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# Historical Group

## NEWSLETTER and SUMMARY OF PAPERS

**Editor: Dr Anna Simmons**

**No. 80 Summer 2021**

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**Save the date:** *The handed world, 150 years of molecular  
chirality:* planned for 13 October 2021 in Burlington House – see  
within for details

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### From the Editor

Welcome to the summer 2021 RSC Historical Group Newsletter, the eightieth issue to be published. Group members have certainly been busy over lockdown and I am very pleased to include a bumper list of their publications plus several short articles. As mentioned below, the postponed meeting, *The Handed World: 150 Years of Chiral Molecules*, has been rescheduled for Wednesday 13 October 2021. Booking will open once we are confident that Covid will not prevent the meeting from taking place (please keep an eye on e-alerts and monitor the webpage for developments).

There are three short articles and four book reviews in this issue: Alan Dronsfield and Pete Ellis write about *The Rise and Fall of Phenacetin*; Anne Green explores the life of *Evelyn Marion Hickmans, 1882-1972: A Neglected Pioneer of Paediatric Biochemistry*; and Anthony Travis has contributed *For the Scientific Record: Chemistry, Photography, and Raphael Meldola*. The books reviewed are as follows: Frank A. von Hippel, *The Chemical Age: How Chemists Fought Famine and Disease, Killed Millions, and Changed Our Relationship with the Earth*; Paul M. Wassarman, *A Place in History: The Biography of John C. Kendrew*; Geoffrey A. Ozin and Mireille F. Ghossoub, *The Story of CO<sub>2</sub>. Big Ideas for a Small Molecule*; and Donovan Moore, *What Stars Are Made Of: The Life of Cecilia Payne-Gaposchkin*. My thanks to Anthony Travis, Peter Morris, Peter Reed and Richard Buscall for these reviews.

Finally, I would like to thank everyone who has sent material for this newsletter, particularly the RSCHG Committee and a wider group of colleagues who have responded to my appeals for content. I also want to thank the newsletter production team of Gerry Moss and Bill Griffith, and also John Nicholson, who liaises with the RSC.

Contributions of articles of around 2,500 words in length on topics of current interest in the history of chemistry are warmly invited for inclusion in future newsletters. I'm very happy to discuss possible contributions in advance so please do get in touch. The deadline for the winter 2022 issue will be **Friday 3 December 2021**. Please send your contributions, to [a.simmons@ucl.ac.uk](mailto:a.simmons@ucl.ac.uk) as an attachment in Word. The newsletter usually appears on both group websites

[www.rsc.org/historical](http://www.rsc.org/historical) and <https://www.qmul.ac.uk/sbcs/rschg/> in January and late July/August of each year. We inform members through an e-alert sent out via the RSC, but as we are limited to one e-alert a month and last-minute problems beyond my control occur, the timings don't always work. This is what happened in January 2021!

Anna Simmons, UCL

## ABOUT THE RSCHG

The Royal Society of Chemistry Historical Group (RSCHG) was founded in 1975 for RSC members interested in all aspects of the history of chemistry and the chemical industry. Membership is free to any member of the RSC. Currently we have 778 members. We normally hold two one-day or half-day meetings every year, at the RSC headquarters at Burlington House, Piccadilly, London. However, this has not been possible since the pandemic started in 2020, although we hope to resume this autumn. Instead, we have held a series of webinars on Zoom almost every month, given by experts in various historical fields. We issue a twice-yearly *Newsletter and Summary of Papers*, edited by Dr Anna Simmons, usually some sixty pages long, appearing normally in January and August. This is our eightieth edition; a complete run of past issues is held at the RSC Library and at the British Library. The bulk of the *Newsletter* consists of short essays or articles of items of historical interest, normally but not exclusively written by members. It contains summaries of past RSCHG meetings, details of upcoming meetings, lists of members' current publications and of general publications of interest. There are also accounts of other chemical-historical meetings, book reviews and announcements on future webinars, meetings and conferences. There are twenty-two such *Newsletters* on our website going back to 2010. We also publish *Occasional Papers* of lectures given to the Group by distinguished experts on aspects of historical chemistry (see 'Other Publications' on our website). A list of published histories of British and Irish Chemistry Departments is also available. The Group maintains contact with the Society for the History of Alchemy and Chemistry (SHAC), and with the historical groups of the Institute of Physics (IoP), the American Chemical Society (ACS), and the European Chemical Society (EuChemS).

### *How to join the Historical Group:*

If you are already a member of the RSC the easiest way to join the group is to ring 01223 432141, giving your name and membership number. You can also join *via* the RSC website by updating your details in the "My communities and subscriptions" tab of the online RSC membership area. All members of the Group can download the *Newsletter* from <https://www.qmul.ac.uk/sbcs/rschg/> or [www.rsc.org/historical](http://www.rsc.org/historical). The RSC issues email reminders (e-alerts) to RSCHG members of upcoming meetings and information about the latest *Newsletter*.

If you are not a member of the RSC we strongly urge you to consider joining it ([www.rsc.org/membership-and-community/join/](http://www.rsc.org/membership-and-community/join/)). RSC Members also have access to the rich resources of its online Historical Collection (<https://pubs.rsc.org/historical-collection>). However, if you do not wish to join the RSC you are still welcome at our meetings and Zoom webinars as advertised at [www.rsc.org/historical](http://www.rsc.org/historical) and in the newsletter. You can also read our newsletter and other publications at the RSC and the QMUL web addresses since they are not password-protected.

If you have any problems or queries, please contact the RSCHG Membership Secretary, Prof. Bill Griffith, 48 Milton Road, London SW14 8JR, [w.griffith@ic.ac.uk](mailto:w.griffith@ic.ac.uk).

## ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP NEWS

### Online Seminar Series

The Historical Group's webinars will be taking a break in August 2021 but will resume in September, in their usual slot at 2 pm on the third Tuesday of the month. Recordings of some past talks can be found on [www.rsc.org/historical](http://www.rsc.org/historical).

## ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP MEETINGS

### The Handed World: 150 Years of Chiral Molecules

*Wednesday 13 October 2021, Royal Society of Chemistry, Burlington House, Piccadilly, London W1J 0BA*

The meeting will review optical activity and molecular chirality from a historical perspective – beginning in the nineteenth century and ending with techniques that are used today in the latest facilities such as the Diamond Light Source, with special reference to the biological and pharmaceutical importance of chirality.

### Programme

10.15 Registration and tea or coffee

10.45 Welcome – Dr Peter Morris (Historical Group, Chair)

### Session 1: Introduction; the Science to about 1890, with Postscripts

Chair: Dr Michael Jewess (Meeting Organising Committee)

- 10.49 *Introduction to the Day* Dr Michael Jewess
- 10.55 *Discovery of the Phenomenon of Polarisation of Light*  
Prof. John Steeds, FRS (University of Bristol)
- 11.35 *Discovery of Optical Activity and Chirality in Molecules*  
Prof. Alan Dronsfield (University of Derby)
- 12.30 Lunch: this is not provided but there are many cafés and bars close by.

### Session 2: The Science from about 1890

Chair: Dr Jane Skelly (Lewis Carroll Society)

- 14.00 *From d and l to R and S: Discovery of Absolute Configuration*  
Prof. Henry Rzepa (Imperial College)
- 14.30 *Polarised Light and Chemistry today*  
Dr Giuliano Siligardi (Diamond Light Source)
- 15.15 Tea interval

### Session 3: Chirality and Pharmaceuticals in Recent Decades; Conclusion

Chair: Dr Viviane Quirke (Oxford Brookes University)

- 15.45 *Does the Right Hand know what the Left Hand is Doing?– Chirality in Real Life*  
Dr Ian Blagbrough (University of Bath)
- 16.55 Concluding remarks – Dr Michael Jewess
- 17.00 Close of meeting

Fuller details are available at <http://www.rsc.org/events/detail/40046/the-handed-world-150-years-of-chiral-molecules>. Also, see elsewhere in this *Newsletter* issue for “Alice, Kitty, and Biochemistry – and a Request to Readers”.

### REGISTRATION

There is no charge for this meeting, but prior registration is essential, which will be possible *via* the “BOOK NOW” button at <http://www.rsc.org/events/detail/40046/the-handed-world-150-years-of-chiral-molecules> once we are confident that Covid will not prevent the meeting from taking place (please monitor the webpage for developments). Alternatively, e-mail [michaeljewess@researchinip.com](mailto:michaeljewess@researchinip.com) or write to Dr Michael Jewess, The Long Barn, Townsend, Harwell, Oxon, OX11 0DX, *quoting your RSC membership number if you have*

*one*. As usual, this is expected to be a popular meeting, so if, having registered, you are unable to attend, please cancel through the link provided in the confirmation e-mail (if you have used the “BOOK NOW” button) or by notifying Dr Jewess.

### George Porter Meeting

*6 December 2021, Royal Society of Chemistry, Burlington House, London*

Subject to confirmation nearer the time, this meeting will explore the life and career of the Nobel Prize-winning chemist George Porter (1920-2002), on the day which would have been his 101<sup>st</sup> birthday. For further information contact Frank James: [frank.james@ucl.ac.uk](mailto:frank.james@ucl.ac.uk)

### Sir Geoffrey Wilkinson: An Anniversary Celebration

*Wednesday 23 March 2022, Royal Society of Chemistry, Burlington House, Piccadilly, London W1J 0BA*

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

The meeting will cover the scientific life of Professor Sir Geoffrey Wilkinson 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). The meeting is free of charge. Registration will be essential, but is not yet open, pending possible restrictions.

### MEMBERS' PUBLICATIONS

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

William H. Brock and David E. Lewis, “A Different Kind of Nierenstein Reaction. The Chemical Society’s mistreatment of Maximilian Nierenstein”, *Annals of Science*, 2021, vol. **78**, no. 2, 221-245.

Between 1920 and 1922, the University of Bristol Biochemist, Maximilian Nierenstein, published four papers in a series exploring the structure of catechin in the *Journal of the Chemical Society*. The Society then abruptly refused to accept any more of his papers on catechin, or any other subject and provided with him with no reasons for the

embargo until 1925. The paper explores the Chemical Society's treatment of him and his reaction, sheds new light on his career and examines some of the structural chemistry involved in the disputes.

John Burgess and Martyn V. Twigg, "Professor Robert D. Gillard: Transition Metal Chemist 1936-2013". Part I: From early life to the University of Kent at Canterbury.

Part II: From the University of Cardiff to retirement interests and scientific legacy.

*Johnson Matthey Technol. Rev.*, 2021, **65** (1), 4-22 and 23-43.

<https://www.technology.matthey.com/article/65/1/4-22/>

<https://www.technology.matthey.com/article/65/1/23-43/>

This account of Gillard's career in Chemistry starts with his undergraduate days in Oxford, where a Part II project with Dr Harry Irving on alkaline earth and cobalt complexes proved seminal. His PhD research at Imperial College in the Geoffrey Wilkinson group broadened his experience into the then poorly developed chemistry of rhodium and other platinum group metal complexes. Gillard next went to Sheffield University as a Lecturer where he developed independent research while continuing to work on earlier topics. There followed a move as a Reader to the University of Kent where he spent a particularly productive seven years. Then at Cardiff University Gillard built on earlier work while extending his scientific interests still further into mineralogical and archaeological chemistry, and even into forensic dentistry. His penchant for discussion led him into several controversies, particularly over his 'covalent hydration' hypothesis of coordinated nitrogen-carbon double bonds in metal complexes which included those with platinum and 2,2'-bipyridine.

Stephen M. Cohen and Brenda H. Cohen, *America's Scientific Treasures: A Travel Companion*, 2nd edition (Oxford University Press, 2000).

Stephen M. Cohen and Brenda H. Cohen, a mother-son pair, take readers through countless museums, arboretums, zoos, national parks, planetariums, natural and technological sites, and the homes of a few scientists in this volume. The two combine their expertise in chemistry and history, making this an educational travel guide for science and technology enthusiasts. The book is split into nine geographic regions and organized by state, with the history and significance of each location provided.

Helen Cooke, Heidi L. Dobbs, Katherine Haxton, Fabio Parmeggiani and Glynn Skerratt, "From Nantwich to Oxygen: Public Engagement in Chemistry at a Local History Museum", *J. Chem. Educ.*, 2021, **98**, 4, 1249–1255.

<https://doi.org/10.1021/acs.jchemed.0c01152>

Joseph Priestley, discoverer of oxygen, lived in Nantwich in Cheshire from 1758 to 1761. In 2019, an exhibition featuring his life and achievements, and also celebrating the International Year of the Periodic Table, was developed by the Nantwich Museum. The historical research of Priestley's life, development of the exhibition, and rationale behind the public engagement events and activities are described. The integration of chemistry for all age groups throughout the exhibition and during events is discussed, with instructions for experiments and demonstrations available as Supporting Information for this paper.

Chris Cooksey, "Quirks of dye nomenclature. 16. Dyes, and a pigment, named after places", *Biotechnic & Histochemistry*, Published online: 12 Jan 2021

<https://doi.org/10.1080/10520295.2020.1849798>

Many dyes produced during the nineteenth century were named after locations. Manufacturers proliferated the number of synonyms used and in time, the original names were forgotten. The stories of some of these dyes that have survived into the twenty-first century are recounted in this article. Topics covered: Berlin blue; Blackley blue; Bordeaux red; Buffalo black; Buffalo garnet; Buffalo yellow; Chicago blue; Congo red; London orange; Manchester brown; Manchester yellow; Nile blue; Nile red; Oregon green; Paris violet; Sudans; Texas red.

Anne Green, *Sheila – Unlocking the Treatment for PKU* (Redditch: Brewin Books, 2019).

This book tells the remarkable story of Sheila and her important legacy - the introduction of new-born screening and worldwide treatment for the rare disorder Phenylketonuria (PKU). The work was carried out in Birmingham by three pioneering doctors; Evelyn Hickmans, John Gerrard and Horst Bickel, a visiting doctor from Germany. In 1951, at two years of age, Sheila Jones was diagnosed with PKU at Birmingham Children's Hospital. With no treatment available, her mother persevered until she obtained help from these three doctors. Together they worked tirelessly in the hospital laboratory to prepare a special formula for Sheila making her the first person in the world to receive dietary treatment for PKU. All proceeds from the book will be for the

Birmingham Children's Hospital Charity. For UK orders the book is available to purchase directly from Birmingham Children's Hospital for £12.95 with free P&P at <https://store.bch.org.uk/>

J.W. Nicholson and L. Parker, "Discovering Rhenium: Claims and counter-claims", *Chemical Educator*, 2021, 26, 9-13.

