reply (April 11th 1968):

The designation 'phlorin' is a play on words. The chlorins and chlorine enjoy their sobriquets in consequence of their green color and the fact that the Greeks used the word 'chloros' to describe that color. In casting about for a name for the phlorins, we had in mind their familial relationship with the chlorins: from there one thinks of fluorine, chlorine...., succumbs to homonymy....voila!

So there we are – the man himself, in words!

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Raymond Bonnett

## Measuring Glucose Levels during a Century of Insulin Therapy

Almost exactly 100 years ago, on Monday 23 January 1922, 14-year-old Leonard Thompson, in the terminal stages of then-fatal diabetes mellitus (later known as *Type 1 diabetes*), began a course of injections with an abattoir-sourced extract of pancreas glands. Sugars in his urine became almost undetectable and his blood glucose level dropped four-fold. The team that pioneered this treatment reported “This resulted in immediate improvement. ...The boy became brighter, more active, looked better and said he felt stronger” [1]. The extract was later christened *Insulin* and Leonard continued to receive life-prolonging injections for the next thirteen years, eventually dying from pneumonia. His diabetes may have contributed to this, either through increased vulnerability to infection due to poor (in modern terms) control of his diabetes, or the extent to which even well-controlled diabetes somewhat impairs the immune system.

An account of diabetes survives from AD 100. The Turkish physician Aretaeus of Cappadocia described: “A melting down of the flesh and limbs into urine...the thirst is unquenchable...they are affected with nausea, restlessness and a burning thirst, and at no distant time they expire”. However, the illness had been recognized in ancient times in Egypt, China and India. That the urine was characterised by a sweetness [2] that attracted ants and flies had been known since about 500 BC and in 1674 Oxford physician Thomas Willis reported “diabetic urine [tasting] wonderfully sweet as if it was imbued with sugar or honey”. A patient with severe untreated type 1 diabetes may excrete up to 10g glucose per 100 cm<sup>3</sup> urine [3]. By the nineteenth century there was a host of “remedies”, amongst them creosote, ferrous sulfate, boric acid, codeine and, unbelievably, large quantities of sugar. Perhaps the most frequently prescribed was opium. All were ineffective, but the last had the dubious advantage of inducing stupor so that the patients became resigned to their inevitable fate. In the late nineteenth and early twentieth centuries it was recognised that carbohydrate consumption was harmful, so regimes to prolong the life of diabetics were devised that replaced carbohydrates with energy-supplying fats. But this was not much of a solution, as acidosis eventually intervened, causing a host of unpleasant symptoms before death intervened. Frederick Allen, an American specialist in the disease, recommended a near-starvation diet with minimal fat and carbohydrate content. Although it could prolong patients’ lives for a few months if followed rigorously, it led to death

from starvation. Returning to a normal diet instead led to death from the disease.

The success of Leonard Thompson’s treatment led to international excitement. Diabetes, if not curable, was controllable and compatible with a near-normal life. While the story of the discovery of insulin is well described [4], three related controversies are less well known. Firstly, some allege that Frederick Banting and Charles Best (who today are most commonly recognized for the discovery) gave insufficient credit to other workers who travelled the same path and came close to their discovery [5]. Secondly, the Nobel Prize committee awarded the 1923 prize to Banting and John McCleod (who ran the laboratory in which the discovery was made and who facilitated the Banting/Best work) and the former felt that his colleague Best had been unfairly overlooked [6]. Thirdly, McCleod felt that James Collip’s contribution (in devising methods to extract the insulin from the raw pancreas glands and preparing it in a pure enough form for regular injections) was under-recognised. Thus McCleod shared his Prize money with biochemist Collip, his generosity perhaps following Banting’s lead in sharing his Prize with colleague Best [6].

### The Chemistry

We have to admit that there is little *novel* chemistry in the Banting/Best discovery of insulin. Collip persevered in applying established methods of extraction, concentration and purification until he had achieved a potent product safe enough for injection [7]. Without his expertise, the patients treated from 1922 would have had lingering deaths from the disease or a succession of abscesses from daily injections of low purity. However, during their remarkably brief, albeit successful, biochemical journey, Banting and Best used a variety of historical analytical methods, some of which had their origins in the preceding century, to analyse blood extracted from laboratory dogs to monitor the effects of the injected pancreatic extracts. These laboratory methods (and urinary glucose measurements) were used on patients, first on Leonard Thompson and then, after success there, on a wide range of patients to check that their insulin dose matched their carbohydrate intake. Later, home self-testing kits became available, some based on nineteenth century chemistry and others on the burgeoning methods of twentieth century colorimetric analysis.

Until the mid-1950s, virtually all the methods of patient self-monitoring were based on testing for urinary glucose through the glucose-mediated reduction of copper(II) to copper(I). However, glucose does not appear

in urine until blood glucose levels are significantly above normal, so monitoring urinary glucose is a poor proxy for what is happening in the blood. But as blood glucose measurements were not technically feasible outside a hospital laboratory setting at that time, it had to suffice.

The  $\text{CuSO}_4$ -based urinalysis method devised by Karl Trommer (1841) [8], improved by Hermann von Fehling (1849) [9] and again by Stanley Benedict (1909) [10], was both quick and cheap. A positive result (the deposition of a brick-red precipitate of  $\text{Cu}_2\text{O}$ ) was seen as a qualitative indicator of the presence of glucose, and thus the need to increase the daily insulin dose. The 1909 variant could be seen as being semi-quantitative: “The test produced a colour reaction from blue, through green, yellow and orange to brick-red...I was given 20 units of insulin if the colour was orange and 10 if it was yellow...If I reported the result of my test to be blue (correlating to a blood-glucose level of 10 mmol/litre or less) on two consecutive occasions the nurses would give me sugar in water to drink” [11]. An insulin intake above that required to match the carbohydrate in the diet can reduce blood glucose to dangerously low levels (hypoglycaemia), putting the patient at risk of collapse, hence the need for continual monitoring – even by this somewhat crude method.

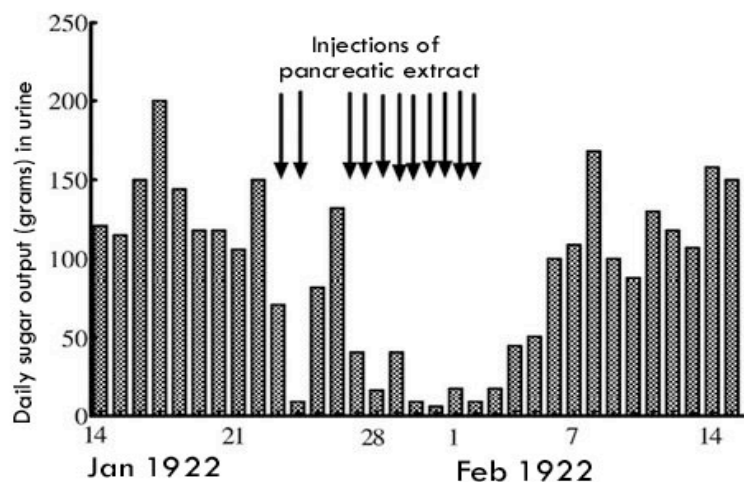


Fig 1. The effects of injections (8 or 10  $\text{cm}^3$ ) of purified pancreas extract on the sugar content of Leonard Thompson’s urine [adapted from Ref. 1].

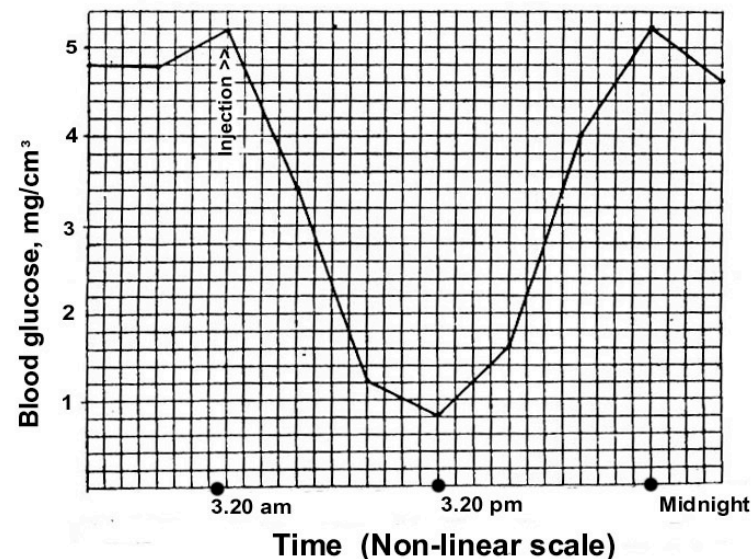


Fig 2. The effect of a single injection (at 3.20am on 17th February 1922) on Leonard Thomson’s blood glucose concentration [adapted from Ref. 1].

