Historical Group

NEWSLETTER
and
SUMMARY OF PAPERS

No. 73 Winter 2018

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RSC Historical Group Newsletter No. 73 Winter 2018

Contents

FROM THE EDITOR

Welcome to the winter 2018 RSC Historical Group Newsletter. The next meeting organised by the group explores some of the Chemical Consequences of the First World War and will take place on Wednesday 14 March 2018 at the Royal Society of Chemistry, Burlington House. Full details on how to register for the meeting can be found in the flyer enclosed with the hard copy version of the newsletter and also in the online version.

This issue contains a wide variety of news items, short articles and reports. Following on from the RSCHG meeting held last October, Alan Dronsfield, Margaret Hill and John Pring write about "Halothane – The First 'Made to Measure' Anaesthetic". Chris Cooksey and Peter Morris contribute to the occasional series, "Mauveine – The Final Word? (5)" and Jeffery Leigh comments on "The *Conversations* of Jane Marcet and Delvalle Lowry". Michael Jewess has contributed an essay review of Jim Baggott's book, *Mass: The Quest to Understand Matter from Greek Atoms to Quantum Fields*. Since the summer 2017 newsletter, the group has organised or contributed to a number of meetings. Members who were unable to attend will be able to enjoy reports on these events, including the RSC's Symposium Commemorating the 150th Anniversary of the Gesellschaft Deutscher Chemiker.

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

The deadline for the summer 2018 issue will be Friday 8 June 2018. Please send your contributions to a.simmons@ucl.ac.uk as an attachment in Word. All contributions must be in electronic form. If you have received the newsletter by post and wish to look at the electronic version, it can be found at: http://www.rsc.org/historical or http://www.sbcs.qmul.ac.uk/rschg/

David Knight (1936-2018)

As the online *RSCHG Newsletter* went to press, it was with great sadness that we learnt of the death of David Knight on Friday 19 January 2018. Eminent as an historian of chemistry and of the links between science and Romanticism, especially in the work of Humphry Davy. David served as Professor of the History of Science at the University of Durham and Editor and President of the British Society for the History of Science.

David was the author of a series of well-received books, including *Ideas in Chemistry. A History of the Science* (London: Athlone Press, 1992); *The Making of the Chemist: The Social History of Chemistry 1789-1914* (Cambridge: Cambridge University Press, 1998); *Science in the Romantic Era* (Aldershot: Ashgate Variorum, 1998); *Humphry Davy: Science and Power* (Cambridge: CUP, 1998); *Science and Spirituality: the Volatile Connection* (London and New York: Routledge, 2004); and *The Making of Modern Science: Science Technology, Medicine and Modernity 1789-1914* (Cambridge: Polity, 2009). He served on the editorial boards of *Annals of Science*, *Ambix*, *Foundations of Chemistry* and *Interdisciplinary Science Reviews*.

David was a long-standing member of the Royal Society of Chemistry Historical Group and he spoke at a number of the group's meetings and also at the RSC Annual Chemical Congress. His Wheeler Lecture, *Davy and the Placing of Potassium among the Elements,* was published as the group's fourth *Occasional Paper* in August 2007.

We extend our sympathy to his wife Sarah, his children and all his family. He will be greatly missed by all his family, friends and colleagues.

An obituary will appear in the summer 2018 *RSCHG newsletter*.

Anna Simmons
UCL

MESSAGE FROM THE CHAIR

Welcome to the latest edition of our Newsletter. We publish the Newsletter in two formats – online and hard copy. The online version is accessed via the Historical Group's page on the RSC website, and also posted on the Group's page hosted by Queen Mary University of London. You should get an automatic email from the RSC when the latest version is available, but for the record the Newsletter appears twice each year – usually in January and July. If you don't receive an automatic email from the RSC please contact the RSC membership department to make sure you have opted in to receive electronic communications from the organisation. In the online version, we have greater flexibility in presenting some of the material – for example, it is possible to reproduce some of the illustrations in colour. We post the hard copy version to those members who request it. Printing and posting the hard copy version is expensive, and if you are receiving the Newsletter in hard copy and would be happy to read it online, please send an email to our Membership Secretary, Bill Griffith (w.griffith@ic.ac.uk). Similarly, email Bill if you don't currently receive the hard copy and would like to do so.