This article considers the history of the discovery of the element rhenium, element 75. Although usually attributed to the German group of Noddack, Tacke and Berg in 1925, some authors have advanced claims of the English duo of Druce and Loring, also in 1925, and the Japanese chemist Ogawa in 1908. Nicholson and Parker examine these possibilities by reference to the original literature. After careful examination of all the published evidence, they conclude that Noddack *et al* should be regarded as the sole discoverers of rhenium, and that the claims for the others should be dismissed.

Barry J. Oliver, *Ludwig Oertling, Balance-Maker: The Man, His Company and its Products*, 2021.

Ludwig Oertling was born in Mecklenburg-Schwerin in 1818 and trained as an instrument-maker under his elder brother in Berlin. Ludwig first arrived in London in 1842 as a journeyman instrument-maker in one of London's top workshops. He founded the company bearing his name in 1846 which rapidly became foremost in fine-balance making in the United Kingdom for 150 years. The primary aim of this book is to preserve the history of the company, its production methods, and first-hand knowledge of its products before they are lost for ever. It is in part a biography, in part a company history and partly a practical guide and reference work. Available from the author [barry.oliver@keme.co.uk](mailto:barry.oliver@keme.co.uk) for £30 plus postage.

Anna Simmons, "From purgatives and powders to fulminate and factories: Archives and sources regarding the Society of Apothecaries' drug supply to India, c. 1703-1882", *Pharmaceutical Historian*, vol. 51, issue 2, June 2021, pp. 41-50.

<https://www.ingentaconnect.com/content/bsph/ph/2021/00000051/00000002/art00002>

This article examines the origins of the Society of Apothecaries' drug supply to the East India Company in the early eighteenth century through to the award of a monopoly in 1766 and changes to the India Office's purchasing policy in the 1870s. It aims to bring the attention of the Society's rich archival collections to a wider audience. The chemist Henry Hennell's ill-fated attempt to manufacture the explosive mercury fulminate at Apothecaries' Hall is discussed, along with the Society's

little-known proposal to the India Office to operate a drug factory in Nassik (now Nashik) in north-western India.

## **FOLLOW UP FROM THE WINTER 2021 AND SUMMER 2020 NEWSLETTERS**

### **The Explosive Life of Col. B. D. Shaw (another reminiscence).**

Alan Dronsfield (*RSCHG Newsletter Winter 2021* p. 8) and John Nicholson (*RSCHG Newsletter Summer 2020* p. 25) have commented on Colonel Shaw's lectures. Many years ago, I attended one of his explosive lectures in the UCL Chemistry department lecture theatre when it was in Gordon Street. The experience was being filmed. In those days that involved silver halide emulsions and gelatine. Apart from shooting candles at plywood sheets, demonstrating the barking dog with carbon disulfide and nitrous oxide, and more, he showed how a potassium chlorate and yellow phosphorus mixture can produce a big bang when touched with a warm long metal rod. It worked very well, but with such enthusiasm that the rod rebounded on to his head. Shaw mopped up the blood with a handkerchief and carried on. Following shouts of "cut", filming was paused and then resumed following repair work.

Chris Cooksey

### **The Mond in Swansea (RSCHG Newsletter Winter 2021, p.61)**

The Watford and District Industrial History Society (WADIHS) visit to industrial sites in Swansea in 2019 has been documented in thirty-two illustrations which can be found here: <http://www.wadihs.org.uk/index.php/gallery>.

## **PUBLICATIONS OF INTEREST**

Mitteilungen GDCh-Fachgruppe Geschichte der Chemie, vol. 26. Gesellschaft Deutsche Chemiker. Frankfurt am Main, 2020. Pp 294, illus. ISSN: 0934-8506. 10 euros for members; 20 euros for non-members.

With the retirement of Prof. Christoph Meinel in 2018, the papers of members of the historical group of the German Chemical Society (GDCh) now appear under the capable editorial hands of two University of Bielefeld historians of chemistry, Prof. Carsten Reinhardt and Marcus B. Carrier. The change of editorship is marked by a new design for the publication and an increase in the number of illustrations (albeit,

some are poor in definition). The lead article by Alexander Kraft offers a tour of chemical sites that existed in Berlin at the time of the foundation of the GDCh in 1867. The article is a model of what chemist historians might do for the “historical geography of sites of chemistry” in other European cities. Kraft also has a second essay on the Berlin alchemist, Georg von Welling (1655-1727), who claimed to have extracted gold from pyrite ores in the Harz mountains. The King of Prussia invested heavily in a factory in the neighbourhood of Berlin’s present-day Bunsenstrasse, to work the process, but then had Welling arrested in 1710 because the process failed. Kraft provides full details of the legal case against Welling who only escaped the King’s wrath in 1715.

Two essays refer to the 150<sup>th</sup> anniversary of the publication of Mendeleev’s periodic system in 1869. Gisela Boeck (Rostock) analyses German textbooks and popular writings between 1869 and 1910 and concludes that the principal interest in the periodic arrangement was that it suggested the complexity of elements and their potential evolution. The other essay is a German translation of the English article on “the ordering of the elements” that Michael Gordin published in *Science* 363 (1 February 2019): 471-473. There is just one article in English by Klaus Ruthenberg (Coburg) and Hasok Chang (Cambridge) on the development and use in biochemistry of the glass electrode by the physiologist, Max Cremer. This is a good example of how chemists and historians of chemistry can collaborate on twentieth-century and contemporary chemistry. Their exemplary article combines chemical, biochemical, historical and instrumental insights and provides a deeper context for understanding the development of the pH measurement of acidity.

Two essays by Klaus D. Röker provide an overview of the career of Guillaume-François Rouelle (who is identified as the founder of modern French chemistry), and of the ideas and experiments involving heat from caloric to thermodynamics. The remaining four articles offer an archaeological survey as evidence for sulphuric acid manufacture in the Swiss canton of Schaffhausen at the beginning of the eighteenth century (Peter Kurzman); a history of the creation of the synthetic vanillin and flavour industry in Holzminden by Wilhelm Haarmann in 1872 (Klaus Stanzl); an account of the high temperature research of Hans Joachim von Wartenberg in Berlin in the first half of the twentieth century; and, finally, in continuation from vol. 23 (2013) of the *Mitteilungen*, the concluding part of the history of East Germany’s Chemical Society between 1979 and its reunification with the post-war German Chemical

Society in 1990 to form the present GDCh (Renate Kiessling). Overall, the contents show that our sister historical division is in fine fettle.

William H. Brock

Takaaki Inuzuka and Haruko Laurie, *Alexander Williamson: A Victorian Chemist and the Making of Modern Japan* (UCL Press, 2021).

In 1860, Japan had been a closed feudal society for two hundred years and it was a capital offence to attempt to leave the country. Its governance, economy, and technology were largely frozen in time, but the industrial revolution was taking place in the West. In 1863, five samurai students from the Chōshū clan made their way to England and were put in the charge of the Professor of Chemistry at UCL, Alexander Williamson, and his wife, who arranged for them to learn about cutting-edge Western technology, science, economics and politics. When they returned home, they rapidly became leading figures in Japanese life at a particularly turbulent time; one of them serving as the country’s first Prime Minister, one becoming Minister of Foreign Affairs, and another the first Director of the Mint. Subsequently many other Japanese students followed in their footsteps and studied at UCL.

Williamson is revered in Japan, and his biography was published in Japanese by Takaaki Inuzuka in 2015. It has now been translated into English by Haruko Laurie of Selwyn College, Cambridge, and published by UCL Press. This short, accessible biography explores Williamson’s contribution to nineteenth-century science as well the role he and UCL played in the modernisation of Japan. An afterword briefly outlines the extraordinary careers of the pioneering students after they left Britain. The soft-back edition costs £20, and the hard-back edition £40, but a pdf copy can be downloaded free of charge from UCL Press: <https://bit.ly/2TgK2GU>

Alwyn Davies

### ***Ambix* – The Journal of the Society for the History of Alchemy and Chemistry**

*Ambix*, February 2021, volume 68, issue 1

Alan J. Rocke, “A Woman’s Life Alongside Chemistry: The Memoirs of Theresa Kopp Baumann”.

Mike A. Zuber, “Alchemical Promise, the Fraud Narrative, and the History of Science from Below: A German Adept’s Encounter with Robert Boyle and Ambrose Godfrey”.

Mark I. Grossman, “John Dalton’s “Aha” Moment: The Origin of the Chemical Atomic Theory”.

José Ramón Bertomeu Sánchez, “Lead Poisoning in France around 1840: Managing Proofs and Uncertainties in Laboratories, Courtrooms, and Workplaces”.

Theresa Levitt, “Morphine Dreams: Auguste Laurent and the Active Principles of Organised Matter”.

### RSC Booklet on Past Presidents

David Allen from the RSC Library has put together a booklet on the Past Presidents of the Chemical Society and Royal Society of Chemistry to tell the stories of those who have led the organisation.

<https://www.rsc.org/globalassets/02-about-us/our-history/rsc-presidents-1841-2024.pdf>

## SHORT NOTES

### Alice, Kitty and Biochemistry – and a Request to Readers

Lewis Carroll’s *Through the looking-glass and what Alice found there* was 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” [1]. (In 1871 and long afterwards, a pet cat’s staple diet included milk, contrary to modern recommendations [2].)

Like Gardner [3] but *pace* O’Leary [4], the present writer thinks it likely that Carroll was making a “shot in the dark” rather than deploying precise chemical knowledge. However that may be, Alice’s idea that Looking-glass milk was different was confirmed by a line of chemical thought [5] that began in 1860 with Louis Pasteur (1822-1895) and culminated in the independent 1874 publications of Jacobus Henricus van’t Hoff (1852-1911) and Joseph Achille Le Bel (1847-1930). This work established the possibility of optical activity of solutions of compounds CWXYZ with different groups W, X, Y, and Z tetrahedrally disposed about the carbon atom C [6]. No mirror plane passes through the molecule and the mirror image of the molecule is not superimposable on its original, any more than left- and right-hand gloves are superimposable [7]. The two “enantiomeric” forms in solution, for the same concentrations and path lengths, rotate plane-polarised light through equal angles but in opposite directions (now

designated (+) and (–)). Later, Lord Kelvin (1824-1907) coined the term “chirality” (literally “handedness”) for such non-superimposability [8].

To celebrate this work of approximately 150 years ago, the Historical Group is planning (Covid permitting) a one-day meeting in London on Wednesday 13 October 2021 <https://www.rsc.org/events/detail/40046/the-handed-world-150-years-of-chiral-molecules> – as it happens, in the precise sesquicentenary year of *Through the looking-glass*.

Milk contains the C<sub>12</sub> sugar (+)-lactose. Healthy babies – and most adult Northern Europeans – metabolise (+)-lactose to an equimolar mixture of the C<sub>6</sub> sugars (+)-glucose and (+)-galactose by means of the enzyme lactase. But some adults do *not* produce lactase, especially non-Europeans; such people are “lactose-intolerant”, suffering “bloating” and other unpleasant symptoms if they consume milk.

Now, enzymes bind specifically to an active site in the molecule being metabolised. In (+)-lactose, the site will be of a single “handedness”. Therefore, real-world lactase would be unlikely to metabolise the (–)-lactose of Looking-glass milk, just as a left hand fits only uncomfortably into a right-hand glove. If so, even real-world lactose-tolerant people might well get unpleasant symptoms if they drank Looking-glass milk, *ie* as Alice’s speculates, it would *not* be good to drink. In principle, Looking-glass (–)-lactose could be made in the laboratory and experimented with to settle the point; an *in vitro* experiment would at least partially suffice, without risking making someone ill! But the present writer is not aware of this having been done, or even of an enzyme expert predicting authoritatively what the result of such an experiment would be. If any *Newsletter* reader can enlighten the present writer, please can he or she do so? Such information would no doubt be received with acclaim by the audience on 13 October.

### References and Notes

1. Lewis Carroll, *The Annotated Alice – The Definitive Edition*, ed. Martin Gardner (London: Allen Lane the Penguin Press, 2000), 148.
2. John Bradshaw, *BBC Science Focus Magazine*, “Why can’t cats drink milk? Plus 6 other feline myths”, 20 May 2019, <https://www.sciencefocus.com/nature/why-cant-cats-drink-milk-plus-6-other-feline-myths/> (accessed 28 May 2021).
3. Carroll, *The Annotated Alice – The Definitive Edition*, 151-152, Note 6.

4. Joanna Shawn Brigid O'Leary, "Where 'things go the other way': the stereochemistry of Lewis Carroll's looking-glass world", *Victorian Network*, Summer 2010, 2(1), 70-87.
5. J.R. Partington, *A History of Chemistry*, Volume 4 (London: Macmillan, 1964), 755-759.
6. The discussion here applies to pure liquids or vapours as well as solutions, but not to crystals. It excludes special cases such as  $W = CXYZ$ .
7. Non-superimposability is the fundamental condition for optical activity. For CWXYZ, absence of a molecular mirror plane amounts to the same thing – but not for all molecules, see F. Albert Cotton, *Chemical Applications of Group Theory*, 3rd edition (New York: Wiley, 1990), 34-39.
8. Lord Kelvin, *The Molecular Tactics of a Crystal* (Oxford: Clarendon Press, 1894), 27, footnote 1.

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## SOCIETY NEWS

### Society for the History of Alchemy and Chemistry: Morris Award 2021

The SHAC Morris Award for 2021 has been given to Ernst Homburg for his outstanding work on the history of the chemical industry. His contributions include major studies on the history of the madder industry; his seminal paper on the early history of industrial R&D laboratories; his comprehensive history of twentieth-century modern chemistry and the chemical industry embedded within a broader history of the Netherlands in *Techniek In Nederland in the Twintigste Eeuw*. And, particularly (in the context of this award), his "The Era of Diversification and Globalization (1950-2012)" in *Solvay: History of a Multinational Family Firm* (CUP, 2013), a book he co-edited with Kenneth Bertrams and Nicolas Coupain.