### Banting and Best’s Glucose Assays

Banting and Best in their world-changing paper [1] record quantitatively the effects of injecting pancreatic extract into Leonard Thompson. The levels of glucose in his blood and urine reduced dramatically. Details of the (non-referenced) method are confined to “urinary sugar estimated by Benedict’s method”, but we presume that they used the colorimetric method that he published in 1918. Urine, typically 15-20  $\text{cm}^3$ , is pre-treated with mercuric nitrate to precipitate nitrogenous interferences and then heated with a mixture of picric acid and sodium hydrogen carbonate. Any glucose present reduces the acid to picramic acid, a reddish-coloured material, the concentration of which can be determined against standards using a colorimeter (typically of the Duboscq type) [12]. Leonard’s urinary glucose measurements are shown in Fig 1. They measured the blood glucose using a method recently published by Otto Folin and Hsien Wu who refined the nineteenth century copper-based assays [13]. These workers used tungstic acid to deproteinise the blood sample (typically 3 $\text{cm}^3$ ) and the filtered product was then treated with a solution of copper(II) tartrate,

which, Fehling's-like, produces a precipitate of  $\text{Cu}_2\text{O}$ . This is then oxidised back to  $\text{Cu(II)}$  by the addition of a colourless complex prepared from ammonium molybdate and phosphoric acid. As the  $\text{Cu}_2\text{O}$  is oxidised, the phosphomolybdate complex is reduced to give an intensely blue material, *molybdenum blue*. Its simple name belies a complicated and uncertain structure [14]. The concentration of glucose can be correlated to the intensity of the blue colour using colorimetric methods, referenced against standards prepared from glucose solutions of known dilution. Leonard's blood glucose measurements following a single injection of pancreatic extract are shown in Fig 2.

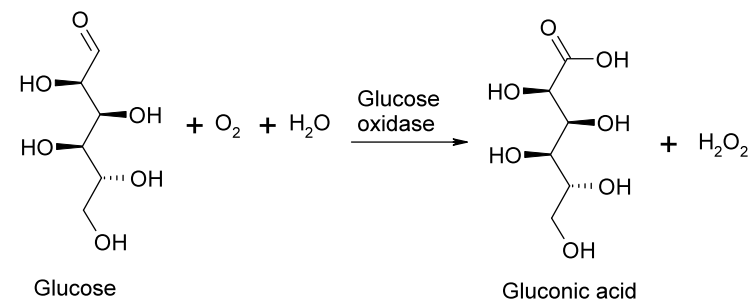
### Home Testing

Carrying out both Benedict's and Fehling's tests in the home demanded access to a Bunsen burner and a measure of chemical expertise. William Pavy in 1880 incorporated the Fehling's test ingredients into a tablet, but even so, boiling the urine over a flame remained an important step and a significant drawback. This was overcome with the introduction of Clinitest tablets in the USA in 1941. With these, heating was achieved simply by hydration of solid  $\text{NaOH}$ , a major ingredient in the tablet, along with  $\text{CuSO}_4$ ,  $\text{Na}_2\text{CO}_3$  and citric acid. Precisely five drops of urine and ten drops of water were added to one tablet contained in a small test tube. The exothermic hydration caused the water to boil. When this subsided, the contents of the tube were mixed to give a  $\text{Cu}_2\text{O}/\text{aq.Cu(II)}$  suspension. The glucose concentration was roughly estimated by comparison against a colour chart. Though this was an advance on Pavy's tablets, Clinitest tablets had two major disadvantages. Firstly, the tablets were highly hygroscopic, so if they were improperly stored, they absorbed water from the air and became useless. Secondly the corrosive nature of the  $\text{NaOH}$  could lead to severe burning on skin contact and they were especially dangerous if swallowed.

More useful would be a urine "dipstick" method, preferably one that avoided the need for heating. The Parisian chemist Jules Maumené impregnated a woollen strip with  $\text{SnCl}_2$  solution (1850). When dried, moistened with glucose-containing urine and heated over a candle flame, the metallic tin reduction product formed a black stain [15]. His strips never gained widespread use – we presume the heating was a drawback. Too little and a false negative would be recorded; too much, and you'd set fire to the wool or char it to blackness and record a false positive. In 1885 test kits devised by Harrogate physician George Oliver were marketed by the firm of Parke Davis & Co., now part of Pfizer Ltd. These contained filter paper strips impregnated with the dye indigo carmine and a base, presumably sodium carbonate. The kit

contained a test tube to which the paper and water were added, followed by the urine sample [15]. Again, heating was necessary. Glucose in the urine reduced the dye, now in aqueous solution, from its blue colour through purple, red and orange to yellow. The kits were available at least for a decade, indicating a measure of popularity, despite the need for a Bunsen burner.

Miles Inc., the firm marketing the Clinitest tablets, was aware of the drawbacks of their product. They asked their chief biochemist, Alfred Free, to devise a dipstick method for urinary glucose detection. He had recently married his colleague, Helen Murray, and together they formed a formidable research team [16]. In October 1956 they submitted a patent application that formed the basis of the Clinistix dipstick to detect glucose in urine. This was first marketed in 1956, presumably whilst the patent was under consideration, and they remained on sale for the next half century. They were based on a new urinalysis method that, unlike its predecessors, was specific for glucose rather than any sugar. This came from their use of the enzyme, glucose oxidase. This had been isolated in 1928 by a professor of botany, Detlev Muller, from the mould *Aspergillus niger*, a common contaminant of fruit and vegetables. The enzyme is stable and can catalyse the aerial oxidation of aqueous glucose to form gluconic acid and hydrogen peroxide (Scheme 1).



Scheme 1. The aerial oxidation of aqueous glucose

Essentially, the Miles' test uses this  $\text{H}_2\text{O}_2$  to oxidize an aromatic amine to form a coloured product. This reaction is slow, but can be catalysed by another enzyme, typically the peroxidase extracted from common horseradish. The amine of choice was *o*-tolidine which oxidizes to a blue-coloured charge-transfer complex [17], the intensity of which roughly correlates to the concentration of glucose in the urine. Some internet accounts state the amine is *o*-toluidine, but we presume that this

is an uncritically repeated mis-transcription. Free and Murray prepared a 20 cm<sup>3</sup> solution containing gelatin (100 mg), peroxidase (5 mg), glucose oxidase (200 mg) and *o*-toluidine dihydrochloride (200 mg). Paper or plastic strips, or wooden spills, were dipped into this mixture and dried. The gelatin may stabilize one or more of the components but it certainly has a glue-like action binding the chemicals to the strip. A pinkish dye may be incorporated to make the colour change appear more dramatic. Clinistix were marketed as *qualitative* tests for urinary glucose, but a 1964 study showed that a perceptible colour change correlated to an average concentration of 0.244 g/100cm<sup>3</sup> urine and an intense purple colour to 2.640 g/100 cm<sup>3</sup> urine [18]. They were progressively withdrawn from the market from 2000, perhaps because the incorporation of *o*-toluidine, a possible carcinogen, presented a hazard to the manufacturing workforce. They have been replaced by Diastix™ dipsticks which work on the same principles, but replace the amine with potassium iodide. The H<sub>2</sub>O<sub>2</sub> (+ peroxidase catalyst) rapidly oxidises the iodide ion to elemental iodine, and the intensity of the associated brown colour can give a semi-quantitative indication of the concentration of urinary glucose [19].

### Technology and the Treatment of Diabetes

The holy grail of diabetes management is to mimic the body's exquisitely sensitive homeostatic control of blood sugar through pulsed secretion of insulin.

Direct measurement of blood glucose in the home setting was developed in the 1970s using electrochemical methods. Trials demonstrated how this improved blood sugar control, and home glucose monitors became available from the early 1980s. The user stabbed their finger with a needle or lancet to produce at least one drop of blood and touched it to a disposable test strip that sucked up a set amount of blood by capillary action. The meter then produced a reading after a minute or less. Of course, this had to be repeated to track variations in blood sugar during each day. People's tolerance for repeatedly stabbing their increasingly callused fingers meant these tests were done a few times each day at best, so monitoring remained intermittent. Another problem was people's reluctance to alter the 'routine' dose of insulin prescribed by the doctor, for fear of inducing a hypoglycaemic episode.

Another advance during the 1980s was the widespread introduction of measuring glycosylated haemoglobin (HbA1c) which provides a measure of the average blood glucose over the preceding 8-12 weeks, complementing the episodic measures from home glucose monitoring.

The next major step was the development of continuous glucose monitoring. First available in 1999, initial systems lacked precision and were cumbersome. However, in 2011 the FDA approved the Freestyle Libre flash glucose monitor. This is a small sensor stuck to the patient's arm. It has a very thin needle penetrating a short distance below the skin that allows measurement of the glucose level in intercellular fluid (closely correlated with blood glucose). Readings are sent to an external meter by Bluetooth. The sensors can be safely worn in the shower and their batteries last two weeks, when the unit is replaced. Blood sugar levels can be read at any time, providing a much more detailed picture of blood sugar variation during the day. It has been a particular boon for parents of young children with diabetes, as they can monitor blood glucose at will, even when their child is asleep, without the trauma of a finger-prick test.

The next step was to link continuous monitoring to continuous insulin infusion. The first such system was developed in 1963 by Dr Arnold Kadish, although the pump was the size of a modern microwave and had to be carried in a backpack. These have developed dramatically since, particularly in the last decade or so. There are a range of integrated close-loop devices, some attached with adhesive patches that minimise the impact of the device on the user's daily life. They come close to mimicking the function of the natural pancreas. Their sophistication and reliability continues to evolve, and they are effective in Type 2 as well as Type 1 diabetes.

There has also been interest in transplanting pancreatic islet cells (the cells that make insulin) as a treatment for diabetes. Although there have been encouraging results, the requirement for long-term immunosuppressive treatment and the side-effects of this, and the limited supply of donor cells, mean this remains an experimental treatment. For now, it seems technology is outpacing 'nature'.