Last year was another successful one for the Group. Once again, we published two high quality editions of the Newsletter. I am delighted that the practice of each edition containing a few short essays on historical topics is now well established – please keep them coming. Chemistry has been called the central science, and two of the three 2017 symposia emphasised the application of chemistry in other areas. These featured the role chemists played in understanding radioactive processes in the early twentieth century, and the role chemistry has played and continues to play in the development of anaesthetics. Synopses of the papers presented are included in this issue. These two meetings were collaborative events with the historical groups of the relevant disciplines (the History Group of the Institute of Physics and the History of Anaesthesia Society respectively). Members of our Group provided significant assistance when a celebration was held at Burlington House to mark the 150th anniversary of the German Chemical Society. Finally, we published an Occasional Paper by Peter Morris entitled *Robert Burns Woodward in his Own Words*.

In the recent past we have all been remembering World War 1. While the terrible human toll has been foremost in our minds, the conflict had many enduring impacts. Among these were the consequences for chemistry, and this is the topic for our symposium in March 2018. I expect this symposium to be popular, so please sign up early; details are included in this issue. Our autumn symposium is on the subject of dyes, a topic that I am sure will interest many members and further details will appear in the summer 2018 newsletter.

But in the meantime, enjoy this edition. I am not going to apologise when I repeat what I have said in the past, namely that the Newsletter is a credit to our Group, and a huge "thank you" is due to our Editor, Anna Simmons, for all her hard work.

John Hudson
RSCHG Chairman

ROYAL SOCIETY OF CHEMISTRY HISTORICAL GROUP MEETINGS

Some Chemical Consequences of World War 1

Wednesday 14 March 2018, Burlington House, Piccadilly, London

10.30-11.00: Registration, Tea or coffee

Session Chairman: John Hudson

11.00: John Nicholson, *The Consequences of World War 1 on the Education of Chemists*

11.30: Brian Balmer, *Porton Down after World War 1*

12.00: Alan Dronsfield, *Fighting Cancer with Chemicals – The Mustard Gas Connection*.

12.30–14.00: Lunch. This is not provided but there are various eating places nearby.

Session Chairman: Alan Dronsfield

14.00: Mike Sutton *Munitions, Mergers and Military Imperatives: from WW1 to ICI*

14.30: John Hudson, *James Morton and the Formation of Scottish Dyes Ltd*

15.00: Cliff Lea, *WW1 – The Catalyst which Spurred the Development of Britain's First Onshore Oil Wells*.

15.30–16.00: Tea

Session Chairman: John Nicholson

16.00. Peter Morris, *Ersatz Rubber in Germany*

16.30: Peter Reed, *The Hesitant Emergence of Chemical Engineering in the Aftermath of the Chemists' War*

17.00-17.10: Concluding remarks.

REGISTRATION FORM

There is no charge for this meeting, but **prior registration is essential**. Please use the form below and send it to Professor John Nicholson, 52 Buckingham Road, Hampton, Middlesex, TW12 3JG, or email jwnicholson01@gmail.com. **As usual, this is expected to be a popular meeting so, if having registered, you are unable to attend, please notify Professor Nicholson.**

I wish to attend the HG meeting on 14 March 2018 at Burlington House, Piccadilly, London on **Some Chemical Consequences of WWI**.

Name……

Address……..

Email…….Acknowledgement required: Yes/No

OBITUARY

Frederick Kurzer (1922-2017)

Frederick Kurzer (affectionately known simply as "Fred") was a Fellow of the Royal Society of Chemistry for over seventy years and a member of the Historical Group since its foundation. He was born in 1922 in the beautiful spa town of Karlsbad in the German-speaking area of what was then Czechoslovakia, now the Czech Republic. He lived in Karlsbad with his parents until 1939 when the family fled to London to escape the Nazis. After graduating in chemistry at the former Chelsea College of Science and Technology he took his doctorate at King's College, London. Following a period in industry he moved into academia at the Royal Free Hospital School of Medicine, first at its Hunter Street site in central London and then at its medical school in Hampstead until his retirement as Reader in Biochemistry in 1987. As well as lecturing to medical students in chemistry, biochemistry and pharmacy, Fred was also responsible for a research laboratory specialising in heterocyclic chemistry that attracted many British and overseas doctoral students. His research was published by the Royal Society of Chemistry, the Royal Society, *Angewandte Chemie* and other peer-reviewed journals.