Ernst Homburg has given great service to the history of chemistry community. He edited the *Ambix* book reviews for ten years; served as a member of SHAC Council for twenty years; chaired the Historical Group of the Dutch Chemical Society for twelve years; was president of the Dutch History of Science Society (GeWiNa) between 1995 and

1998; and chaired the Working Party on the History of Chemistry of the European Association for Chemical and Molecular Sciences for six years up to 2009. He was a Professor in the Faculty of Arts and Sciences at the University of Maastricht until his recent retirement.

*The Morris Award honours the memory of John and Martha Morris, the late parents of Peter Morris, the former editor of Ambix and recognises scholarly achievement in the History of Modern Chemistry (post-1945) or the History of the Chemical Industry. The next award will take place in 2024. A call for nominations will be circulated in 2023.*

The HIST Award for Outstanding Achievement in the History of Chemistry for 2021

The Division of the History of Chemistry (HIST) of the American Chemical Society is pleased to announce that Dr Mary Virginia Orna will receive the 2021 HIST Award for outstanding achievement in the history of chemistry "for her exemplary leadership in the worldwide community of the history of chemistry, especially for her original research in the area of colour and pigment chemistry and the discovery of the elements, her commitment to education, her decades of service to the Division of History of Chemistry, and her continuing role in supporting and participating in the worldwide research in the archeology of chemistry".

Sister Dr Orna joined the College of New Rochelle (New York) in 1966 and is now Professor of Chemistry Emerita. Although she is being honoured for her contributions to the worldwide community of historians of chemistry, she has devoted her life first to her Ursuline order and to her students, both in her own college and in the rest of the world. She has received many awards for her devotion to chemical education and continues her efforts to inform and educate the world about Chemistry through her NSF spin-off enterprise, ChemSource. She has devoted her technical career to the study of colour and its role in human culture and been a champion of the Archaeological Chemistry community.

### Citation for Chemical Breakthrough Award to UCL

Since 2006, the Citation for Chemical Breakthrough Award programme, administered by the ACS Division of the History of Chemistry, has honoured scientific publications, books and patents that have been revolutionary in concept and broad in scope, and that forever changed the face of chemistry. In 2020 a plaque was presented to the Chemistry Department of University College London for Professor William

Ramsay and Lord Rayleigh's paper which announces the discovery of argon. "Argon, A New Constituent of the Atmosphere", was published in the *Philosophical Transactions of the Royal Society, London*, A 1895, 186A, 187-241.

## SHORT ESSAYS

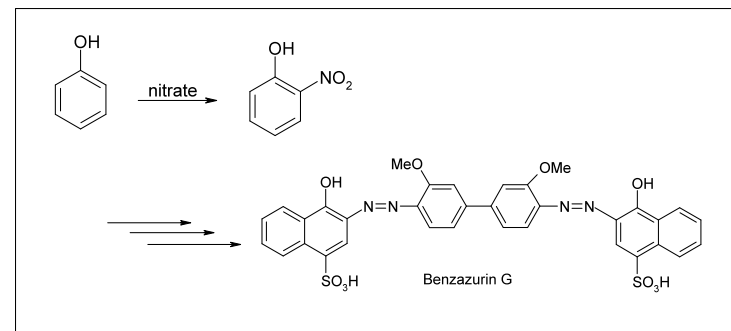
### The Rise and Fall of Phenacetin

In the 1871 textbook *A Manual of Practical Therapeutics* a multiplicity of treatments is listed to alleviate headaches and reduce fevers. Apart from cinchona bark extract (crude quinine) and salicine (a salicylic acid-related extract of willow bark) others would have exerted a placebo effect, at best [1]. Synthetic organic chemistry had little to offer aside from salicylic acid until the early 1880s and the advent of the Kairins, Kairolins and Thallin [2]. These were undoubtedly effective both as antipyretics and analgesics but caused significant side effects, including a reduction in the oxygen-carrying capacity of the blood. This led to breathlessness and a blue tinge to the lips and skin, which, unsurprisingly, was alarming to both patients and carers. These drugs were manufactured by German dyestuffs firms that had expanded into the profitable nascent pharmaceutical industry. Success led to world-wide domination in the period prior to the First World War. They saw collaboration with university chemists as a key strategy to identify better, and more lucrative, compounds. Significantly, Farbwerke Hoechst AG exploited a discovery by the future Nobel Laureate Emil Fischer and his former PhD student Ludwig Knorr (both working at the University of Erlangen) and marketed Antipyrin from 1884, just in time to benefit from the great 'influenza' pandemic of 1889/90. Recently, evidence has been presented that this might have been due to a coronavirus [3]. Antipyrin rapidly displaced the antipyretics marketed earlier in the decade and was in widespread use for some forty years. Although it was to face fierce competition from aspirin after its introduction in 1899, its eventual demise was due more to the gradual realisation that its use was not without risk. Prolonged medication with Antipyrin could lead to agranulocytosis, *i.e.* suppression of production of white blood cells by the bone marrow, leaving the patient without defences against infection, which was then generally fatal.

But Hoechst was not alone in its collaborations with chemists. In 1883 a twenty-two-year-old Carl Duisberg [4] (a former student of Adolf Baeyer) was appointed as a chemist by the dyestuffs company Farbenfabriken Bayer, then based at Elberfeld, Germany, with the brief "to make inventions". Duisberg and his chief, Carl Rumpff, noted that

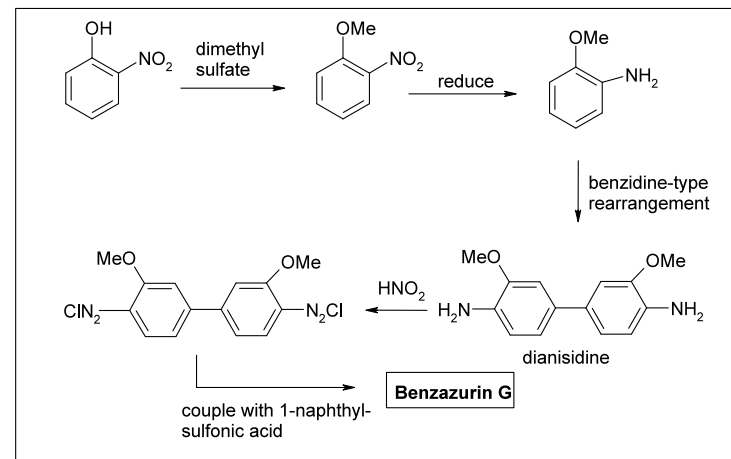
competing dyestuffs manufacturers were diversifying, profitably, into pharmaceuticals and sought to emulate them. But how?

By 1885 Bayer was selling large amounts of the blue dye Benzazurin G, which, like indigo, had the advantage that it could tint cotton without the need of a mordant. The starting material was phenol, a cheap coal tar-derived product, which had to be nitrated to yield 2-nitrophenol (Scheme 1a).



Scheme 1a. The synthesis of Benzazurin G from Phenol

The central part of this molecule is doubly diazotised dianisidine which is then coupled with 4-hydroxynaphthalene-1-sulphonic acid. Bayer's synthesis of the dianisidine is shown in Scheme 1b.



Scheme 1b. Bayer's dianisidine intermediate

It was clear to Duisberg that the process could be rendered more profitable if a use could be found for the 4-nitrophenol by-product arising from the nitration of the phenol. Typically, the nitration of phenol yields 30-40% of the 2-isomer and about 15% of the 4-isomer. Bayer was accumulating vat-loads of the latter product with no apparent commercial use. Works chemist Oskar Hinsberg was given the job of converting the waste nitrophenol into a marketable medication [4]. Success came within a matter of weeks. Presumably he was guided by knowledge of the formulae of the existing antipyretic drugs. His molecule thus might incorporate some of their features such as:

- an acylated amino group, attached to an aromatic ring (*vide* acetanilide, successfully marketed under the brand name of Antifebrin)
- an alkoxy group attached to an aromatic ring, as in Thallin. (Fig 1).

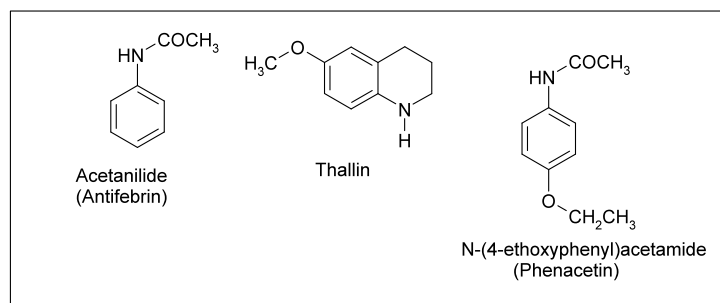
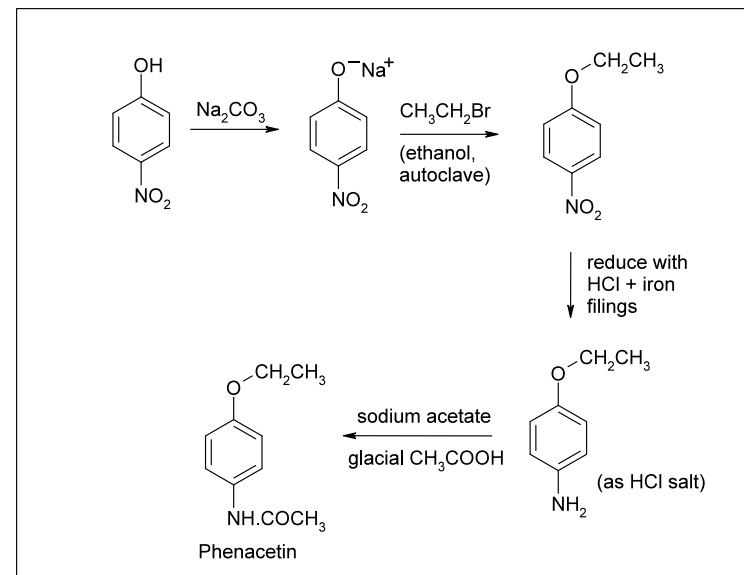


Fig. 1. Phenacetin and earlier antipyretic drugs

The product, *N*-(4-ethoxyphenyl)acetamide, was accessible from the nitrophenol by simple chemical manipulations, and was found to have fewer side effects than Kairin, Kairolin or Thallin. Marketed under the tradename of Phenacetin from 1887, it competed with Antipyrin until the latter's demise in the 1930s, and then continued in use for another forty years. Hinsberg went on to patent his industrial manufacture for it in the USA, in his name but on behalf of the Bayer company (Scheme 2) [5]. Hinsberg went on to develop an industrial manufacturing process and patented it in his name on behalf of the Bayer company in 1889 (Scheme 2) [5].

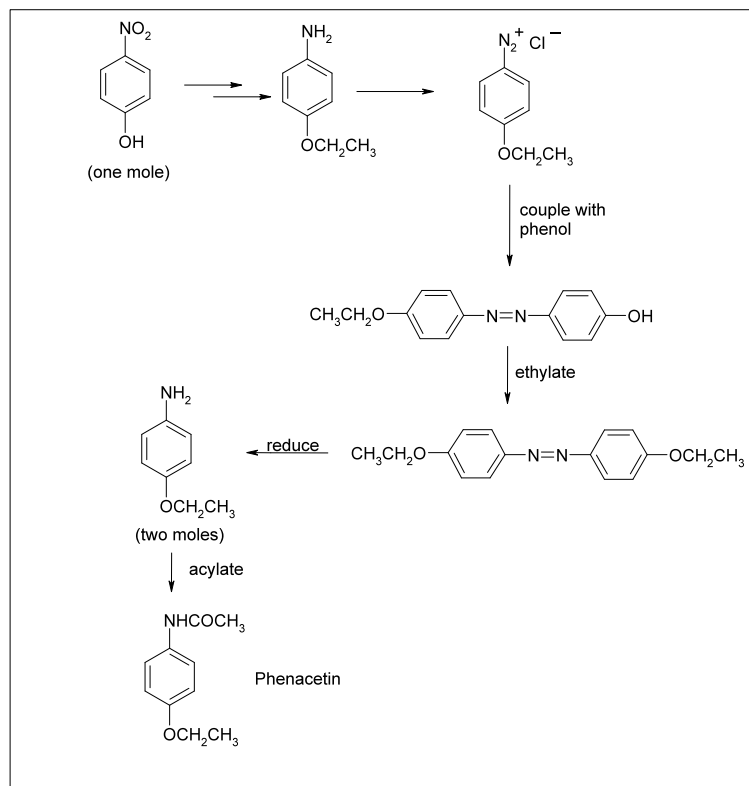
Cheap, effective and (ostensibly) without side effects, at least compared to other antipyretics, it became a best seller. The UK imported 8.5 tons annually up to 1914, mainly from Germany. Indeed, the drug became so popular that supplies of the 4-nitrophenol side-product from the manufacture of Benzazurine G were no longer sufficient to meet the

demand. Consequently a new synthetic route was developed (Scheme 3). This had more stages than the route shown in Scheme 2, but was adopted "because of the difficulty of producing pure 4-nitrophenol, and in this way an initially small amount of 4-nitrophenol can be made to produce a large quantity of phenacetin" [6].



Scheme 2. Hinsberg's industrial patent for manufacturing phenacetin

During the greater part of the twentieth century phenacetin was sold largely in the form of "combination therapies", typically sachets or pills containing, additionally, aspirin and/or codeine, salicylamide, phenylephrine hydrochloride and caffeine. The amount of the last ingredient varied from 35 -160 mg. The lower dose is typically the amount contained in half a cup of coffee. The use of caffeine in combination analgesics, although widespread, is not well supported by evidence, other than in combination with ergotamine for migraine headache. Use of over 600mg/day can lead to caffeinism, characterized by anxiety, restlessness and sleep disorders, and abrupt cessation can lead to withdrawal symptoms, including headaches. One might speculate that its inclusion in combination analgesics may have been with the best of (manufacturers') intentions, notwithstanding the element of additional risk to the patients.