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Alan Dronsfield and Pete Ellis

(Pete Ellis is a retired medical practitioner based in New Zealand)

### ***Onfang fun Khemye: The First Chemistry Book in Yiddish***

Chemistry literature in European languages is well-known - only if serious research is performed in those languages, such as English, French, German, Italian, Swedish, and Russian. When speaking of chemical literature in *minority* languages, such books are rare. Yiddish, as a minority language spoken by people whose ability to enter higher education was suppressed, is an excellent example of relative rarity of scientific literature, including chemistry [1].

The Yiddish language may be classified in two distinct ways: (1) linguistically as a Germanic language, descended from *Mittelhochdeutsch* and developing for about a millennium in parallel with modern German; (2) sociologically as one in a set of Jewish languages, all of which are primarily spoken by Jews, and are written with the Hebrew alphabet. Other examples of Jewish languages are Hebrew, Aramaic, Dzhudezmo (Judeo-Spanish), Tsarfatic (extinct Judeo-French), and Yevanic (extinct Judeo-Greek). Yiddish-speaking Jews currently are those primarily whose ancestors came from central and eastern Europe.

Because access to higher education among central and eastern-European Jews was drastically limited, Yiddish literature in science was lacking until the close of the nineteenth century, when the Enlightenment finally began reaching the Russian Empire, and also when the great migration of Jews from Russia to North America was reaching its peak [2]. Jews in Eastern Europe were not illiterate; there was a consistent effort to give basic instruction in reading Biblical and some Talmudic Hebrew plus Yiddish to boys, as well as some Yiddish to girls. This essay concentrates on the first known chemistry book in Yiddish, *Onfang fun Khemye* (Introduction to Chemistry), by Dr Abraham Caspe, which I mentioned in this newsletter in 2014 [3]. All Yiddish text in this essay is transliterated into Roman characters as per YIVO standardization rules [4].

דיא אינטערנאציאנאלע ביבליאטעהק.

Caspe, Abraham, 1811-1929

אנפאנג פון כעמיע

צווייטע אויפלאגע

Onfang fun Khemye



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פון ד"ר אב. קאספע.

Fig. 1. Title page of Abraham Caspe's *Onfang fun Khemye* (image provided by Stephen M. Cohen).

*Onfang fun Khemye* (2<sup>nd</sup> edition) was published in 1900 by The International Library Publishing Co. in New York, USA [5]. It is a short book, sixty-six pages, designed for self-learners without formal higher education, with five chapters: *Der Onfang fun Khemye* (the beginnings of chemistry), *Di Tsvey Elementn fun Vaser* (the two elements of water), *Vi Azoy Vaser Vert Bashafn* (how water gets made), *Natryum un Kalyum* (sodium and potassium), and *Ftor un Khlor* (fluorine and chlorine). (See Fig. 1.)

Chapter 1, the beginnings of chemistry, summarizes briefly the history of chemistry to the mid-nineteenth century. It includes topics such as ancient Greek four-element theory of matter; Robert Boyle's definition of "element;" Lavoisier's understanding of oxygen and combustion; and Berzelius's standardization of names and symbols of elements. Of course, with no scientific access - but plenty of traditional Jewish learning - readers are given an interesting definition of "element". Caspe used the Hebrew term יסוד *yesod* to explain an element [6], and supplies the following footnote: "Aristotle's beliefs ruled during the course of the entire Middle Ages. They affected the thoughts of the *Tannaim* and *Amoraim*, who, as is known, also said that everything in the world consists of *Esh, Mayim, Afar, Ruach*" [7].

Caspe also uses charged language for medieval alchemy: "The people of those days often used to bog themselves down with such holy words which contained essentially no explanation concerning the questions which interested them. Over the course of many hundreds of years they, for example, bogged themselves down with the empty word [*dem pustn vort*], in this way on all important questions. 'Why is this?' to which they answered 'God made it this way', and thereby told themselves that their difficult questions [*kashes*] really were already truly answered" [8].

Caspe inventively introduces ideas of modern chemistry in Chapter 2 by discussing the composition of water—thus making chemistry immediately accessible to the average person. In Chapter 2, he covers elemental analysis of compounds, and then the reaction of water with sodium to show how basic chemical observations work: appearance, feel, taste(!), sound, use of a match to test flammability, and litmus paper to test acidity and alkalinity. He asks the readers to try this at home: he notes that sodium metal is available in any chemist's shop for \$1/lb. [9] (later he prices sodium at \$0.20/lb.) [10]. Caspe includes a diagram of a simple gas-collection apparatus so that the reader can collect hydrogen gas [11]. (See Fig. 2.) Then he concludes with reactivity of metals and non-metals with oxygen. The methods to

separate elements he lists as: purely physical (heat or electricity), purely chemical (Na contacting  $H_2O$ ), and chemical with assistance from physical (heating which materials are mixed). Only in passing does he mention a “new” spectroscopic method—but gives the caveat that this is used only for rare elements, and hence unnecessary for further discussion [12].

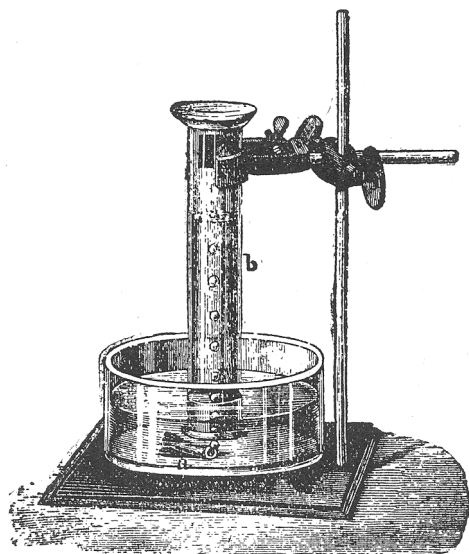


Fig. 2

Fig. 2. Gas-collection apparatus from *Onfang fun Khemye*, page 20 (image provided by Stephen M. Cohen).

Chapter 3 is chemically the “opposite” of Chapter 2: synthesis instead of analysis. Caspe talks of synthesizing new compounds, for example  $H_2$  gas, and ways to synthesize water. A diagram shows how to synthesize water from gaseous  $H_2$  and  $O_2$  plus an electric spark [13]. (See Fig. 3.) Caspe introduces the idea of metals as an opposite of non-metals. Metals combine weakly with other metals and mix; non-metals combine to create non-metallic substances; metals and non-metals combine powerfully to create other substances. As a better classification of elements beyond metals versus non-metals he introduces Mendeleev’s Periodic Table of 1869.

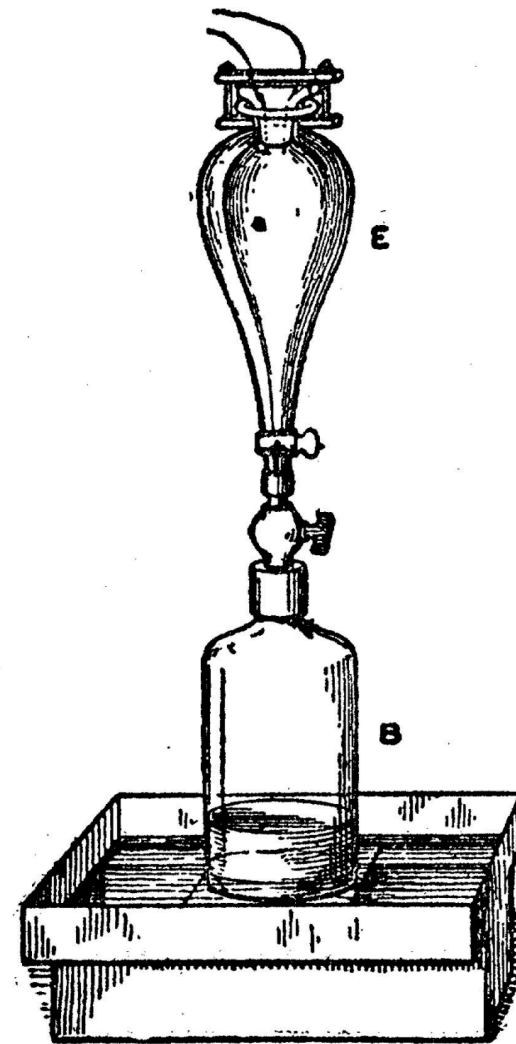


Fig. 3. Synthesis of water from *Onfang fun Khemye*, page 33 (image provided by Stephen M. Cohen).

Chapter 4 delves deeper into metals by discussing prototypes sodium and potassium. Thereby he introduces geochemistry, and that salts are combinations metals with non-metals. He adds biochemistry: that plants

need potassium solutions more than sodium solutions for growth. Then he discusses electrochemistry, and the construction of a  $\text{Cu}|\text{Zn}|\text{H}_2\text{SO}_4$  galvanic cell, the purification of sodium metal, and finally various properties of potassium and sodium salts.

Chapter 5 is a short chapter, dealing with properties of non-metals. Here he talks about fluorine and chlorine, their properties, and their uses. He makes a point of mentioning Moissan's recent isolation (1886) of fluorine as a highly reactive gas.

Because Yiddish developed outside of the technological world, Yiddish chemical terminology was lacking at the time Caspe wrote his book. Thus the language he used was heavily influenced by its closest linguistic relative, German. We note that German was of high prestige in the scientific world at the time, *and* of high prestige in the Jewish world; Yiddish was often considered a debased or degenerate form of *Hochdeutsch*, to the point that Yiddish was sometimes referred to (by Yiddish-speakers) as *zhargon* (jargon) [14]. In this cultural and scientific milieu, it is easy to see why Caspe used Germanicisms such as *fabrikatsyon* instead of Yiddish *fabrikatsye*, *um* instead of *kedey* (from Hebrew), and *vehrend* (German *während*) instead of *beshas* (also from Hebrew). From Russian *фтор* he borrowed the word *ftor* to name fluorine. There is American influence in his language, perhaps to appeal to the assimilating immigrants, in his use of *trobl* (trouble) instead of Hebrew-derived *tsores*, and even *londre* for a laundry.