Scheme 3. A more economical commercial route to phenacetin (from 1905)

### Phenacetin – The Chief Suspect

In the early 1950s, physicians in Switzerland noticed a sudden increase in patients presenting with kidney failure, sometimes alongside anaemia and high blood pressure. It was assumed this was due to a single new environmental factor, such as the increased prescribing of barbiturates or antibiotics. It was not until 1957 that a clinician, Sven Moeschlin, made the link with phenacetin [7]. But this was a decades-old drug with a good safety record, so why had it suddenly become a problem? He suggested that it might be a consequence of the post-war boom in the Swiss watch industry. Assembling the small, delicate mechanisms by hand under pressure to meet tight production targets was causing

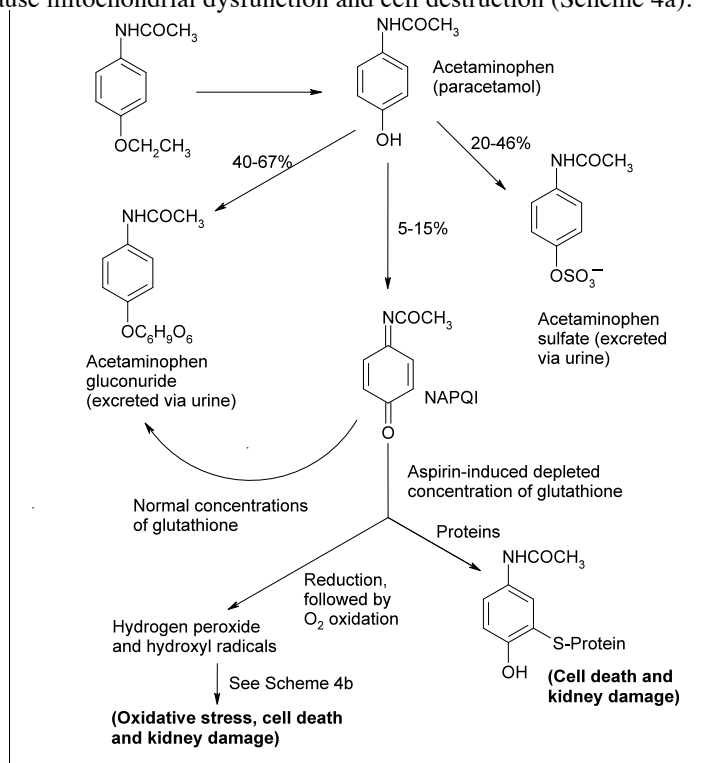
headaches and stress for the many women recruited to this task. Regular breaks away from the work bench might well have helped, but the workers were employed on a piece-rate basis and were keen to keep working – and earning. Consequently, they resorted to ‘headache pills’, the most popular of which was *Sarindon*, a Hoffmann-La Roche product, then containing phenacetin, caffeine, propylphenazone (a relative of Antipyrin) and barbiturates. It was not recognized at the time that continued use of such analgesics could actually cause headaches (the rebound effect), perhaps compounded by caffeine withdrawal headaches. So these further headaches led to increased use of ‘headache pills’. Sadly, this escalating dose had unforeseen damaging effects on the kidneys.

In Australia, too, there was a similar ‘epidemic’ of renal failure. In the 1970s, of all the patients on dialysis, 22% had suffered renal failure due to excessive use of analgesics. The principal offenders were “*Bex*” powders, sachets containing equal amounts of phenacetin and aspirin, plus up to 160mg of caffeine [8]. They were heavily advertised as a pick-me-up. Women, isolated at home, or trying to juggle work and family, would come to rely on Bex to keep them going. Mild dependence, possibly connected to the addictive effects of the caffeine, or escalating self-dosage to alleviate the headaches that the powders themselves induced, sometimes led to daily doses of up to a dozen sachets per day, although some reports suggested that 30-40 doses a day was not uncommon.

By 1967, phenacetin was identified as the common element amongst the various combination analgesic preparations associated with this problem. When new cases of this form of renal failure considerably reduced after it was progressively withdrawn or banned, this confirmed it as the toxic agent. But did it? The essayist H.L. Mencken observed “For every complex problem, there is an answer that is clear, simple - and wrong”. In 1969, physician and researcher Priscilla Kincaid-Smith challenged the view that phenacetin was the villain in the APC (aspirin, phenacetin, and caffeine) preparations [9]. She found that just over half of a group of rats given doses of APC equivalent to those taken by patients who had developed kidney failure, suffered similar kidney damage. However, perplexingly, this kidney damage was not noted in rats receiving twice as much phenacetin alone. These findings supported the argument that phenacetin should not be singled out as the substance responsible for analgesic-induced kidney damage in man. Used *alone*, and in the recommended amounts, it appeared to be an effective and safe analgesic.

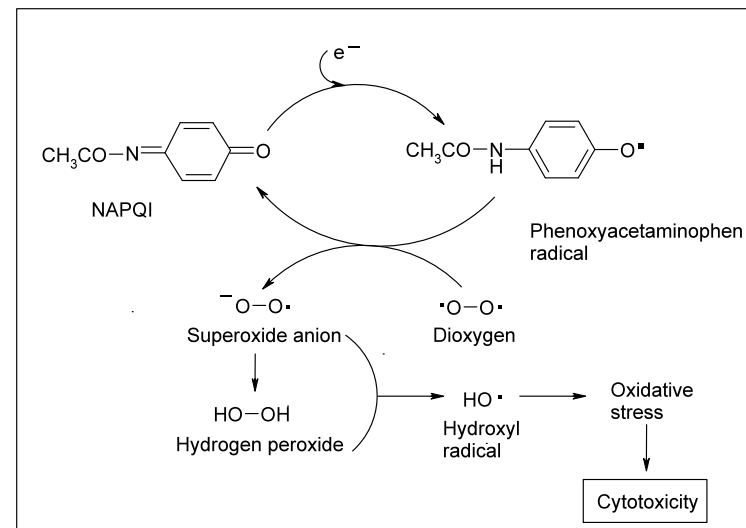
## Aspirin – The Culprit

The first stage in the elimination of phenacetin from the body is its conversion into acetaminophen (itself later marketed as *paracetamol*), and aspirin potentiates the nephrotoxicity of this product. Most of the acetaminophen is converted into water-soluble glucuronides and sulfates and excreted via the urine, but 5-15% is oxidised to N-acetyl-*p*-benzoquinoneimine (NAPQI) [7]. If the phenacetin is consumed alone, there is usually sufficient glutathione in the kidneys' papillae to detoxify this imine safely, by formation of the glucuronuride. If the phenacetin is ingested alongside aspirin (acetyl salicylic acid), the latter is hydrolysed to salicylate, which depletes the glutathione in both the kidney's cortex and papillae. Thus the imine, deprived of its excretory route via the urine, remains longer within the kidney with the potential to inflict damage. There it reacts with proteins forming sulphur bridges that can cause mitochondrial dysfunction and cell destruction (Scheme 4a).



Scheme 4a. Excretory pathways for phenacetin

Alternatively, the imine can facilitate the formation of highly destructive hydroxyl radicals leading to tissue stress, cytotoxicity and in extreme cases, death (Scheme 4b) [10].



Scheme 4b. Involvement of NAPQI in oxidative stress and cell death

In medicine, as in science more generally, if a single explanation appears to fit the available data, this is preferred over multiple or complex explanations. But as Mencken points out, this approach has its weaknesses, as well demonstrated by the complex mechanism of toxicity of phenacetin. However, by the time these biochemical processes were elucidated, phenacetin was long gone from the pharmacopeia. As an old drug long out of patent, and with a very tarnished reputation, no pharmaceutical company was prepared to argue a case for its return. It serves as a reminder that the old principle of using one drug at a time is generally safer than combining drugs. The current return of combined pain killers to the pharmacy shelves seems to fly counter to this principle and we are reminded of Churchillian injunctions on the importance of learning the lessons of history.

## Notes and References

1. E. J. Waring, *A Manual of Practical Therapeutics*, 3<sup>rd</sup> Edn (London: J & A Churchill, 1871). Among the scores of internal remedies listed are iron picrate, ammonium chloride, camphor, arsenic iodide, silver nitrate, sodium chlorate, lead acetate and hydrocyanic acid (HCN).

2. A. Dronsfield and P. Ellis, *RSC Historical Group Newsletter*, 2021, 79 (Winter), 12.
3. M. Buchanan, *Bloomberg Opinion*, 20 May 2020, available online at <https://www.bloomberg.com/opinion/articles/2020-05-15/coronavirus-of-today-eerily-similar-to-1889-russian-flu-pandemic>
4. Carl Duisberg was three years younger than Oskar Hinsberg, though the former seems to have guided this research. He went on to have a stellar career in the German chemical industry, marrying the niece of Bayer's Chairman, Carl Rumpff, on the way: <https://www.bayer.com/en/history/carl-duisberg>
5. O. Hinsberg, *United States Patent 400,086*, 1889.
6. G.T. Morgan, *Science Progress in the 20<sup>th</sup> Century*, 1908, 2(8), 572.
7. Contribution discussed in K. Brune, B. Renner and G. Tiegs, *European Journal of Pain*, 2015, 19, 953.
8. Wikipedia article [https://en.wikipedia.org/wiki/Bex\\_\(compound\\_analgesic\)](https://en.wikipedia.org/wiki/Bex_(compound_analgesic))
9. P. Kincaid-Smith, *British Medical Journal*, 18 Jan 1969, 161.
10. The role of NAPQI as a nephrotoxic agent is discussed in "Toxicity of over-the-counter drugs" in R. C. Gupta (Ed) *Veterinary Toxicology*, Cambridge, Mass, USA: Academic Press 2018). Available for downloading at <https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/napqi>.

Alan Dronsfield and Pete Ellis  
(Pete Ellis is a retired medical practitioner)

### **Evelyn Marion Hickmans, 1882-1972: A Neglected Pioneer of Paediatric Biochemistry**

Evelyn Hickmans was a chemist whose contribution to the study of biochemistry and nutrition of children in the early twentieth century was of international importance. She was the first biochemist to establish chemical analyses in a children's hospital in the UK, and one of the first scientists in the world to apply biochemistry to the study of metabolic diseases in children. I had the privilege of working in the same department which Evelyn Hickmans had established fifty years earlier. Her work is little heard of today, and this short review charts her long career and highlights her achievements.

### **Family Background and Early Life**

Evelyn was born on 9 April 1882 in the small village of Coseley, Staffordshire. Originally a small farming community, but owing to its location on the South Staffordshire coal field, Coseley became highly industrialised in the early nineteenth century, going through a period of rapid expansion and counting a population of around 22,000 in 1881. Evelyn's mother, Mary Elizabeth Parsons, was born in nearby Kingswinford into a farming family. Mary married John Hickmans who had a house with a grocery and provisions business in the main shopping area of Coseley, known as Roseville. Sadly, John died at a young age in 1876, leaving Mary a widow with two little girls. Mary continued to live in Roseville and managed the grocery business, later marrying her late husband's younger brother, David, who became Evelyn's father.

The Hickmans' were a large working-class family, living close by in a small terraced house. David's father and older brother had jobs in the iron works, but David himself had become an elementary school teacher, and this was probably a significant factor in Evelyn's future. She initially lived with her parents and step-sisters in their home at the top of Castle Street, at the grocery and provisions store. Little of the original street remains in 2021, with the location of the home now a pizza take-away. One can only try to imagine Evelyn's early life in Coseley, a close-knit industrial community where people usually lived all their lives, and wonder what it was that sparked her interest in chemistry and led her to move away from the area for further education and work. Her family were staunch Methodists and this was an important aspect throughout her life.

### **Education**

After local schooling, probably at Mount Pleasant School, Coseley, it is unclear where Evelyn received her secondary education. There is a suggestion, albeit unconfirmed, that it was at King Edward's High School for Girls in Birmingham. By 1901 the family had moved away from Coseley, to the countryside environment of Codsall, a small village outside Wolverhampton. By now her father had changed profession, and had become a businessman in the rapidly developing milk contracting business (Hickmans and Mould of Wolverhampton) of the early twentieth century. Evelyn's younger brother, Wilfred, joined the business, while her two step-sisters continued to live at home. Her eldest sister, Florence, became a domestic science teacher.

It was an era of developing science and technology with new ideas and opportunities. Evelyn continued her studies at Wolverhampton Science and Technical School in Garrick Street, an institution that provided technical, scientific and commercial evening classes. In 1902, Evelyn, now aged twenty, was the 'chief student' of the year. Her matriculation results, including maths and chemistry, were outstanding, and she was awarded the newly created Mander scholarship of £24 per annum to attend Birmingham University. The Theodore Mander Scholarship was created from a new fund raised by private subscription by the citizens of Wolverhampton in memory of the late Mr Samuel Theodore Mander (1853-1900), Mayor of Wolverhampton (1899-1900). The scholarship was open to the sons and daughters of burgesses of Wolverhampton, and tenable at the University of Birmingham for two to three years. It was awarded on the results of the matriculation examinations in June each year, with preference given to those attending courses preparing for degrees in science or commerce. Evelyn was its first recipient. At Birmingham, Evelyn studied a combination of science subjects, including Chemistry, in her first two years, but the university records are incomplete for her final year. She was awarded her BSc in Science/Chemistry in 1905 and an MSc a year later. The work resulted in two publications of extensive work on the freezing point curves and stability of different isomeric forms of methyl esters of mandelic acid.

Evelyn was one of the very few women at the time to study academic chemistry [1], and although she obtained both BSc and MSc degrees, there were few employment opportunities open to her. There is no evidence that she obtained a job, and in 1908 she went to King's College, London to study household science [2]. It was whilst at King's College, she became interested in nutrition. Her abilities and achievements made a good impression, and she was subsequently invited to help with a new Department of Household Science at Toronto University. World War I intervened to delay her departure, but soon after in 1919 she set forth, alone, to Canada.

#### **Toronto 1919-1922**

In January 1919 she was appointed lecturer in applied chemistry and dietetics in the newly established Department of Household Science at Toronto University. The course taught nutrition, dietetics and food chemistry. The department was housed in the Lillian Massey Building, at the time considered to be one of the finest facilities of its kind in North America [3]. The building located at 159 Bloor St West included living accommodation as well as housing the faculty. Members of the faculty included Annie Laird from whom Evelyn learnt a great deal. It



Fig. 1: Graduation Photograph of Evelyn Hickmans

*Image is copyright of Birmingham Children's Hospital and is reproduced with its kind permission.*

is likely that Evelyn's interest and expertise in dietetics began at this point in her career.

Evelyn's time in Toronto was cut short by her mother's illness and subsequent death, and she returned to Wolverhampton in 1922. Although she was invited back to Toronto, her career thereafter remained rooted in the West Midlands. Serendipity undoubtedly played a role here. Her cousin, Dr Leonard Parsons, was an eminent paediatrician at Birmingham Children's Hospital. He looked after children with a variety of wasting disorders and had become aware that the way forward in understanding these medical conditions was to investigate them with chemical analyses. Knowing Evelyn's background in chemistry, he asked her to establish chemical tests on body fluids to support his research work.

### **The History of Clinical Chemistry**

The use of chemistry for the diagnosis of human disease, in its widest sense, can be traced back to 1686 when Robert Boyle identified sodium chloride as the principal salt in blood. The earliest aids to diagnosis were simple measures of specific gravity, volume, taste, colour and smell of urine. The emergence of clinical chemistry as a distinct discipline is marked equally by physicians who became committed to the development of chemistry as an aid to understanding disease, and scientists who believed their science could answer questions in physiology and medicine [4]. The subsequent *ad hoc* development of chemical assays for blood and other body fluids came about by individual medical doctors, usually with appointments in medical schools, investigating a specific clinical condition. Elucidating the constituents of renal calculi, measuring hydrochloric acid in gastric juice, and uric acid in gout are early examples. Before the twentieth century, little had been done to accommodate clinical laboratories in hospitals, and those few, early labs that were established were generally focused on bacteriology and infectious diseases. They were usually in cramped conditions, often in temporary garden or Nissen huts at the back of the hospital, or subterranean in disused laundries or next to the boiler room. No quantitative blood chemistry was available. For paediatric investigations there was the added challenge that any analysis had to be micro scale [5]. Evelyn Hickmans' laboratory at Birmingham Children's Hospital (BCH) was one of the earliest to rise to this challenge, and in 1923 it became the first paediatric biochemistry laboratory housed in a Children's Hospital in the UK [6].

### **Birmingham Children's Hospital – The First Paediatric Biochemistry Laboratory 1923**

Undaunted by this new scientific and medical territory, and the responsibility that had been placed on her, Evelyn Hickmans established the first Paediatric Biochemistry Laboratory in the UK – on a voluntary basis initially without pay. She was only the second biochemist to be employed in a hospital in the whole of England (the first was also in the West Midlands, at Dudley Road Hospital in 1921). She was provided with a small side room off one of the wards, but no chemicals, and no equipment other than a rack of dirty test tubes [7]. She claimed she didn't know much about blood analysis, but there was in fact very little to know. Blood chemistry analyses posed particular problems because of the need to precipitate proteins, with the breakthrough in 1920 by Folin and Wu with their method for blood glucose [8].

It was not long before Evelyn had established several chemical tests to support Leonard Parsons' investigation of children with wasting disorders, and she became funded by the MRC for 'assistance to Dr Parsons'; the initial assays included measurement of fats, proteins, calcium and chlorides. Her attention to detail and hard work were impressive; in one study she collected and analysed 5-day stool samples, which had to be dried before analysis, on forty-eight infants. This early work centred on producing results for the Gulstonian Lectures which Leonard Parsons had been invited to deliver in 1924 [9]. Typically for this era, Evelyn, based 'in the side room', was initially acknowledged as the assistant to the medical doctor, but her work soon gained her a second MSc in Biochemistry at the University of Birmingham in 1923. In 1924 she published her first paper from her work at BCH showing that there was a relationship between calcium absorption and fat intake.

Her reputation as a chemist grew, and in 1925 she was invited in her own right to the Annual Conference of the Teachers of Domestic Science in the prestigious setting of the Pump Rooms at Bath. This was an important occasion, with 300-400 delegates including the Lord Mayor. As well as the more traditional domestic science subjects, there were three high-level medical presentations, including one by Evelyn Hickmans, when she delivered her forty-five-minute presentation on the diets of undernourished infants and provided valuable information on the value of different foods. Later in 1925, she was awarded a PhD from Birmingham University for this work. Evelyn was now Dr Hickmans.

Her department at BCH began to grow, with an assistant and a PhD student, and in 1925 the laboratory moved into larger rooms, now in the basement of the hospital in the outpatient building. She continued developing new micro methods suitable for use with the small volumes of blood from babies and infants. It is often been said that children are not just small adults, and nothing is more true when considering clinical chemistry in children. The concept that there would be different levels of chemicals in children of different ages was something Evelyn appreciated very early on, and she established reference interval data on large numbers of children, including young infants and babies for several different analyses for the first time. The most remarkable study was that of plasma protein over 150 babies using only 0.01ml plasma specimens.

### Contribution to Understanding Disease in Children

Evelyn was no longer simply supporting the research of Leonard Parsons; she was providing a clinical chemistry service for the whole hospital. MRC grants continued throughout the 1920s and 1930s when she worked with many hospital physicians of diverse specialities on a range of clinical disorders. In reading her publications, the attention to detail is striking, as are the large numbers of subjects in her studies. The scientist in her was evident, with great caution being emphasised when drawing conclusions where only small numbers were involved and/or there were methodological limitations.

In the 1930s, research with Leonard Parsons continued with investigating the effects of different diets on anaemia. For their initial work, Evelyn turned her hand to feeding different diets and measuring the size of the red blood cells in cohorts of rats. A common problem in childhood was rickets, and Evelyn describes how she used colonies of rats placed in gardens in different parts of Birmingham with differing degrees of sunlight, to study the effects of a rachitic diet.

A study on the biochemistry of children with acute rheumatism compiled data on the blood analyses of calcium, phosphate, cholesterol, chloride, creatinine, urea, and non-protein nitrogen. In order to get a control group for comparison, she worked with school Medical Officers to obtain blood from ten to twelve-year-old children before they went to school (and gave them a free breakfast at the hospital afterwards!). She had clearly come a long way from 'household science'.

Work continued at pace producing many publications throughout the 1930s. Evelyn was developing quite a following, and two other female biochemistry graduates from Birmingham, also from Wolverhampton,

joined her team [Fig. 2]. Interestingly at the time, the staff of her laboratory were all female, which only serves to highlight the often-forgotten role of women chemists in the first half of the twentieth century.



Figure 2: Tea Party in Early Biochemistry Laboratory at Birmingham Children's Hospital

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### Many Firsts and New Observations

Birmingham is known for its elucidation of the structure of Vitamin C, and Leonard Parsons for the first time used synthetic vitamin C to treat deficiency. Evelyn was soon to include its measurement in her repertoire of analyses in children. The analytical challenges cannot be overstated. Apart from a balance, glassware, centrifuge, water bath, extraction hood and colorimeters, there was little by way of equipment. Only later did the introduction of spectroscopy enable pigments to be studied. The lack of specificity of methods was a difficulty she frequently encountered and highlighted.

One of the special investigations Evelyn established in the late 1940s was paper chromatography for amino acids. Her laboratory became one of the few places in the UK where this technique was being applied successfully in a hospital setting. She arranged a series of meetings so that other laboratory workers from across the country could learn about the technique, and it was this initiative that catalysed the setting up of a

formal association for biochemists working in a hospital environment. At Birmingham Children's Hospital on 15 December 1949, the Midlands Association of Clinical Biochemists was inaugurated with Evelyn as the first chairman. She then played a crucial role in the formation of the national organisation in 1953. Interestingly, this paralleled similar developments in the US where the American Association of Clinical Chemists was being formed [10].

The most significant part of Evelyn's work took place close to the end of her long and distinguished career. In 1951 a two-year-old infant, Sheila, was diagnosed with the rare inherited condition Phenylketonuria (PKU). There was no treatment at the time, but after pressure from the distraught mother, Evelyn, together with a visiting doctor from Germany, Dr Horst Bickel, prepared a special, phenylalanine-low dietary formula from hydrolysed casein. Together with Dr John Gerrard, they showed the disease was treatable, and Sheila became the first person in the world to receive dietary treatment for PKU [11]. With Evelyn's expertise this work led to the commercial production of diets for PKU, and to new-born screening for the condition across the world [12, 13]. Her work stimulated the world-wide interest in the prevention of other forms of mental retardation.

Evelyn Hickmans retired in 1953 aged seventy-one, but she continued to contribute to the teaching of laboratory science locally for many years. She established the first course in biochemistry at the Wolverhampton College where she had first studied, and in 1962, together with Professor Bickel (now in Germany) and Professor Gerrard (now in Saskatchewan) was given the prestigious John Scott Award from Philadelphia, for the work on the preparation of the diet for PKU [14,15]. She was a true pioneer of chemistry as applied in a medical setting, and it is disappointing that she never became a member of The Chemical Society.

### **Her Legacy: Paediatric Clinical Chemistry in 2021**

Evelyn left a thriving department with a world-wide reputation which has grown steadily and from strength to strength over the last seventy years. From thirty to forty tests per day in the 1950s, the daily workload is now around 3,500 tests. The amino acid work alone, which in the 1950s took three days to process a handful of samples, is now around 13,000 samples per annum. Paediatric Clinical Chemistry, as part of Paediatric Laboratory Medicine, became established as an International Organisation in 1980 [16] and is now an established part of the

*International Federation of Clinical Chemistry and Laboratory Medicine* [17].

### **Evelyn as a Person**

From those who knew her she was described as: "her personality combined dignity with charm and she enhanced the life of all those close to her. She stimulated her medical and scientific colleagues with her ideas and at the same time could make immediate contact with small children" [18]. Clifford Parsons (Dr Leonard Parson's son) commented: "she was a wonderfully stimulating person and her laboratory was the place where people met and talked, where new ideas were inspired and where clinicians and laboratory scientists found common ground" [19].

Dr Hickmans was an active Soroptimist and founder member of the Wolverhampton branch of the Association of University Women. She lived a full life and was a keen gardener and photographer. She never married and died unexpectedly on 16 January 1972, aged eighty-nine. After a service at Hotel Trinity Church, Compton Road, Wolverhampton her remains were buried in the Remembrance Garden at Bushbury Crematorium Wolverhampton [18, 20].

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### For the Scientific Record: Chemistry, Photography and Raphael Meldola

In an era of digital photography, it is easy to forget that until the end of the twentieth century chemical manipulations were essential in photographic processing. Nothing could have been achieved without light sensitive materials, coated papers, developers, fixers, sensitizers, etc. The silver halide processes that were almost universally adopted required stabilizers, sensitizing dyes, developing agents, couplers, etc. Many of these are aromatic organic chemicals closely related to intermediates used in the manufacture of synthetic dyes. An early enthusiast for the chemistry of photography was the English dye chemist Raphael Meldola (1849-1915). His scientific interests were wide ranging and encompassed natural history, anthropology, evolution, and astronomy [1]. This brief account is mainly concerned with the role of photography in certain of these endeavours. Thus in 1875, Meldola was a member of a party charged with recording the total solar eclipse for the Royal Society. From the late 1880s, he promoted technical education for those embarking on careers in photography. This was in keeping with Meldola's more general lobbying for improved scientific and technical education in Britain, in order to meet the threat posed by the powerful German synthetic dye industry.

### Meldola's Early Years

In 1866, Raphael Meldola enrolled with the chemistry department at London's Royal School of Mines, successor to the Royal College of Chemistry, directed by Edward Frankland, a pioneer in organometallic chemistry. Through Frankland, Meldola became engaged in analysis of London's waters. He assisted John Stenhouse at the Mint, and in 1871 took up an appointment with the firm of Williams, Thomas & Dower, at Brentford, west London, one of the early British manufacturers of synthetic, or coal-tar dyestuffs. Meldola was perhaps fortunate that the synthetic dye industry reached prominence towards the end of his studies, and provided an opportunity to foster his various scientific interests.

While a student at the college, Raphael Meldola had embarked on entomological excursions in Epping Forest, northeast of London, in the county of Essex. Around 1868-69, this introduced him to the serious study of the small creatures of nature, and photography. Entomological friends included William John Argent of Wansted, Essex, and the Cole brothers of Buckhurst Hill, also in Essex. William Cole later recorded that he met Meldola “in a glade near Woodford, in Epping Forest. On that afternoon I was aiding my friend, the late W.J. Argent, in the somewhat arduous task of taking photographs in the open by the old wet collodion process, which necessitated the carrying about of a small tent to serve as a ‘dark-room’ (invented by Argent) and one or two cans filled with water for washing the negatives!” [2].

Following this introduction to photography, Meldola must have taken a great interest in learning as much as he could about the subject, including chemical processing and application to recording images from the natural world. This was useful when in 1873 he joined the Royal College of Science, successor to the Royal School of Mines, and was appointed an assistant of the spectroscopist Norman Lockyer. Lockyer was the founding editor of *Nature*, which provided an opportunity for Meldola to act as a junior editor for the journal. This included review articles that reveal his considerable knowledge of photography, and an interest in Hermann Wilhelm Vogel’s pioneering work on “special sensitizers”, or dye sensitizers [3]. In 1873, Vogel, in Berlin, discovered that by tinting collodion film with certain coal-tar dyes, such as corallin, aldehyde green, eosin, cyanin, etc., silver halide was sensitized to yellow and greenish yellow [4].

### **The 1875 Solar Eclipse**

Meldola’s expertise in both spectroscopy and photography led to a post with the Royal Society’s expedition to the Nicobar Islands in order to record the total eclipse of the sun on 6 April 1875. Captain J. Waterhouse of the Indian Army, an experienced photographer, was in charge of the members of the eclipse expedition based on the Nicobar Islands, which drew on the manpower of the Nancowry Penal Settlement. Meldola was responsible for the chemicals, the quartz prism telespectroscope, the photography, and the processing. Vogel was a participant in the expedition. Due to poor weather the expedition was not successful, though the ultraviolet region at least was recorded.

Accounts of the trip provide a vivid picture of the sometimes adverse conditions under which photography was carried out, involving plate cameras, during expeditions outside the temperate zone. Wet collodion

plates were preferred, and every effort had to be made to prevent them from drying, though that was perhaps less of a problem in a humid climate. In an effort to maximize sensitivity, the plates were stained with aniline orange dye (Judson’s), also to “impart density to the negatives”, following experiments by Waterhouse with roseine aniline dye. This was a novel way of altering photographic materials. However, the failure of the solar observations meant that “the value of this method for photographing the corona in a total eclipse could not be ascertained” [5].