Born as Avrom Mints in Cherykaw, Mogilev Gubernia (now in eastern Belarus) in 1869, Caspe studied at a traditional yeshiva (hence his familiarity with traditional Jewish terminology), and then at a secular *gimnazyum* (high school) in Vilnius. In 1882, he emigrated to the USA as a member of the failed *Am Olam* agricultural colonists [15], then returned to Russia in 1888, where he was lucky enough to be accepted to the science/mathematics faculty of St. Petersburg University. After graduation, he re-emigrated to New York in 1894, where he received a medical degree (hence his books all note his name as "Dr"). Seeing the miserable sweatshop and tenement conditions, he often treated patients at no cost. Meanwhile, he became science editor for the left-wing *Forverts* (German *Vorwärts*) newspaper. He wrote a variety of science books (chemistry, physics, and geology) for self-instruction, between 1900 and 1920. He became heavily involved in the socialist movement till he died in New York in 1929 [16].

Starting at this time, Yiddish self-instruction in topics formally available only to those with a secular education appeared, including science,

hygiene, history, and politics. But the non-Jewish world also had similar types of books for the layperson. For example, in chemistry, there were the long-running updates to Jane Marcet's *Conversations on Chemistry*, starting in 1806 [17], and Michael Faraday's *Chemical History of a Candle* (1861) [18]. Probably much more familiar to Eastern-European-educated Caspe was Aaron Bernstein's *Aus dem Reiche der Naturwissenschaft* (1853–6, later reprinted as *Naturwissenschaftliche Volksbücher*, 1880). Even Bernstein's work was translated into Yiddish - starting in 1909, well after Caspe's *Onfang fun Khemye*. [19] Also likely known to Caspe was Stöckhardt's *Die Schule der Chemie* [20], eventually translated into many languages, but not in Yiddish until 1923, based on revisions by Lassar-Cohn [21].

Caspe introduced Mendeleev's Periodic Table of 1869–72, but shortly thereafter, van't Hoff and Le Bel explained chirality in 1873, Gibbs proposed free energy in 1876, and Arrhenius developed his theory of ionic solutions in 1883—none of which appear in the book. Nor did Ramsay's discovery of noble gases in the 1890s, nor Werner's octahedral structures of complexes. The idea of physical chemistry as a discipline congealed in 1887—and again, these three latter topics were not mentioned. Hall and Héroult independently patented cheap aluminum in 1886—which *is* discussed. The earthshattering discoveries of radioactivity and the electron in 1896–7 are unmentioned.

Caspe refused to use the terms atom and molecule. He took great pains to describe equivalent amounts of compounds, rather than explain via atomic or molecular theories. Caspe learned his science at St. Petersburg University, where Mendeleev was Professor until 1890 [22], and presumably heavily under Mendeleev's anti-atomistic, conservative influence [23]. Nineteenth-century chemistry often referred to chemical atoms as a convenient form of bookkeeping in reactions, but physicists rejected this because of lack of relatively direct experimental evidence [24]. Caspe (like many nineteenth-century scientists) perhaps didn't want to be drawn into the controversy over physical versus chemical atoms, largely settled only in 1905 after Einstein's explanation of Brownian motion. Aqueous solutions in Caspe's book are devoid of ions—which necessarily requires atoms and molecules. Finally, much of the book describes elements as either metals or non-metals *à la* Berzelius. Thus we can say that *Onfang fun Khemye* is a conservative publication, not willing to speculate on new chemical ideas.

The book's publisher, The International Library, was forthright about its radical leanings. Among its titles (in the catalogue at the back of the book) were anarchist Philip Krantz's writings; the liberal poet Yehudah

Leib Gordin's *God, Human Being, and Devil*, and *Walter: His Biography*; Caspe's own science books: *Mechanics, According to Sir Isaac Newton*, and *Astronomy*; Leo Tolstoy's *Patriotism and Government* and *The Only Way*; Maxim Gorky's *Explanations*; revolutionary poet Morris Rosenfeld's *Collected Songs*; and a variety of biographies of traditional Jewish leaders. Why would science be included in a catalogue of radical leftist works? Because to the political left in that era, science was a deliberate break with traditional learning, ascribing worldly phenomena to a clockwork, Godless world.

**Acknowledgements:** I thank Ri J. Turner of the Parisian *Bibliothèque Medem - Maison de la culture Yiddish*, and Amanda Seigel at the New York Public Library for pointing me toward some important source material, and Dr Mara Cohen Ioannides of Missouri State University (Springfield, Missouri, USA) for the impetus to investigate this topic.

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Stephen M. Cohen

### Edwin Ernest Jelley (1898–1965)

Edwin Jelley was born on 2 November 1898 in Darnall, Yorkshire, England. Darnall is now a suburb of eastern Sheffield, about three miles (five kilometres) east-north-east of Sheffield city centre. Edwin's parents were Christopher (b. 1872) and Mary Lizzie (b. 1876) and he had an older brother John Bertram (1894–1977) [1]. A younger brother, Christopher, was born in 1902 and, following a move to South Africa, a sister, Edith, in 1908.

Between 1915 and 1925, Jelley was employed as Chemist and Works Manager in the Natal Sugar Industry at Malvern [2], which is now a suburb of Durban. Malvern was renamed Queensburgh in 1952. Natal Province was renamed KwaZulu in 1977 and then changed again to KwaZulu-Natal in 1994.

Jelley returned to England in 1924 and was a Photographic Technician at Kodak Limited in Harrow between 1926 and 1928 before being promoted to Research Chemist.

In 1933, Jelley, already an Associate of the Institute of Chemistry, AIC, was recommended for Fellowship of the Chemical Society, and elected [2]. By then, Jelley had been awarded a BSc degree in Chemistry (London, 1st Class Hons.). In 1934, he was awarded a PhD degree by the University of London for his thesis "The Constitution of Thiostannates". These researches were published in the *Journal of the Chemical Society* [3,4]. By 1936, he had added FRMS (Fellow of the Royal Microscopical Society) to his qualifications [5].

He visited Eastman Kodak in Rochester, N.Y., between October 1934 and January 1935. Then in August 1935, travelled to Cape Town in South Africa to give a series of talks on Kodak research activities. As he was preparing to speak at a meeting in Durban, a young man greeted him with "Hello, Edwin, how's everything in England?". Jelley did not have a clue who the young man was but after the meeting he revealed that he was Christopher, his younger brother, who he had not seen for many years and claimed that he had driven in some hundreds of miles "to give him a surprise". "I got one", Dr Jelley agreed [6].

Evidence of his interest in photographic matters while at Malvern, was provided when he filed a six-page long patent for a photographic sensitizer in 1924 [7]. His early publications while at Kodak included "A Sensitive Test for Thiosulphates" in 1929 and "A Cause of Yellowness in Sepia Toning" in 1932 [8,9]. It has been reported that the first research report ever produced by the Harrow Research Laboratory was made by Walter Clark and Edwin E. Jelley, dated 12 January 1929 and entitled the "Investigation of removal of dye from red-backed and green-backed Cine Kodak film" [10]. The majority of publications up to 1940 concerned applications in microscopy and a collection of his photomicrographs of crystals and dyes from the 1930s can be seen at the George Eastman Museum in Rochester, N.Y. [11].

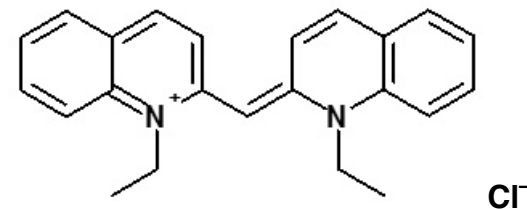


Fig. 1: 1,1-diethyl cyanine chloride

The publication which gained most attention appeared in 1936 [12]. He observed that solutions of 1,1-diethyl cyanine chloride (see Figure 1) in ethanol showed two broad absorptions at 488 nm and 526 nm. But in a water solution, a new sharper absorption appeared at 571 nm which was intensified by the addition of sodium chloride. By 26 March 2021, the paper had been cited 1514 times. Twenty-first century authors still like to illustrate the observed effect [13,14]. Crystallographers have investigated the molecular structure of the cation with a variety of anions, e.g., the 1,1-diethyl cyanine chloride hydrate (Figure 2) [15]. The cause of the behaviour in aqueous solution is due to molecular aggregation and is now referred to as J-aggregation after its discoverer.