Norman Lockyer supplied a 6¼ in. equatorial refractor made by the firm of Thomas Cooke, “at the service of the expedition”. According to Meldola, “The instruments placed at the disposal of the branch of the expedition were designed with a view to attempting to obtain photographs of the spectra of the different gaseous layers composing the sun’s atmosphere and likewise photographs of the eclipse showing the state of polarization of the light emitted by the corona, the observations thus dividing themselves into spectroscopic and polariscopic” [6].

Alexander Pedler, chair of chemistry at the Presidency College in Calcutta, who joined the expedition, later described the conditions under which the party had to work after it arrived at the island of Camorta on March 22 [7].

The expedition had to live aboard the Government steamer *Enterprise* throughout the period, as the islands are noted as being very malarious....every silver article we possessed was blackened by the amount of sulphuretted hydrogen in the air. Every morning, before landing on the island for work during the day, every member of the expedition had to submit to “quinine” drill by taking 5 grains of quinine; but even this did not prevent some of us contracting jungle fever...Meldola, I think was lucky and escaped this fever.

The work of preparing for the eclipse was very interesting, and at the same time quite unusual. The Nicobar Islands are the extra-punishment place of the penal settlement in the Andaman Islands, and the prisoners on the island of Camorta. Gangs of six or eight prisoners were assigned to each observer to help in erecting observatories, etc. “They were all of them bad characters and many of them murderers. Of course, every observer was protected by a Sepoy guard during the working period. This was indeed absolutely necessary”.

Everything was in very good order on the day of the eclipse, and Meldola was in charge of the quartz telespectroscope for photographing the spectrum of the corona and prominences of the sun. It was hoped

that excellent results would be obtained, for the duration of the totality at Camorta was calculated to be no less than 4 minutes 27 seconds, which is an unusually long period for a total eclipse. Unfortunately, however, though the whole of the forenoon was quite fine and the sky almost cloudless, and the party was successful in observing the external contacts at the beginning and end of the solar eclipse, during the progress of the eclipse clouds gathered in front of the sun, and of the period of totality absolutely nothing was to be seen of the sun, and only the shadow of the moon could be seen, making everything like night for this period.

The young physicist Arthur Schuster led the part of the expedition that was based in Siam. Jointly with Lockyer, he drew up an extensive report on the results of the expedition [8].

### **Meldola's Dyes**

In 1877, Meldola re-entered the dye-making industry, this time at Brooke, Spiller & Simpson, of Hackney Wick. The firm manufactured Meldola's yellow silk dye Citronine from around 1878. Another of his discoveries was a fast green dye, Viridine. In 1879, Meldola obtained what became known as Meldola's Blue. It was manufactured on a large scale in Germany by Cassella & Co., of Frankfurt, and other firms. The process was to become the basis for a more general synthesis applied in industry, though mainly outside England. In 1888, Meldola's Blue was recognized to be a member of the oxazine class by Rudolf Nietzki at Kalle & Co., in Germany.

Following investigations into the action of nitroso compounds on phenols that afforded products of use as technical colorants in 1880, Meldola discovered the first nitrosonaphthalenesulphonic acid. Its mixed iron salts were manufactured by Gans & Co., in Germany, from 1884, and generally known as Naphthol Green B. At AGFA's new photographic department, opened in 1888, Danish-German chemist Momme Andresen in 1889 converted the green into a photographic developer, known as Eikonogen, the sodium salt of 1-amino-2-naphthol-6-sulphonic acid (sodium 1-amino-2-naphthol-6-sulphonate) [9].

### **Entomology and Evolution**

Epping Forest was within easy reach of the Hackney Wick factory, as were Meldola's old entomological friends, which renewed an interest in the natural history of Essex. Through these acquaintanceships Meldola became in 1880 co-founder and first president of the Essex Field

Club [10].

Though a local society, the early membership list of the club was impressive, and included women. A founding luminary was Sir John Lubbock, Bart, trustee of the British Museum. There were also industrial chemists associated with Brooke, Simpson & Spiller, including the photographer John Spiller, who discussed with Meldola butterflies, photography and investments in Eastman Photographic. Spiller, a former president of the Photographic Society of Great Britain (later Royal Photographic Society), investigated the chemistry of albumen processes. Other early members included Lord Rayleigh, later a president and Lord Lieutenant of Essex, publisher T. Fisher Unwin, and Henry Roscoe.

Meldola's many contributions to the society's journal, the *Essex Naturalist*, included articles of photographic interest. There was an obituary of Colonel J.P. Russell, of Romford, an early member of the field club and a pioneer in the 1850s of dry-plate photography [11]. In 1901, two of Meldola's photographs graced the pages of the club's journal, showing "remarkable trees", at Easton Park, Essex, including an oak tree, and a hornbeam. "It is much desired that members photographically inclined would follow [Meldola's] example, and thus insure the preservation of pictures of interesting trees which may be noticed in various parts of the County" [12].

Meldola's main interest as a field naturalist was in moths and butterflies, and in mimicry. This work was stimulated by his commitment from at least 1871 to natural selection, and correspondence with Charles Darwin. Through Darwin, Meldola made contact with leading like-minded naturalists and biologists, particularly Alfred Russel Wallace, and the Germans Fritz Müller, in Brazil, and August Weismann, at the University of Freiburg. At the end of the 1870s, Meldola made known in the English-speaking world Müller's work on mimicry, and undertook the English translation of Weismann's *Studies in the Theory of Descent* (1882). Darwin and Wallace were honorary members of the Essex Field Club. A close colleague of Meldola was the evolutionary biologist Edward Bagnall Poulton, from 1893 Hope Professor of Zoology at Oxford. Along with Poulton, Wallace, and Weismann, Meldola was from the early 1890s a fervent neo-Darwinian [13].

### **Decline in England**

It was mainly following dissatisfaction with his employer's unwillingness to invest in research that led Meldola to leave Brooke,



Raphael Meldola (1849-1915)

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Spiller & Simpson in 1885. Thereupon he became Professor of Chemistry at the new Finsbury Technical College (City & Guilds of London Institute; in 1885 renamed Central Technical College). He continued with dye-related research into azo compounds, aromatic amines, and phenol derivatives. In 1886, Meldola warned of the dangers

of neglect of scientific education, giving as an example the decline of Britain's synthetic dye industry. He soon after drew on the connection between applied chemistry and photography in order to promote a new branch of industrial chemistry.

In 1889 he published the extensive monograph, *The Chemistry of Photography*. It was based on nine lectures given during the spring term of 1888 as a special course at Finchley addressed to a mixed audience composed of chemical students and practical photographers. Meldola observed "The claim of Photography to be recognized as a branch of Chemical technology is now generally admitted..."

Orthochromatic photography, important in studies of scientific interest, particularly outdoors, required further scientific investigation. Meldola noted that: "Mr C.H. Bothamley of Yorkshire College, Leeds, has succeeded in preparing plates which are more sensitive to yellow and orange than to blue and violet, and which thus approach the ideal coincidence between visual and photographic intensity....But although the utility of orthochromatic photography has been proved in many ways....so far as the scientific aspect of the discovery is concerned, we are at present only on the threshold of an unknown region" [14]. Meldola had taken up a strong interest in the dry-plate process, which had occasionally been used in wildlife photography from the early 1860s.

He increasingly promoted the chemistry of photography as a branch of technology, and its application to meteorology and other scientific endeavours. At the 1890 Leeds meeting of the British Association for the Advancement of Science, Meldola became a member the committee for the "Application of Photography to the Elucidation of Meteorological Phenomena", subsequently reporting under photographic meteorology. This encouraged amateur photographers with an interest in natural history to engage in surveys of scientific value, in keeping with Meldola's wish to bring together communities of amateurs and professionals.

There were also lectures at prestigious locations in London. In May 1890, Meldola spoke on "The Photographic Image", before the Royal Institution [15]. In March 1891, he gave a series of lectures on "Photographic Chemistry", before the Royal Society of Arts. It was through the "numerous applications which photographic processes have found, both in art and in science", that, according to Meldola, photography should be considered "a distinct branch of science or technology .... urged upon all those who are in any way interested in the

advancement of technical education”. However, in keeping with Meldola’s warnings on decline of chemical industry in Britain, “when our efforts are compared with the keen appreciation of the subject which is borne witness to by the splendidly equipped photo-chemical laboratories of the technical high schools of Berlin and Vienna, it will be admitted that in this, as in other departments of chemical technology, we have allowed ourselves to sink into a secondary position...” [16].

In *Nature* on 22 October 1891, under the heading of “Technical Chemistry”, Meldola observed: “A person may become adept as an operator without knowing anything of physics or chemistry; there are thousands of photographers all over the country who can manipulate a camera and develop and print pictures with admirable dexterity, who are in this position. If we adopt the narrow definition of technical instruction, we should appoint such experts in our Colleges, and through them impart the art of taking pictures to thousands of others. But would our position as a photographing nation be improved by the process? I venture to think not....our position in the scale of industry would not be materially raised by the wholesale manufacture of skilful operators. And so with all other branches of applied chemistry; it is technologists whose knowledge is based on a broad foundation that are wanted for the improvement of our industries. These are the men who are raised in the technical high schools of the Continent, and whose training the Continental industries have had the wisdom to avail themselves of” [17].

Reviews with similar messages continued to appear in *Nature*, notably of the fourth edition of part 1 of Vogel’s *Handbuch der Photographie*: “....the author is Director of the Photochemical Laboratory of the Imperial Technical School in Berlin. The existence of such a post as that occupied by Dr Vogel in one of the foremost technical schools of Germany is as much an indication of the advanced state of technical education in that country as the non-existence of such specialists in the technical schools of this country is a sign of our comparatively backward condition in the field of chemical technology” [18]. Significantly, Meldola supported Gabriel Lippmann’s novel colour photography process (1891-1892), based on interference phenomenon (Lippmann received the 1908 Nobel Prize in Physics for this work) [19].

In 1892, before the Royal Photographic Society of Great Britain, Meldola proposed the creation of a photochemical institute, on German lines [20]. As with his calls for placing the British dye industry on a more scientific, German style, of footing, it was not to be.

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## BOOK REVIEWS

Frank A. von Hippel, *The Chemical Age: How Chemists Fought Famine and Disease, Killed Millions, and Changed Our Relationship with the Earth*. (University of Chicago Press, 2020), Pp xiii + 389. ISBN 978-0-226-69724-6, US\$ 29.

The subtitle of this volume is somewhat misleading. Ostensibly the book is about the long and challenging path to the development of pesticides, and the emergence of the environmental movement following the publication of Rachel Carson's *Silent Spring*. However, to this curious reader at least, it turns out to be more about the uses and releases of toxic elements and compounds, and an attempt to shock us into reconsidering the relations between our modern, technology-based world and nature. The prologue starts with a short summary devoted to Thomas Midgley Jr's work, on leaded gasoline and Freon, just to remind us of how cruel chemists and chemistry, often inadvertently, have been to human life and the environment. Soon after we find that many of the protagonists, as such, are not chemists, but scientists from different disciplines. More problematic are those who, far from being scientists, inflicted evils of the worst kind upon others using chemical products. Then there are the chemicals themselves, and the methods of synthesis, developed for crop protection and feeding humanity but

applied to purposes of war, and vice versa. The historian of chemistry will find little or nothing new here.

This is not to say that *The Chemical Age* is a bad book. It is well written, and in many parts very engaging. I particularly appreciated the first five chapters, dealing, successively, with the Irish potato famine, emigration, devastation of vineyards, yellow fever, malaria, colonisation, typhus, and plague. As von Hippel shows, seeds are the raw materials that nature supplies to society, and geography dictates where those seeds flourish best. Problems arose when, like the plague, plant diseases were transported from one region of the globe to another. At the human level, the accounts are held together by numerous stories and anecdotes, and rivalries such as between the French physician Alexandre Yersin and the Japanese doctor Kitasato Shibasaburo in establishing the bacterium responsible for the plague, and the inevitable question of priority (pp. 112-119). Thus far, chemistry does not play the major role, though there are several examples of its use in alleviating problems of health and plant diseases.

Chapters six to nine, the core of the book, and are mainly about chemists and chemistry, and their toxic legacies. They take us through Fritz Haber's invention of a method for capturing atmospheric nitrogen, Haber's (and others) role in the introduction of gas and chemical warfare, the pesticide Zyklon B, and its notorious role in industrial extermination of people during World War II, antimalarials, DDT and organochlorines, the herbicide Agent Orange, nerve agents, organophosphate and neonicotinoid insecticides, etc. Their various applications, again originally mainly to protect lives and crops, and the more problematic and occasionally even deadly outcomes, direct and otherwise, of their usages, are described. IG Farben, scientists in the service of the National Socialists, industrial disasters, and corporate malfeasance are not neglected. Chapters ten and eleven are devoted to the life and work of Rachel Carson, with emphasis on the early widespread rejection of her warnings, from among the media and lobbyists for chemical companies, which like governments, lagged in acknowledging the problems. Unfortunately, von Hippel gives short shrift to certain major stories in the history of chemistry, and as a result provides one or two howlers. Thus William Henry Perkin's synthetic dye, mauve, is credited with ending the Indian monopoly on mauve (p. 187). There are also problems of time compression. Haber's magnificent ammonia synthesis in 1909 did not initiate what has been called the Green Revolution (of the 1960s) (p. 142).

The author states at the outset that the book relies on primary source material. That may be true in part. The chemical background, however, tends to rely mainly on secondary sources. The approach of von Hippel is in no small part dictated by his expertise in the field of ecotoxicology. There is also a more personal connection. His great-grandfather was the physicist and Nobel laureate James Frank; his grandfather was the physicist, Arthur von Hippel. In the 1930s, both fled Germany for the United States. This final part of the story (Chapter 12), I found very interesting.

Anthony S. Travis

Paul M. Wassarman, *A Place in History: The Biography of John C. Kendrew*. (New York: Oxford University Press, 2020). Pp. 360. ISBN: 9780199732043, £22.99 hardback.

Although he won the chemistry Nobel Prize in 1962 with his colleague Max Perutz, Sir John Kendrew might be considered to be the forgotten man of post-war British molecular biology. The discoverers of the structure of DNA, James Watson and Francis Crick, are household names and Kendrew is also overshadowed by his more colourful scientific partner although his work on myoglobin was more significant than that of Perutz. Yet Kendrew played such an important role in the creation of molecular biology as a scientific discipline, by founding the Laboratory of Molecular Biology in Cambridge (LMB) in 1947 and the *Journal of Molecular Biology* in 1958, and ensuring that Britain would play a major role in its development, punching above its weight as the cliché has it. How can this low profile be explained? It was partly the fact that he and Perutz had been independently persuaded by J.D. Bernal that the structure of proteins held the secret of life rather than DNA. Furthermore Kendrew had a quiet reserved personality, perhaps more suited to that of a civil servant, than his publicity-seeking colleagues. He had no desire, for example, to write an autobiography. It is perhaps no surprise that he had an excellent relationship with the Science Museum and Frank Greenaway. His reserve may be connected to the divorce of his parents when he was only four (who knows what trauma that may have caused?) and his own marriage was a rapid failure at a time when divorce was still frowned upon. After winning the Nobel Prize, in contrast to Perutz, he decided to leave the laboratory bench and join the ranks of the “great and good”, ending up in his sixties as president of St John’s College, Oxford (despite being a lifelong Cambridge man). As a practising scientist, the author of this biography seems to disapprove of this choice and even attribute some of Kendrew’s obscurity to this fact. Perhaps Wassarman is still miffed that

he hardly ever saw Kendrew when the great man was his nominal research supervisor at the LMB. Yet compared with the bad choices made by some Nobel laureates, this was a sensible decision as Kendrew clearly decided that he had shown that the X-ray crystallography of proteins was both possible and useful and had nothing more to prove.

So what is this book like as a biography of Kendrew? The author was hampered by the lack of any close relatives (Kendrew had no children) and he did not have access to some important archives. He also set himself a difficult task by electing to write a non-scientific biography although he is a scientist. It would have been far better in my view if he had played to his strengths and written a scientific biography which could have been of great value. Scientists are rarely good at writing popular science and Kendrew is a not a good subject for a popular science book – he was not Richard Feynman or even Max Perutz. Unsurprisingly it is a rather short biography at 245 pages of substantive text. One wonders what a seasoned science writer, for example Georgina Ferry (the biographer of Perutz and Dorothy Hodgkin), would have done with Kendrew. Certainly, I think she would have made a better job of Kendrew’s short-lived marriage. Wassarman does not explain how Kendrew became romantically involved with Mary Elizabeth Gorvin-Jarvie nor if any doubts were expressed about the marriage beforehand. He explains the breakdown of the marriage to Kendrew’s preoccupation with his laboratory research and his devotion to his college Peterhouse. However, I suspect that they were a refuge rather than the cause. Furthermore, Wassarman argues that Kendrew’s failure to remarry was a result of his worries about another divorce, while I suspect deeper causes may have been at work here. However, the book is generally well written, the scientific material is covered in an engaging way and it is easy to read. Non-scientists will not have any trouble reading *A Place in History*, although whether they will have any interest in it is another matter entirely. Nevertheless, a biography of a leading figure of post-war British molecular biology, perhaps its most important figure, is always welcome and currently offered at £15.72 on Amazon UK, it is remarkably cheap.

Peter Morris

Geoffrey A. Ozin and Mireille F. Ghoussoub, *The Story of CO<sub>2</sub>. Big Ideas for a Small Molecule* (London: University of Toronto Press, 2020). Pp. xviii + 255, ISBN 7981 4875 06360, £26.99, hardback.

The publication of this book is timely with the next meeting of the Intergovernmental Panel on Climate Change in Glasgow, 1–21

November this year. *The Story of CO<sub>2</sub>* provides a useful handbook in the lead up to this meeting by reviewing the overall challenges of climate change, what levels of CO<sub>2</sub> individual countries (especially the main polluters) have set as their targets for the coming decades, the extent to which these targets are likely to be met and how new targets with more aggressive reductions will be required to keep CO<sub>2</sub> levels between 300 and 350 ppm by 2050 and then maintained going forward. The recently reported level was 416 ppm. But these issues raise the daunting question: how are they to be achieved? This question forms the basis of the remainder of the book and it was this part that really engaged this reviewer during a ZOOM event with the two authors.

*The Story of CO<sub>2</sub>* reviews first the essential but challenging move away from fossil fuels for energy generation and the embrace of renewal energy sources (wind, solar, tidal and geothermal), and the replacement of road vehicles (and other modes of transport) using fossil fuels with electric vehicles relying on battery storage. While reducing the carbon footprint, these changes would also bring a dramatic reduction on the particulates that are so damaging for human health. While considering the potential for these energy sources, the storage of energy to meet the changing demand within the electricity grids and the transition towards renewal sources have immense policy implications for every country but especially for the major polluters. To reach targets by 2050 will require some mitigation by storing CO<sub>2</sub>. Much concern has been expressed about the viability of storing CO<sub>2</sub> underground within porous rocks with which the CO<sub>2</sub> reacts to form carbonates. Other storage options for CO<sub>2</sub> flue gases include amine solutions in what are interconnected absorber and stripper towers that gradually concentrate the CO<sub>2</sub> stream. Even stripping CO<sub>2</sub> from the atmosphere is part of current R&D investigation and some pilot plants are operating.

While most attention is on CO<sub>2</sub> because of its release into the atmosphere in such large quantities, other gases are also strong greenhouse gases and have high global warming potential (GWP). Over a twenty-year period and compared to CO<sub>2</sub>, GWP for methane is 84, for nitrous oxide 264 and for CFCs 6,000 to 11,000. Sulphur hexafluoride that is used in torpedo- and missile-propulsion engines has a GWP value over 100 years of 23,900 compared to CO<sub>2</sub>.

But the really intriguing part of the book for chemists and historians of chemistry is the section on the future role of CO<sub>2</sub> as a chemical feedstock for those essential chemicals that today are derived from petroleum. It is this extensive section of the book where the two authors bring important insights and highlight current worldwide initiatives.

Geoffrey Ozin is a distinguished university professor at the University of Toronto and Government of Canada Research Chair in Materials Chemistry and Nanochemistry, and Mireille Ghoussoub is a doctoral candidate in Materials Chemistry working with the Solar Fuels Team at the University of Toronto.

While today manufacture of most chemicals relies on fossil-derived feedstocks increasing attention is being given to using CO<sub>2</sub> as a feedstock. One example focuses on methanol which today is a major fuel as well as a feedstock for many synthetic chemicals. While CO<sub>2</sub> is a very stable chemical, attempts are underway to produce methanol using CO<sub>2</sub> and hydrogen (from the electrolysis of water). The main challenge is finding an effective catalyst. The earlier process for producing methanol used a chromium and manganese oxide-based catalyst with a feedstock of synthesis gas (carbon monoxide and hydrogen). Current catalysts are more accommodating of CO<sub>2</sub> present in the feedstock. The search is currently underway to find an effective catalyst for a feedstock of CO<sub>2</sub> together with hydrogen. Many other industries including fertilizers, steel and cement are also put under the microscope.

Underpinning the book's narrative is the daunting task for governments as they navigate policy changes to transitions from fossil fuels to renewal energy sources while also encouraging R&D and entrepreneurial ventures to move towards CO<sub>2</sub> as a chemical feedstock. So many of the issues are in themselves complex but they are also closely interconnected when trying to lower carbon footprints. There are questions underpinning these considerations: to what extent will countries share new technologies to resolve what is a global issue and should a new global organization have some oversight?

This book is thoroughly recommended to all chemists irrespective of their specialist area and historians of chemistry who have an interest in how chemists and chemistry are confronting the existential threat of climate change. It is also a progress report on likely directions of travel on CO<sub>2</sub> mitigation, with early indications outlined in the book pointing to many promising industrial ventures. A revised and updated edition would be valuable within the next few years to highlight progress while pointing out the technical challenges that remain. In the meantime, the book's list of companies (with their website) engaged in the transformation of CO<sub>2</sub> allows readers to further review these important ventures that are likely to determine how successful we are in achieving the goal of keeping global temperatures between 1.5°C and 2°C above pre-industrial times.

Peter Reed  
Carmichael, California, USA.

Donovan Moore, with a Foreword by Jocelyn Bell Burnell, *What Stars Are Made Of: The Life of Cecilia Payne-Gaposchkin* (Cambridge Mass., Harvard University Press, 2020). Pp. 320. ISBN 9780 6742 37377, £23.95, hardback.

Cecilia Payne-Gaposchkin (1900-1979) of the Harvard Observatory - often referred to just as Cecilia Payne - was the first person to determine the elemental composition of the stars quantitatively from their spectra. She did so in 1925 at the start of a long career leading to her publishing over 250 papers and several books in astronomy and astrophysics. However, it was not until 1956 that she was finally promoted to full professor, becoming the first woman to hold this rank at Harvard. She was a superb teacher; her lectures were very popular, except that they were long given 'anonymously', inasmuch that it was to be over two decades before her name was included in the Harvard course catalogue.

Spectroscopy had been used in astronomy for around half a century by the time that Cecilia Payne moved from Cambridge England to Cambridge Massachusetts in 1923 to start postgraduate work. Harvard had by then amassed a very large collection of photographic plates of spectra, which, although classified in terms of star type etc., awaited interpretation. Her initial aim was to use them to test the newly-derived Saha ionization distribution, a first theoretical attempt account for the effects of pressure and temperature on ionic speciation. However, it soon became clear that it worked well enough to allow elemental abundances to be estimated (it was refined a little later by Fowler, Milne and Russell to take excited states into account). She made two very significant findings: Firstly, that the abundancies of elements heavier than Helium were similar in all the stars for which spectra were available and similar to those on Earth. Secondly, that the stars comprised mainly Hydrogen and Helium.

The first conclusion was in line with expectation, since it provided observational confirmation of the presumption of 'uniformity' (of composition) espoused by leading astronomers such as Arthur Eddington, meaning that it had the status almost of dogma, even if unproven hitherto. Her second conclusion was a considerable surprise and counter to the thinking of the time regarding stellar evolution, to the point that she was required to suppress it in order to make her thesis acceptable to Harlow Shapley, her supervisor, and to her external examiner, Henry Norris Russell of the Princeton Observatory (and the USA's leading astronomer). She was persuaded that the apparent abundance must be some sort of anomaly and somehow not

representative of the bulk composition. She was nevertheless correct, as others, including Russell, were soon to find using somewhat different methods within a very few years. Moreover, it was to be a long time before she received proper recognition. However, the first conclusion was enough to make a big impact. Her thesis was published and widely distributed by Shapley (who had ambitions to raise the status of the Observatory to that of a Harvard University department, with all that entails) as *Harvard Observatory Monograph* number one, with a print run of 600 copies. This was more than enough to saturate the astronomy world at the time.

Chance events and encounters played a large part in defining Cecilia Payne's career. She went up to Newnham to read biological sciences in the first instance, but in her first year she was given, by chance, a ticket to a public lecture by Eddington, a lecture that changed her life. As a scientist she could not transfer to Astronomy at Cambridge, as such, since it was part of Mathematics, so she joined the Cavendish Laboratory to read physics, at a time when it was starting to embrace early quantum physics, although she attended astronomy lectures too. As a result, she received a preparatory education in astrophysics, in effect, not available elsewhere or hitherto. Joining the Newnham and Cambridge Astronomical Societies gave her telescope access and throughout her life she got by with little sleep (a necessary qualification for astronomers perhaps).

Donovan Moore, a mathematics graduate, but journalist and TV producer by trade, has, to my mind, written a most engaging and readable account of the life and times of an exceptional and important pioneering woman scientist. One who, like other determined and patient women, faced huge barriers because of her sex, with the result that she only achieved just rewards and professional status and recognition rather late in life. However, the book is not entirely without its shortcomings. The book is very light on scientific detail, which might frustrate some readers, even if the author's aim was to make the book accessible to a wider audience. British readers are likely to notice that the author struggles a little with some aspects of the English class and educational systems. The narrative of Payne's later life is rather compressed, particularly when compared with her early life and career. However, overall this is an extremely enjoyable and informative read, and one full of incident and surprise. For example, the story of how Payne met her Russian husband and how she rescued him from an increasingly dangerous Germany would not seem out of place in an Alan Furst historical spy novel. The cast of characters is impressive, as

many of the better-known pioneers of astrophysics and cosmology are there. These names are as famous as Cecilia Payne should be, and, hopefully this biography will help to continue to redress the balance.

Richard Buscall

## RSCHG WEBINAR REPORTS

### Joseph Priestley's Later Life - Helen Cooke (January 2021)

This talk started with a brief recap of his early life, before picking up on Priestley's story after leaving Nantwich in 1761. Priestley held a number of ministerial and tutoring positions at locations across the UK. His first move after Nantwich was to Warrington, where he developed a network of influential people who helped inspire his experiments and discoveries. Priestley's life was dedicated to his religious non-conformist beliefs, but he always found time for science. While living next to a brewery when a minister in Leeds, Priestley investigated the properties of carbon dioxide and when a tutor in Calne, Wiltshire, he discovered oxygen. Priestley's most important discoveries were highlighted and short videos created by Dr Fabio Parmeggiani brought these to life. Priestley was a prolific writer and some of his publications were discussed, including his famous *Experiments and Observations on Different Kinds of Air*. His publications reflect his many interests, including religion, theology, dissent, education, science, philosophy and politics. Over his lifetime, his religious writings were four times as numerous as his scientific ones. In his later years, Priestley's political and religious opinions angered many and concerned his supporters, eventually causing him to emigrate with his wife to Northumberland, Pennsylvania, USA where he joined two of his sons who had gone before him. Priestley continued to write, perform experiments, and add to his library which became the centre of his life in his later years.

### Davy, Faraday and Electro-chemistry - Frank James (February 2021)

This talk focussed on the crucial importance of language in the development of electro-chemistry, a term Humphry Davy had coined by 1808 if not earlier. James noted that following the 1800 announcement by Alessandro Volta of his discovery that a pile of alternate acidified metallic discs would produce an electric current, the twenty-one-year-old Davy, Superintendent of the Medical Pneumatic Institution in Bristol, turned his attention to this wonderful new phenomenon. Davy's one time patron Davies Giddy noted in his diary after dining with Davy

on 7 August 1800, that 'pile' had become a 'battery' in what appears to be the earliest use of the term in this context, though whether it was Giddy's coinage or Davy's is unclear. Early in 1801 Davy moved to the Royal Institution in London where he would spend slightly more than a decade gaining access to ever more powerful batteries. With these he isolated a number of chemical elements for the first time including what he initially called (in accordance with Lavoisierian nomenclature) potogen, but soon named it potassium to stress its metallic nature. Though, as James pointed out, this name was not universally adopted with Kalium (K) used instead.