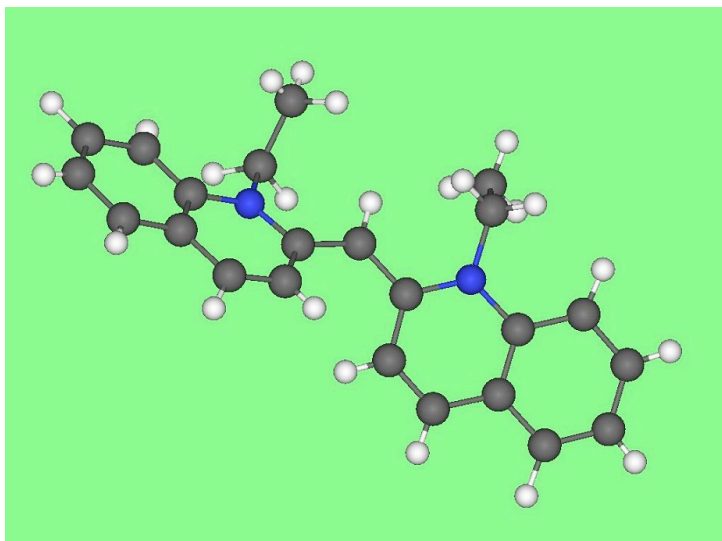


Fig. 2: 1,1-diethyl cyanine chloride hydrate

Jelley visited Eastman Kodak in Rochester, N.Y., again between April and June 1937 and finally moved there in December 1938. On 29 July 1939 he married Violetta Yiull who was born in Wales about 1911 [16].

After 1940, Jelley focussed on his interest in the microphotography of crystals by giving talks at meetings and collaborated over the next decade with other Eastman Kodak employees to obtain US patents for photography related products.

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Chris Cooksey

## BOOK REVIEWS

Dan Kaszeta, *Toxic: A History of Nerve Agents from Nazi Germany to Putin's Russia* (London: C. Hurst & Co, 2020). Pp. xvi + 379 pages, ISBN: 9781787383067, £25.00 hardback.

The organophosphorus chemical warfare agents (often called "nerve gases" although they are actually viscous liquids) took the Allies by surprise when they found them during the invasion of Germany in 1945. An unexpected offshoot of IG Farben's research on organophosphorus insecticides (which produced parathion), these chemicals were further developed by both sides in the Cold War. They sprang to public attention when Sarin was used by the Aum Shinrikyo cult in the Tokyo subway in 1995, with the death of thirteen commuters. Sarin was also used twice in the Syrian Civil War. Since then, nerve agents have been mostly used for assassination purposes. VX was employed to kill Kim Jong-nam in Malaysia in 2017 and Novichok was used in Salisbury a year later. The intended victim Sergei Skripal survived, but Dawn Sturgess died. More recently, in August 2020, the same nerve agent was used against Russian dissent Alexei Navalny, but he also survived.

The author of this book is a former American soldier and a chemical weapons expert rather than a chemist or a historian, but his bibliography is formidable. It even includes a paper given at an International Conference on the History of Chemistry (ICHC) meeting. He cites *A Higher Form of Killing* by two famous journalists Robert Harris and Jeremy Paxman (it is a good book), but not Florian Schmaltz, *Kampfstoff-Forschung im Nationalsozialismus* (in fact he seems to have used only one non-English language book). *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany* by John Gimbel is also missing. Dan Kaszeta has made good use of the material at the National Archives at Kew, but appears to have been unaware of the BIOS archive at the Imperial War Museum at Duxford. The net result is a book which is written in a popular style and is easy to read with many interesting facts. The key actors were the Americans and Russians, with the British and surprisingly the Swedes as the supporting

cast. The Russians lagged badly behind the Americans until the 1970s, partly because the Russian programme was fed erroneous information by the Americans (and possibly by the Germans). A final chapter summarises the work on nerve agents elsewhere. There are two interesting commonalities across the board: the difficulties in scaling up Sarin production and the desire for a persistent nerve agent (Sarin soon evaporates and degrades), which led to the development of VX and Soman. There are also chapters on the use of nerve agents in Iraq, Iran and Syria, the Tokyo attack and their use in assassination. There is a chapter on the psychological effects of nerve agents. I would have liked to have read more about the ethical aspect of nerve agent production and deployment (they are usually claimed to be for deterrence like nuclear weapons).

From my perspective as a historian of IG Farben, the most relevant part is the German development of nerve agents. Kaszeta gives a very detailed account of the development of nerve agents in Germany. It is generally accurate enough although I sometimes feel he does not always understand the context. He makes the intriguing suggestion that IG Farben's Otto Ambros was on the make and deliberately engineered new jobs for himself which is a characterisation I do not recognise from my own research, but will have to consider. That said, Kaszeta does not seem to understand Ambros's position in IG Farben – he was a member of the main board (Vorstand) and even suggests at one point that his boss was the sales director Georg von Schnitzler (earlier in his career, it had in fact been the technical director Fritz ter Meer). As a chemical weapons expert, Kaszeta convincingly shows that it would have been impossible in practical terms to deploy Tabun as a chemical weapon in the closing stages of the war, so the development of nerve agents probably was a waste of time (as Speer believed), but of course other major powers have invested heavily in nerve agents ever since. Kaszeta claims that the money spent on nerve agents would have been better spent on synthetic fuel or synthetic rubber. It is not clear if money was the main problem with synthetic fuel or synthetic rubber, but certainly the trained chemists and materials (e.g. stainless steel) thus liberated could have made a difference as they were major bottlenecks for synthetic rubber. It would have also allowed Ambros to concentrate on synthetic rubber, whilst diversions such as nerve agents may explain why he was less successful with synthetic rubber during the war than beforehand.

This is very much a soldier's and a chemical weapons expert's book on nerve agents. It is very interesting, but one wonders what the audience

for this book really is. It is not really aimed at the academic market (whether they be historians, current affairs specialists or chemists) and probably not technical enough for specialists in this gruesome field. But it deserves to be read.

Peter Morris

Eric Scerri, *The Periodic Table: Its Story and Its Significance* (Oxford: Oxford University Press, 2020). Pp. xxvii + 472, ISBN 9780190914363, £25.49 hardback.

I reviewed the first edition of this book, published in 2007 by Oxford University Press, for *Ambix* in 2008. It then ran to 346 pages, so this edition has been considerably enlarged. There were ten chapters in that first edition and they have the same titles, though expanded in content, in this book, which has four additional chapters.

The Introduction lays out the scope of the book, and the first two chapters, “The Periodic System” and “Quantitative relationships among the Elements” concern the nuts and bolts of the Table, e. g. the development of the concepts of equivalent and atomic weights and related matters. In “Discoverers of the Periodic System” the pre-Mendeleevian classifications of de Chancourtois (1862), Newlands, Odling, Gmelin, the often-forgotten and enigmatic Hinrichs, Lothar Meyer and others are discussed at some length. The following chapter concerns Mendeleev alone: the many versions of his table - thirty published and thirty in manuscript form - and their evolution are well described. His defining table of 1871 accommodated the sixty-four elements then known, and its success was largely due to Mendeleev’s intimate chemical knowledge of them. His courageous assertions that some atomic weights (e.g. tellurium vs. iodine etc.) were “wrong” because they ran against the perceived periodic order are considered, and particularly his predictions of new elements. The predicted properties of three - scandium, gallium and germanium - were given with astonishing accuracy. The question of whether it was the success of these and other predictions or of element accommodation which led to the widespread acceptance of his table is discussed. The next five chapters, beginning with “The Nucleus and the Periodic Table”, take us beyond Mendeleev, discussing X-rays, radioactivity, atomic numbers (a concept originated by Newlands in 1865 but without realisation of its fundamental significance), isotopy, transmutation, and other topics. The contributions of van den Broek and Moseley to atomic numbers, of Bohr, Stoner and Pauli to the structure of the atom and of G.N. Lewis, Langmuir, Bury and Main Smith to the theory underlying the table are

discussed as is the importance of quantum mechanics to periodicity. The tenth chapter, “Astrophysics and Nucleosynthesis”, takes us into the fascinating area of how elements are formed in Nature: Fred Hoyle’s theories are particularly well described.

The first of the additional four chapters in the new edition concerns the seven last infra-uranium elements to be discovered (protactinium, hafnium, rhenium, technetium, francium, astatine and promethium). “Synthetic Elements” follows - an account of elements 93 (neptunium) through to 118 (oganesson). I was pleased to see in this the frequent use of nuclear equations for their formation, rarely cited in other accounts of such ‘superheavy’ elements. The penultimate chapter concerns a selection of “Forms of the Periodic Table” and there is a final roundup of some chemical matters.

This is a useful, wide-ranging book, replete with useful information. Historical aspects are better covered here than they were in the first edition, and the index is much improved. The book is attractively produced, as one would expect of Oxford University Press, and the price has been kept very low (the smaller 2007 first edition cost slightly more than this substantially larger second edition). Highly recommended.

Bill Griffith

François Jarrige and Thomas Le Roux (tr. Janice Egan and Michael Egan), *The Contamination of the Earth: A History of Pollutions in the Industrial Age* (London: MIT Press, 2020). Pp. 440. ISBN: 9780262043830, £32.00 hardback; Pp. 480. ISBN: 9780262542739, £15.99 paperback.

The historiography of pollutants contaminating the planet is very extensive and has markedly expanded over the last decade or so as pollution has advanced and been held responsible for an increasing number of deaths worldwide. So what is the contribution of Jarrige and Le Roux’s *The Contamination of the Earth. A History of Pollutions in the Industrial Age* to our understanding? Much of the published scholarship has addressed pollution of either the air, the water or the land, or a particular pollution episode, or a particular industry, or an individual pollutant or have emphasised the public health concerns. In contrast Jarrige and Le Roux have taken a broad sweep across pollution of air, water and land over the time period 1750 to the early 1970s, a critical period for the phases of industrialization that were evolving across the world.

The book is divided into three parts, each covering a particular time period, 1700–1830; 1830-1914 and 1914-1973. Each part contains chapters that explore the advance of different industries and the resultant loads of pollution, the influence of wars with their unique demands on industry, the changing political and cultural outlooks on pollution, the adoption of regulations, and technical advances for controlling pollutants. While the narrative is driven by industrialization in France, Britain, other European countries and the USA, a serious attempt is made to address industrialization in emerging industrialised countries in Central and South America, Africa and Asia. Where appropriate regulation is reviewed at the regional, national and international level, and some of the pivotal environmental legislation and regulatory authorities are discussed.

It is unrealistic given the available space to deal with all contaminants but the book focuses in the main on those arising from the utilization of coal, petroleum, natural gas and metals, and from chemical manufacturing. Account is taken of how different countries adopted these industries at different times reflecting their stage of industrialization and available resources, though little attention is given to whether countries took account of lessons learned from earlier industrial exploitation. Industrial enterprises that regularly pollute not just one component of the environment but two or even three are fully described where appropriate.

The research underpinning the book is remarkably extensive. Although many of the sources are French to reflect the strong French content to the narrative, this is not to the detriment of the book overall since there is a good balance with other sources. The book also draws on very useful statistical data to illustrate many of its key points. There are eight-four pages of notes with a wide range of sources to form the basis for further reading and research. The index is also very thorough allowing ready access to a particular topic or theme.

At over 400 pages for the hardback, it is a long but worthwhile read since its broad approach provides a valuable insight into the many different perspectives associated with the earth's contaminants in all their forms that is not available in any other book. A few of the book's attributions for responsibility could be challenged but this is a minor criticism for overall this is a very good book. The book's translators should also be complimented on the sensitivity and quality of their translation that adds to the book's readability.

The book is thoroughly recommended to all those with a specialist interest in the chemical contamination of the environment, as well as those seeking an insight into the associated political and cultural contours of regulation and public health. Teachers in higher education might find individual chapters serve as good study aids for class discussions and further research.

Peter Reed

Barry J. Oliver, *Ludwig Oertling, Balance-Maker: The Man, His Company and its Products* (Leicester: Microgramme, 2020). ISBN 978-1-5262-0842-2 and in two formats, complete book as a PDF on DVD-ROM (982 pages) and an abridged printed hardback book (ca. 600 A4 pages). Ca. 100 illustrations in all. £30.

As is often the case, chance played a critical part in Ludwig Oertling's early career. Born in Mecklenburg-Schwerin in 1818, he trained as an instrument maker in the workshop of his elder brother, before becoming a journeyman in order to gain wider experience, as was the custom at the time. He came to London in that capacity with the intention, most likely, of staying a couple of years, except that Cupid had different ideas. Then, in fairly short order, two of London's leading instrument and balance makers died, creating a substantial opportunity at a time when the market for scientific instruments and balances especially was growing rapidly. It is self-evident from his achievements that Oertling had all the qualities needed to step up and meet the burgeoning demand, the not least of which was an eagerness to improve and innovate: his early balances built upon many of the best features of Continental and English practice and incorporated inventions and improvements of his own. The company he founded, which traded from 1846-1996, soon became the world's leading balance maker and in all it made ca. quarter of a million balances in its 150 years of existence.

The sub-title of "The Man, His Company and its Products" tells you concisely what the book is about, in good part. Two versions of the book are offered: a complete version as a PDF on DVD ROM and a shorter version, shorn of balance collector's reference material and many appendices of tables etc. in order to keep down the cost and size of the hardback. The work as a whole, is divided into three parts, with titles as follows, and where I mention too the four broad sections that make up the bulk of the printed book itself.



Part I – 150 Years of Fine Balance Making (*Printed Book & PDF version*)

Historical

Technical

Commercial

Associated Companies Brief Histories

Part II – The Collector's Vade-Mecum (*PDF only*)

Part III – Valedictory Observations (*Both*) & Appendices (*PDF only*)

Mr Oliver claims that the work is a culmination of more than twenty-five years effort, much of it full-time; also that his researches made use of several hitherto untapped sources, including interviews with many former Oertling staff. The decision to leave all of part II and most of part III out of the printed book was, cost considerations apart, motivated by a desire to make the printed book accessible to the more general reader of science history, whilst still meeting his objective of producing "An Encyclopaedia of Everything Oertling" to satisfy collectors and serious students. I am neither a scientific instrument historian, nor a balance collector, and hence I read the book purely out of general interest, albeit as someone old enough to have used several examples of both 'traditional' two-pan and 'modern' single-pan balances, in my time, including, in 1966, a beautiful old, but, pristine brass five-place balance that I can still call to mind very vividly. I can thus only comment on the book from the point of view of an ordinary chemist having a general interest in science history. I would say nevertheless that Mr Oliver looks to have succeeded in making the work dual purpose, inasmuch that I had little difficulty in reading Part I, even if I only scanned Parts II and III. The printed book does rather look a little formidable at first sight, with its 600 or so A4 pages and near 3Kg weight, except that it is printed in a large font (12 Pt Georgia), with what looks like 1.5 line spacing, making it very undemanding on the eye. The other decision Mr Oliver has taken in order to make the book accessible is to offer it at the affordably low price of £30. At that price it might not matter too much to some purchasers if the Collectors Vade-Mecum is irrelevant and if, say, the Commercial section was to be of less interest than the Historical or Technical, as I confess it was to me.

The story of Mr Oertling and his company to be found in part I is likely to appeal to almost anyone interested in the history of chemistry, given all that the balances have enabled over the years and given their attractiveness as artefacts. I found the parts I read, by which I mean Part I, the Valedictory Observations and some selected appendices to be well-written and very readable, not least because of Mr Oliver's

admirably economical and to-the-point style, with its use of short sentences wherever possible.

Mr Oliver is to be congratulated on the huge effort needed to collate and present as much as can be known about Oertling and his dynasty, legacy and company, in my view. I say 'as can be known' because it seems that two significant archives, one family and one company, were lost or destroyed in the mid-twentieth century, something that even someone as dogged as Mr Oliver could do little about.

From a personal perspective, I was interested to see that, like me, Mr Oliver is a Graduate of the Royal Institute of Chemistry: an increasingly rare breed who suffered the ordeal of a four-day practical examination, in which we very likely used Oertling balances, although they could have been Mettler, I suppose, as it is too long ago for me to remember.

Richard Buscall

The book is available directly from the author [barry.oliver@keme.co.uk](mailto:barry.oliver@keme.co.uk) – price £30 plus P&P. A two-page flyer can be found here:

<http://stanton-instruments.co.uk/A5%20Flyer%20-%20Oertling%20Book.pdf>

## **RSCHG MEETING REPORTS**

### **The Handed World - 150 Years of Molecular Chirality**

*Wednesday 13 October 2021, RSC Library, Burlington House, Piccadilly*

This meeting, postponed from 2020 because of Covid, celebrated the sesquicentenary (150 years) of molecular chirality. The RSC Historical Group could have chosen some years on either side; *our* sesquicentenary is of an idiosyncratic weighted average of events from 1860 (Pasteur) to 1874 (van't Hoff and Le Bel). The meeting was inspired in 2017 by Alan Dronsfield's observation that 2019 would be the sesquicentenary of Paterno's ball-and-stick representations of molecules including tetrahedral carbon (discussed below in this report). The postponement of the meeting from 2020 because of Covid did, however, make 2021 the precise sesquicentenary year of the publication of Lewis Carroll's *Through the Looking-glass, and What Alice Found There*. In this (published on 27 December 1871, not in "1872" as indicated inside the book), shortly before Alice jumps through the "Looking-glass" from the chimney-piece, addressing her cat Kitty, she speculates: "Perhaps Looking-glass milk isn't good to drink", and she

may be right at least in relation to the sugar lactose in the milk. In addition, the postponement meant that the meeting took place exactly a week after the award of the 2021 Nobel Prize in Chemistry to Benjamin List and David MacMillan “for the development of asymmetric organocatalysis”.

The Historical Group was pleased to welcome two members of the Lewis Carroll Society, one of whom, Dr Jane Skelly, a biochemist and editor of the scholarly journal *The Carrollian*, chaired the second of the three sessions of the day.

A list of seventy-six relevant historical characters is available at: <https://www.researchinip.com/20211013/0.2histfigs.pdf>

### **Introduction to the Day**

*Dr Michael Jewess (RSC Historical Group, Chair of the Meeting Organising Committee)*

Chemists in the nineteenth century achieved great feats of inductive reasoning. From purely macroscopic observations they drew conclusions that were confirmed in the twentieth century by means of observations on the atomic scale, for instance by X-ray crystallography. From Dalton early in the nineteenth century to Cannizzaro in 1860, reasoning from combining ratios, chemists concluded that molecules comprised known atoms in known numbers bound closely together. From 1860 to 1874, reasoning from optical activity, they created a picture of molecules in 3-dimensional space with known or knowable geometries. In particular, they concluded that a molecule in which a carbon atom was bonded tetrahedrally to four different groups could exist in two mirror-image forms. Each form was unsuperimposable on the other no matter how it was moved about in space, the phenomenon we now describe as molecular chirality. Consistently with Alice’s speculation, chirality matters to life; biological processes often, though not always, rely on and generate molecules in just one of two chiral forms.

### **Discovery of the Phenomenon of Polarisation of Light**

*Prof. John Steeds, FRS (University of Bristol)*

Over a period of 250 years, experiment led to our current understanding that light propagates in the form of transverse waves. The chief pioneers whose work was discussed were as follows: Hooke, Newton, Bartholinus, Christiaan Huygens, Malus, Arago, Fresnel, Foucault, Fizeau, Breguet and Maxwell. The key steps that led to this conclusion were described, together with the reasons why this conclusion took so

long in coming. Not only was Newton with his great authority in favour of a corpuscular theory of light, but also observations with polarised light (no interference when two beams linearly polarised at right angles were recombined) seemed to be against the wave theory so long as one imagined the waves to be longitudinal rather than transverse.