Turning to Davy's successor at the Royal Institution, Michael Faraday, James commented that it was noticeable that Faraday did not carry out any electro-chemical research until after Davy's death – possibly in an effort not to further inflame their already tense relationship. When Faraday did start investigating electro-chemistry it was in the context of attempting to quantify electricity using electro-chemical decomposition as a measure. That led to Faraday's two laws of electrolysis, a word that he introduced into chemistry though may have been originally coined by Whitlock Nicholl, a Member of the Royal Institution. As a result of his experimentation, Faraday realised that the entire theory of electro-chemistry needed to be overhauled and that, in his view, required a theory neutral language. Thus, what had been a pole now became an electrode and what passed between them zetodes, both usages probably attributable to his conversations with Nicholl. But that appears to have been the limit of Nicholl's ability to contribute, so Faraday turned to William Whewell of Trinity College, Cambridge, well known for his neologisms. James went through the 1834 correspondence between the two men from which, out of a lot of possibilities, emerged the now familiar words of anode, cathode and ion. Though Faraday was 'fully aware that names are one thing and science another' (and James left his audience to ponder the significance or otherwise of Faraday putting this passage into paragraph 666 of his *Experimental Researches*), one does wonder whether stecheon or zetode would have had the same usefulness as ion?

### Paraquat: A Historical Reflection - Diana Leitch (March 2021)

In this talk, the background to what is still a commonly used fast-acting herbicide, Paraquat, was described. It also explored the oral history project that Leitch has undertaken with people who worked on Paraquat's production in north-west England at ICI Pilkington Sullivan Works in Widnes. The herbicide's role in a change of farming methods and the toxicological problems associated with it were also considered.

### **Drugs, ICI and the molecularisation of disease - Viviane Quirke** (April 2021)

By developing Inderal, the first successful beta-blocker for the treatment of heart disease, ICI helped to make receptor theory a reality. Later, their anti-cancer drug Nolvadex (tamoxifen) became a research tool for investigating the newly discovered oestrogen receptor. By bridging the gap between theory and practice, these drugs not only improved the outlook for sufferers, but by a process that has been referred to as the ‘molecularisation of disease’, transformed medicine in the second half of the twentieth century. Inderal and Nolvadex were attributable to ICI’s ability to attract outstanding scientists like James (later Sir James) Black, build research networks with external laboratories such as that of Craig Jordan at Leeds, and – importantly – to the accumulation of ICI’s in-house scientific and technical expertise. In her talk Quirke argued that such factors created a reliance on particular individuals which locked ICI into avenues for research that could be described (with the benefit of hindsight) as less fruitful, both scientifically and commercially.

### **History of Dyes: from Ancient Egypt to Modern Times - Christine Holdstock** (May 2021)

Dyes have been used since ancient times to colour fabrics. Up to 1856 all dyes came from natural sources, mainly plants but also insects and shellfish. For thousands of years, the three main European dye plants were woad, madder and weld. The blue dye indigo is obtained from the woad plant and has been identified in textiles that are about 4000 years old. The roots of the madder plant give a red dye and a yellow dye is obtained from the weld plant, both these dyes (and many other natural dyes) require a “mordant” (a metal salt - often alum) to fix them to the textile. When weld is over-dyed with woad it gives the famous “Lincoln Green” colour associated with Robin Hood.

In 1856 a young chemist, William Henry Perkin produced the first synthetic dye mauveine, and, realising its potential, set up a factory to manufacture it. The new colour became very fashionable and soon other synthetic dyes were being made from coal-tar aniline, which led to brightly coloured fabrics becoming widely available for everyone not just the wealthy. Methods for synthesising the important natural dyes, Alizarin red (from Madder) and indigo were invented in the 1860s and soon synthetic dyes replaced the natural dyes. From the 1920s to the 1950s synthetic fibres such as cellulose acetate, nylon and polyester

were invented and new dyes were needed to colour these, leading to the invention of new types of dyes such as disperse dyes.

As well as for fashion, dyes today can be also designed for functional uses and high-tech applications. Chromic dyes react to environmental conditions and stimuli, by changing colour, for example thermochromic dyes change colour as a result of temperature change, these can indicate whether something is too hot so are used in safety applications. Dyes are also used in mobile phone and computer screens, for solar energy conversion and optical data storage. New types of dye have been developed recently which have significant applications in the treatment of medical conditions such as skin cancer and infected wounds. This is known as Photodynamic therapy as the dye is activated by light of a particular wavelength. The photoexcited dye produces singlet oxygen inside the cancer or bacterial cells which kills the cells. Today Photodynamic therapy has considerable clinic use for certain cancers, and the antimicrobial properties of the technology have the potential for tropical disease therapy in the future.

### **History of Laboratories from 1600-2000 - Peter Morris** (June 2021)

Chemical laboratories have existed since the late sixteenth century. Two basic designs have dominated this history: a furnace centred laboratory based on earlier alchemical workshops up to around 1820 and then a design based on the use of the Bunsen burner with benches and bottle racks since the 1850s (the “classical” laboratory). New designs with a focus on health and safety began to appear at the end of the twentieth century. There has been an important interaction between the design of the laboratory and chemical practice, including how chemistry was taught. In particular, the introduction of running water and piped gas was crucial to the creation of the “classical” laboratory in the 1860s. One aspect of the classical laboratory which has disappeared is the chemical museum. The talk covered a variety of laboratories, and also the social organisation of the laboratory, before finally looking at the future of chemical laboratories and chemical practice.

### **Marie Curie, Radium and its Early use in Medical Therapy - Alan Dronsfield** (July 2021)

In 1895 Wilhelm Roentgen was astonished to find that his high voltage discharge tube emitted invisible rays that could “fog” photographic film contained within light-proof envelopes. Interposing a hand between the source of the rays and the film in its envelope yielded the world’s first

X-ray photograph. Henri Becquerel thought he might replicate Roentgen's work by exposing fluorescent or phosphorescent substances to light and seeing if the emitted light associated with the fluorescence or phosphorescence might also penetrate light-proof envelopes and similarly blacken photographic film. He found just laying a piece of uranium ore on a paper envelope containing the film afforded a blackening effect identical to that produced by Roentgen's X-rays. It was 1896 and radioactivity had been discovered.

Pierre Curie investigated this phenomenon and found that he might assess the magnitude of the radioactivity by seeing how long it took for the mystery rays to discharge a charged electroscope of his own design. He married the talented Polish chemist Marie Skłodowska in 1895 and the couple, working in the same department of the *École Supérieure de Physique et de Chimie Industrielles, Paris*, sought a project upon which they could work collaboratively. Using the Curie electroscope, they quantified the activity in various substances and were perplexed that the radioactivity from the ore pitchblende was greater than could be explained from its uranium content alone. With insight, they deduced that a much more active, hitherto unknown, element must be present and they set about the heroic task of isolating it. Success was achieved in 1902 when they reported a new element, *radium*, 0.1g of radium chloride having been painstakingly isolated from seven tonnes of the pitchblende ore. The effects of its emanations seemed to mimic those of X-rays, so it is not surprising that there was a commonality in its early medical applications. Radium glowed in the dark and spontaneously, gave off sufficient heat to be detected by a thermometer. It was, apparently, an inexhaustible source of energy. This attribute was soon taken up by charlatans determined to deprive the gullible of their money with a host of "revitalising" patent medicines, sex aids and the like. Some of the early twentieth-century applications were so outlandish that one is tempted to think that they featured in "spoof" rather than genuine adverts.

## MEETING REPORTS

### Computational Approaches to the History of Chemistry

On 22-23 March 2021 Jürgen Jost and Guillermo Restrepo organised this on-line meeting, which was hosted by the Max Planck Institute for Mathematics in the Sciences (<https://www.mis.mpg.de/calendar/conferences/2021/comap.html>). There were nine forty-minute lectures and two discussion sessions. The aim of the meeting was to discuss the pros and cons of computational

approaches to the history of chemistry, to explore the available data and the data structures required for further computational studies, and to present several case studies. As noted by the organisers, chemistry, as the science with the largest output of publications, is not short of data. This is currently well structured in electronic databases, which constitute an important source of information for historical studies. However, as is true for all sciences, chemistry is more than its material system and it entails other aspects that are not as efficiently and historically recorded in electronic form. Discussing the data and data structures of these non-material systems of chemistry was a further objective for the meeting.

The formal setting for the evolution of chemical knowledge arising from the mutual interaction of the social, semiotic and material systems of chemistry was introduced by Jürgen Jost and Guillermo Restrepo. The social system comprises chemists and their institutions and forms of organisation. The semiotic system corresponds to the signs and concepts devised by chemists to communicate their findings and theorise upon them. Substances, reactions, technologies and apparatus constitute the material system of chemistry. According to Jost and Restrepo, the interaction of these systems can be modelled as a complex dynamical system, which, when unfolding over time, constitutes an important tool for the history of chemistry.

Carsten Reinhardt provided an example of the interaction of the three systems of chemical knowledge, when discussing the rise of chemical instrumentation in the 1950s and its social, semiotic and material conditions. This included new forms of scientific organisation after World War II, novel electronic-based technologies, as well as semiotic objects, such as spectra and software. Evan Hepler-Smith showed how nomenclature systems and methods to store chemical information resulted from the interaction of social interests with the amount and diversity of chemical substances and the different ways of highlighting relevant aspects of these substances. Gerd Graßhoff, when discussing his computational model for the discovery of the urea cycle, emphasised the importance of including semiotic, material and social aspects in those models. These were represented as the ways of encoding chemical knowledge, the number of substances and reactions, and the scientific influences constituting the discovery context.

By analysing some aspects of the social, semiotic and material systems of chemistry in the nineteenth and twentieth centuries, Jeffrey Johnson considered the growth of chemistry institutes and staffs, as well as the number of scientific publications and the growth of inorganic and

organic chemistry. He found that after World War I growth reduced and he highlighted possible reasons tied to the public perception of chemistry and to the social establishment of chemists. Johnson emphasised the importance of data sources such as the *Chemisches Zentralblatt*, now fully available in electronic form, for historical studies of chemistry. Johnson also discussed the H. Plessner-C. von Ferber non-digital database for comparative studies of the evolution of the chemical community, which represents a target source to be digitised.

When discussing data for computational studies on the history of chemistry, Peter Stadler emphasised the highly structured data for the material system of chemistry available today in large repositories of chemical information. This gathers together information on substances and reactions. Stadler showed how a formal setting for chemical reactions, such as regarding them as graph rewriting rules acting upon molecular structures, may enable us to trace the historical rise of new reaction classes and even to solve questions of the sort “what if” by perturbing the data.

An instance of the highly structured data of the material system, discussed by Stadler, is the Reaxys® database, which results from the merging of the Gmelin and Beilstein Handbooks and incorporates chemical information from the most salient contemporary chemical literature. The exploration of Reaxys® to pose and solve historical questions was the subject of Guillermo Restrepo’s talk. Restrepo showed that the number of new substances taking part in chemical reactions (chemical space) has historically expanded in an exponential way following three clearly distinguishable regimes, with transitions occurring in 1860 and 1980.

Regarding the binary relationships between the constitutive systems of chemical knowledge, Hepler-Smith provided an example of the social-semiotic relationship when illustrating how chemical nomenclature has been related to social interests of national chemical communities, for instance at the Geneva congress of 1892. Restrepo provided an example of the social-material interaction through the effect of World Wars upon chemical production. Gerd Blanke illustrated the semiotic-material relationship, where semiotic factors such as the advent of machine learning algorithms, coupled with material factors such as the growing number of chemical reactions, have led to developing further semiotic objects, for instance machine readable representations of chemical reactions. Blanke and Stadler discussed the history of molecular representations, with Blanke emphasising their use for encoding

information on chemical reactions for chemoinformatic and history of chemistry purposes. Jonathan Goodman presented the advantages and disadvantages of several annotation methods for molecular structure and highlighted the semiotic load of molecular representations, as they affect the way chemists regard molecules. He stressed the advantages of RInChI for computational studies related to chemical reactions and mentioned the discussions in the chemical community about what to include and what not to include as part of this annotation procedure for reactions.

Computational approaches to the history of chemistry have both advantages and disadvantages. As pros, the importance of these approaches for detecting large-scale historical patterns was mentioned. A further advantage was the possibility of reconsidering accepted ideas in the history of chemistry with support on large corpora of data. In this case, the role of synthesis in the expansion of the chemical space can be mentioned, as discussed by Restrepo. It is traditionally accepted that synthesis began after Wöhler’s synthesis of urea in 1828. However, the evolution of the chemical space shows that synthesis played a major role in the expansion of the chemical space throughout the entire nineteenth century. A second example challenging accepted ideas involved the historical study of the interplay between the chemical space and the periodic system. Restrepo showed that the size and diversity of the chemical space in the 1840s already provided the salient features of the periodic system of the 1860s, which contrasts with the accepted account that the ripe moment to formulate the system was in the 1860s. A further advantage of computational methods involved the possibility of asking new historical questions and even of perturbing the data and observing the resulting temporal effects, as discussed by Stadler. Some of the disadvantages of computational approaches involve the lack of stable historical records, as highlighted by Blanke, who made the point that electronic databases, especially if updated regularly, may change the historical record by introducing new data from the past or by correcting annotation errors. The need to store stable dumps of these databases was discussed. This requires negotiations with database providers and also a computational infrastructure to store and share this information to assist the research of historians of chemistry. A discussion on the suitability of information for historical studies and the kinds of formats pertaining to the systems of chemical knowledge followed. The rich and structured information of the material system of chemistry was highlighted, which contrasts with the isolated databases for the social system and the lack of semiotic databases.

The meeting concluded with the general sentiment that computational methods constitute a suitable tool to complement methods of research in the history of chemistry. Crucially, the further advance of these approaches requires interdisciplinary work amongst historians, chemists, mathematicians, computer scientists and other specialists.

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### **FORTHCOMING ONLINE SYMPOSIUM**

The fortieth annual meeting of Dyes in History and Archaeology is being organised by the British Museum, London, and will take place between 15 and 19 November 2021. Sessions of the entirely online event are planned for 15:00 – 17:00 GMT each day. Information about the programme will be available after 15 July 2021. <https://www.dha40.uk/>.