The three commonly used ways of generating plane polarized light (absorption, reflection, and birefringence) were discussed together with their use in creating left- or right-handed circularly polarized light. A particularly successful polariser operating by absorption is “Polaroid” invented and commercialised by the American Edwin Henry Land (1909-1991), who consciously modelled it on “herepathite” studied by the English physician William Bird Herepath (1828-1868).

### **Optical Activity – A Century of Perplexity**

*Prof. Alan Dronsfield (University of Derby)*

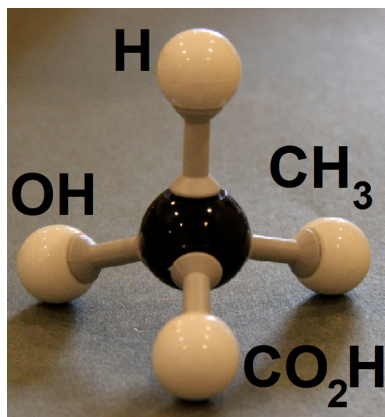
In 1809 Etienne Malus discovered that light reflected off a crystal of quartz was, to use today’s terminology, plane polarised. When this light was passed through a crystal of quartz, the light was rotated, sometimes in one direction, sometimes in the other and the direction of rotation was a characteristic of the crystal’s shape. Inexplicably (at the time) when the quartz was melted and allowed to resolidify this power to rotate light was lost. This was the first of many perplexities associated with the phenomenon of optical activity. Quartz’s behaviour was in contrast with that of barley sugar that showed the ability to rotate the light in the solid state, when molten, when allowed to resolidify and when dissolved in water to form a syrup. Further examples were soon identified which showed barley sugar behaviour, including a few which exhibited rotatory power even in the vapour state.

It was a further perplexity that laboratory-synthesised chemicals were always optically inactive. Those that were active were obtained from Nature. The behaviour of the two types of (visually different) quartz crystal pointed to a difference in underlying morphology or molecular structure, but this could not be extended to the molecular level until chemists agreed on what constituted a molecule, and further, how one was made up of constituent atoms and bonds. Alexander Crum Brown suggested molecular representations very close to today’s structural formulae and Auguste Hofmann used croquet ball models in his lectures, but only constructed his molecules in two dimensions. There is some evidence that Auguste Kekulé advanced the notion of the tetrahedral carbon atom, but he left it to his disciples to promulgate the idea. Emanuele Paterno drew 3D structures identical to those we use

today, but did not connect them to optical activity. This was left to the seminal (and independent) work of Le Bel and van't Hoff, from whom we get the notion of the "asymmetric carbon atom" and the idea that molecules whose mirror images are non-superimposable should display optical rotation in opposite directions. The applicability of these ideas was rapidly and extensively tested. Did the asymmetric atom have to be carbon? Could the idea of non-superimposable object and mirror image be applied to species that did not contain a formal "asymmetric" central atom? Can enantiomers exist for molecules that contain no carbon atoms at all?

Prof. Dronsfield concluded by looking at the history of attempts to achieve enantiomeric excesses by conducting syntheses in the presence of magnetic fields, including some of his own work in the 1990s. He then reviewed "fraudulent" chemistry more generally – including, in a light-hearted vein, that conducted in Adolf Baeyer's laboratory, around 1890.

*Dramatis Personae:* Jean Baptiste Biot, 1774-1862; Louis Pasteur, 1822-1895; Alexander Crum Brown, 1838-1922; Joseph Achille Le Bel, 1847-1930; Jacobus Henricus van't Hoff, 1852-1911; William Jackson Pope, 1870-1939; Alfred Werner, 1866-1919; Eberhard Breitmaier, 1931- present.



If, of the four H atoms of methane (white balls), three are replaced by different groups so as to form a lactic acid molecule, there are two ways of doing this: to form the molecule shown above, and to form its mirror image. Courtesy Michael Jewess.

## From *d* and *l* to *R* and *S*: Discovery of Absolute Configuration

*Prof. Henry Rzepa (Imperial College)*

The main actor in the prologue to this story is Emil Fischer, who in the 1890s set out on an odyssey to prove by chemical synthesis van't Hoff and Le Bel's famous 1874 hypothesis that for an organic molecule containing  $n$  asymmetric carbon atoms (carbons bearing four different substituents in a tetrahedral arrangement), there could be up to  $2^n$  three-dimensional stereoisomers. This in turn led to the development of Fischer's famous notation, a map-like projection from three into two dimensions applied to the carbon backbone of the linear forms of glucose and its fifteen stereoisomeric forms ( $2^4 = 16$ ), of which Fischer actually made twelve. Historical accounts however rarely note Fischer's remarkable proof in 1914 that if two different substituents on a tetra-substituted asymmetric carbon are transposed by chemical transformations without breaking any of the bonds to that carbon to produce a non-superimposable stereoisomer (a process equivalent to reflection of the three dimensional structure of the molecule in a mirror), the sign of the measured optical rotation (known as  $[\alpha]_D$ ) inverts but its numerical value is unchanged. Fischer thus set a formidable challenge; how to link the signed value of  $[\alpha]_D$  measured for an asymmetric molecule with the one or other of its mirror image forms. This became known as the problem of absolute configuration and is encapsulated in his reference molecule for sugars, D-(+)-glyceraldehyde. Here D is the (modern) notation for the absolute configuration of one of the mirror image forms (L being the other) and (+) is the sign of its measured optical rotation at the wavelength of sodium D-line (589 nm). Fischer's association of D with (+) was a pure guess. But how to prove this guess was correct?

Having thus set the scene, the main act of Prof. Rzepa's talk told of attempts by three later actors to respond to this challenge. The first notable attempt was by Werner Kuhn in 1936 and the next a most intriguing and largely unheralded effort in 1937 by John Kirkwood, both using the new theories of quantum mechanics which had been introduced well after Fischer's guess. The final denouement in 1951 was by Johannes Bijvoet using experimental crystallography and which finally proved Fischer's guess to be correct. Nowadays, the latter receives most of the credit, but was it an erroneous sign in his (1937) equations that resulted in Kirkwood's theoretical attempt being scuppered? Or was it that chemists (unlike physicists, *viz* Einstein predicting gravitational waves or Dirac predicting the positron) were not yet ready to trust theoretical over experimental verification? In his 1937

analysis, Kirkwood candidly sets out an important uncertainty in his linkage between the sign of  $[\alpha]_D$  and absolute configuration as being the flexible shape or conformation of the molecules. In this he prepared the stage for players such as Derek Barton in 1948 to formulate a Nobel prize-winning area of chemistry, conformational analysis. Only in 1952, a few months after Bijvoet's work, did Kirkwood report a way of side-stepping the conformational ambiguities of his original choice of molecule with a more rigid system, thus (independently of Bijvoet) verifying Fischer's guess. Bijvoet's assignment of absolute configuration to sugars, and by inference to amino acids, was rapidly accepted and in turn set the stage for two further Nobel-worthy scientific advances to be made at around the same time, the three-dimensional helical structures of some proteins and of DNA by respectively Pauling and Watson and Crick. Both discoveries relied on the absolute configurations of amino acids and sugars to infer, *inter alia*, the right-handed nature of the helical motifs in both proteins and DNA.

The epilogue to Prof. Rzepa's talk noted that although Fischer's stereochemical notation was a great advance, it applied only to sugars and was also associated with much confusion (such as two quite different meanings of the *d/l* notations). This problem was soon solved with articles written between 1951-56 by Cahn, Ingold, and Prelog (known affectionately as CIP). These changes in nomenclature, along with advances in representing the stereochemistry of molecules using line diagrams with perspective after the 1950s, mean that confidently comparing pre-1950s literature with modern CIP notations remains a challenge, especially when writing talks such as this one! The reader can see one part of this story retold at DOI: 10.14469/hpc/6368 with more detail.

*The cast:* Emil Fischer, 1852-1919; John Kirkwood, 1907 – 1959; Johannes Bijvoet, 1892 – 1980; Derek Barton, 1918 – 1998; Linus Pauling, 1901- 1994; Francis Crick, 1916 - 2004 and James Watson, 1928 – present; Robert Cahn, 1899 - 1981 and Christopher Ingold, 1893 - 1970 and Vladimir Prelog, 1906 - 1999 (CIP).

### **Molecular and Supramolecular Chirality**

*Prof. Giuliano Siligardi (Diamond Light Source Ltd)*

This talk gave an overview view of chirality, both in molecular and supramolecular terms, the tools to measure it, and the people who laid the foundations.

A molecule is said to be optically active or chiral or dissymmetric if it is not superimposable on its mirror image as firstly described in 1848 by Louis Pasteur (1822-1895). The configuration of D sugars and the L amino acids, the building blocks of terrestrial life identified by Fischer (1852-1919) recipient of 1902 Nobel Prize in Chemistry, have higher stability than their respective enantiomers (mirror images) due to parity-violating of the electroweak force established in 1956 by Lee and Yang, for which they were awarded the Nobel Prize in Physics (1957). This different stability, amplified through the vast timescale of the universe, has led to the terrestrial homochirality.

Chiral molecules rotate the plane of polarization of linearly polarized light, the variation with the rotation with wavelength being known as optical rotatory dispersion (ORD). Chiral molecules also absorb differentially the left and right circularly polarized light (CPL), this phenomenon being known as circular dichroism (CD). Modern CD instruments modulating the CPL with photo-elastic modulators can also measure ORD with appropriate modifications (Velluz, Grosjean and Legrand, 1965).

For small, flexible chiral molecules, the optical activity from electronic and vibrational CD must be calculated using quantum mechanical theory for all the stable conformations present in solution. This is now the method to assign the absolute configuration of therapeutic drugs as recommended by the Food and Drug Administration. For larger molecules like proteins, nucleic acids and chiral polymers, this is still difficult and expensive to accomplish. As the function and activity of proteins are directly related to their structure, the ability to characterise their conformational behaviour in solution as a function of environment (temperature, solvent and drug binding interactions) is invaluable information that can be used to verify the correctness of molecular modelling *in silico*. This combination is guiding the basic research that, when successful, has led to commercial applications. The pharmaceutical industry is an important example.

Supramolecular chirality is a younger research field of self-assembly of even larger systems that are observed in the solid state for organic optoelectronic and photovoltaic materials, nanocrystalline cellulose, and artificial retina that, if dissymmetric, can be studied with chiroptical spectroscopic techniques. Like for molecular chirality, the physical properties of materials are optimised if the supramolecular chirality is homogeneous. For example, the efficiency of optoelectronic and photovoltaic devices is maximised for specimens prepared with homogeneous supramolecular chirality.

However, these systems are more complex than those in solution because for solid-state the observed CD can have linear dichroism (LD), linear and circular birefringence (LB and CB) contributions hampering any CD analysis. Using the Mueller matrix calculus for manipulating the polarization states of light (Mueller, 1900-1965) these contributions can be extracted and quantified enabling the imaging of optical activity in the visible region pioneered by B. Kahr (2003) and in the UV region with the novel Mueller Matric Polarimeter (MMP) recently installed at B23 beamline of Diamond Light Source. Only with the MMP tool, the homogeneity of supramolecular chirality can be assessed and measured at higher spatial resolution guiding the optimization of the parameters to achieve reproducible specimens, which is the sine qua non for any commercial application.



“Perhaps Looking-glass milk isn’t good to drink”. From *Through the Looking-glass, and What Alice Found There*, by Lewis Carroll (1832-1898), illustration by John Tenniel (1820-1914).

### **Does the Right Hand Know What the Left Hand is Doing? - Chirality in Real Life**

*Dr Ian Blagbrough (University of Bath)*

Dr Blagbrough has an active interdisciplinary research group working in phytochemistry. This requires an understanding of the application of different aspects of handedness. Today it has been set out clearly and

elegantly, unambiguously and without room for contradiction that an optically active molecule is chiral and non-superimposable on its mirror image, as first described in 1848 by Louis Pasteur (1822-1895). Thus, the reflection of its three dimensional structure in a vanity mirror affords a different molecule, its enantiomer, which displays optical rotation equally, but in the opposite direction. This led on to the crucial building blocks of terrestrial life being determined as D-sugars and L-amino acids by Emil Fischer (1852-1919) in the 1890s. That such molecules have higher stability than their respective enantiomers is deeply significant for their biological activity. The plethora of chiral natural products and the importance of molecules arising from the pharmaceutical industry provide simple and then more complicated examples. Of course, handedness without receptors (proteins, DNA, RNA), did not speak to the conundrum that laboratory synthesized molecules were always optically inactive. Those that were active were isolated natural products. What of the molecule displaying handedness not only at chiral carbon atoms, but by its three dimensional helical structure, e.g. proteins (Linus Pauling), DNA (Francis Crick and James Watson)? Such natural helices were initially determined to be right-handed, but then left-handed examples were shown. This interconversion was (perhaps of course) shown to be biologically important.

*The chemical cast:* barley sugar, glucose, fructose, sucrose, lactate, alanine, glutathione, LLD-ACV, penicillins, cephalosporins, monobactams, microcystins, brevetoxin, oranges and lemons, spearmint and dill, thalidomide, ibuprofen, dexibuprofen, handedness in DNA with respect to RH and LH helices for packing and unpacking.

*The players:* poisonous plants, beneficial plants, bacteria, fungi, algae, venomous animals.

Michael Jewess and John Hudson

## **RSCHG WEBINAR REPORTS**

### **A Century of Global Synthetic Ammonia: 1921-2021 – Anthony S. Travis (September 2021)**

Following the tremendous success of BASF’s Haber-Bosch process for synthetic ammonia during World War I, great efforts were made outside of Germany to introduce similar processes. After the cessation of hostilities, as BASF was in no mood to license its strategically important process these efforts intensified. The first success was achieved by the Italian chemist Luigi Casale, who in April 1921



founded Ammonia Casale SA in Lugano Switzerland. Casale's process paved the way for the global spread of synthetic nitrogen technologies. By around 1930, eight novel processes were in use, all based on the high pressure catalytic combination of nitrogen and hydrogen. This presentation summarised the international growth of the industry, including the feedstocks for production of pure hydrogen, the impact of World War II, the role of engineering contractors, the tripling of converter capacities in the 1960s, as achieved by M.W. Kellogg, the contribution to the Green Revolution, the use of ammonia as an instrument of negotiation during the Cold War, and innovations such as those introduced by ICI, and Ammonia Casale.

**Ordeal Beans: Both Therapy and Poison - Ann Ferguson** (October 2021)

One of many ordeal poisons is a bean, used in Calabar in Nigeria. The discovery of this bean, its introduction and investigation in Edinburgh and its subsequent history as a poison and then as a remedy for some complaints was described. The history of the discovery of the physiological principles on which the pharmacological actions of the Calabar bean are based, and the subsequent use of the purified extract and then a synthetic replacement as an essential agent in anaesthesia were covered in some detail.

**Structures: The Key to Chemistry Communication – Helen Cooke** (November 2021)

This talk started by discussing the problems associated with communicating chemical information through the use of nomenclature and linear formulae when compared to graphical structure diagrams which instantly convey meaning to chemists. The speaker then took a step back in time to review the evolution of the representation of chemical structures over the centuries, some key milestones and the chemists involved including Dalton, Loschmidt, Berzelius and Kekulé. Original publications from the seventeenth to nineteenth centuries (many of which are now freely available online) featuring symbols and structure diagrams of various types were shown. How these evolved as chemical knowledge, technology and the associated literature developed was also explored. Reactions, equations and Markush structures were mentioned briefly. Although focusing mainly on the period before 1900, some developments in the computer era and how these changes influenced communication of chemical information, based on the speaker's experiences of working as a chemical information scientist in many capacities, were discussed. Some of the creative and innovative

ways in which structures are used today to communicate chemistry with wide audiences were featured, including some amusing examples.

**The History and Chemistry of Frankincense and Myrrh – Peter Morris** (December 2021)

This seasonally-themed talk discussed two of the traditional gifts of the Magi, namely frankincense and myrrh (gold being left aside as an element rather than a botanical product). Although they are both the products of trees that grow in the Arabian peninsula, they are very different in their appearance and odours. They have both been used for millennia: frankincense in incense used in temples and churches and myrrh in medicine. The origin, history, biology and chemistry of these two botanical products were explored. The chemistry of frankincense in particular has undergone something of a transformation.

## **FUTURE WEBINARS, MEETINGS AND CONFERENCES**

**Society for the History of Alchemy and Chemistry Webinars and Meetings**

The next SHAC webinar will be live on Zoom on Thursday 27 January 2022 beginning at 5.00 pm GMT (6.00pm CET, 12 noon EST, 9.00am PST). The format will be a talk of twenty to thirty minutes, followed by a moderated discussion of half an hour. Anyone, member of SHAC or not, may register to attend the seminars by e-mailing [meetings@ambix.org](mailto:meetings@ambix.org); a link to the seminar will be sent the day before. (If having registered you do not receive a link please check your junk folder). Please check [www.ambix.org](http://www.ambix.org) and SHAC social media for updates on speakers and subjects.

**“The largest and best”: A Symposium to mark the 350th Anniversary of the Society of Apothecaries’ Laboratories**

On Friday 6 May 2022, SHAC will hold a joint meeting with the Faculty of the History and Philosophy of Medicine and Pharmacy of the Society of Apothecaries to mark the 350<sup>th</sup> Anniversary of the opening a laboratory at Apothecaries’ Hall, London. The meeting will take place in the Society’s livery Hall in Blackfriars with speakers including Anna Marie Roos, Patrick Wallis, Peter Elmer and Anna Simmons and will include tours and talks on the Hall and archival collections.



### **SHAC Summer Party**

On Friday 17 June 2022, SHAC will hold a summer party at the Chelsea Physic Garden from 1 pm to 5 pm. Attendees will be able to explore the garden and there will be talks from Elaine Leong and Ernst Homburg, before the presentation of the 2021 Morris Award to Ernst Homburg. It will conclude with a drinks reception and the launch of Bloomsbury's *Cultural History of Chemistry*.

Details on registering for both events will be available on [www.ambix.org](http://www.ambix.org) nearer the time. For further information, email [info@ambix.org](mailto:info@ambix.org)

### **International Conference on the History of Chemistry**

The 13<sup>th</sup> International Conference on History of Chemistry (13ICHC) organized by the EuChemS Working Party on the History of Chemistry (WPHC) was to be held in Vilnius, Lithuania, in May 2021 but has been postponed to 2023 due to the Covid-19 pandemic. The Call for Papers will be distributed in May 2022.