Fred had a creative and exploratory chemical mind but at the same time he was modest and possessed of warm human attributes such as a wry sense of humour and being kind and tolerant with his research students. Not only was he highly respected as a chemist, but he had many interests outside the laboratory, including the history of science. Although he published a few historical papers as a young man, it was in retirement that he found the time to delve into archives and to publish significant papers on the chemical work of Samuel Parkes, Charles Tomlinson, William Hasledine Pepys, Arthur Church, and the lexicographer, Samuel Johnson, as well as the scientific activities of the "lost" Surrey and London Institutions. These papers were meticulously researched and are models of how the chemical historian can make invaluable contributions to the history of science.

Apart from the sciences, Fred was also versed in the arts and humanities, with a great love of classical music, books and ornithology. He especially enjoyed long walks by the Thames and in the Lea Valley. He was true Renaissance man – intellectual, always questing for knowledge, and deeply knowledgeable himself. A kind and generous man who hid his many talents, he was one of the "old school" of gentleman bachelor scientists who had little interest in television, the internet, sports or celebrity gossip. He remained content with the radio, a

newspaper, his library and his circle of friends and former students, and occasional attendance at meetings of the RSC Historical Group or of the Society for the History of Alchemy and Chemistry. During the past three years, as the result of a period of hospitalization, he was compelled to abandon his London flat where he had always enjoyed his independence. He reluctantly moved to a residential home in Golders Green accompanied by his familiar writing desk and chair. He continued to work at his desk most mornings and his only regret was that space restrictions prevented him from being surrounded by his fine collection of books and memorabilia. Mentally sharp until the end, aged ninety-five, Fred passed away peacefully in his sleep on 11 October 2017.

Stanley S. Langer

William H. Brock

Select Bibliography of Dr Kurzer's Historical Publications

"An Early Application [1907] of Paper Chromatography", *J. Chem.Educ.,* 1978, **55,** 312-22.

"Samuel Parkes: Chemist, Author, Reformer", *Annals of Science,* 1997, **54**, 431-62.

"Samuel Parkes' Lost Analyses of Roman Imperial Brass Coins", *J. Historical Metallurgy Society*, 1998, **32**, 47-53.

"Life and work of Edward Charles Howard, FRS", *Annals of* Science, 1999, **56**, 113-41.

"The Surrey Institution", *Annals of Science*, 2000, **57**, 109-41.

"Fulminic acid in the History of Organic Chemistry", *J. Chem. Educ.*, 2000, **77**, 851.

"Chemistry and Chemists at the London Institution", *Annals of Science*, 2001, **58**, 163-201.

"William Hasledine Pepys", *Annals of Science*, 2003, **60**, 137-83.

"Chemistry in the Life of Samuel Johnson", *Bull. Hist. Chem.*, 2004, **29**, 65-88.

"Life and Work of Charles Tomlinson, FRS", *Notes and Records of the Royal Society*, 2004, **58**, 203-26.

"Arthur Herbert Church, FRS and the Palace of Westminster Frescoes", *Notes and Records of the Royal Society*, 2006, **60**, 139-59.

"George S.V. Wills and Westminster College of Chemistry and Pharmacy", *Medical History*, 2007, **51**, 477-506.

NEWS FROM CATALYST

Widnes Successes: The Widnes Research Laboratory and the Catalyst Science Discovery Centre and Museum

On 5 October 2017 I received an email from Ian Campbell, a former ICI Research Chemist, who is a Friend of the Catalyst Science Discovery Centre in Widnes regarding an interesting article in that week's *Widnes Weekly News*. It was entitled "Science Honour for Lab" and reported that a former ICI laboratory in Widnes where a life-saving invention was created had been named among the top ten places in the science and discovery section of Historic England's campaign "Irreplaceable: a History of England in 100 places". He wondered if I knew anything about this as the Widnes Research Lab had been chosen by Professor Lord Robert Winston.

Indeed, I did. Back at the end of June 2017 an article had appeared in the *Manchester Evening News* entitled "Search on for Historic Places" which was encouraging the public to nominate famous places that would be voted for. At the end of the article it said that Historic England was looking for places in north west England in the hope of uncovering some hidden gems. The closing date for submission was early July 2017. With two days to go I put forward a proposal for the great Widnes Research Laboratory of ICI General Chemicals Division where in the 1950s the first ever non-flammable anaesthetic Halothane (Fluothane) was invented by Charles Suckling (1920-2013) CBE, FRS, BSc, PhD, DSc (Liverpool). I heard no more until I received the email from Ian Campbell. On investigation I discovered that the ten places chosen for their historic scientific significance were Greenwich Observatory, Bletchley Park, Jodrell Bank, Ouse Wastes, Cambridgeshire, Calder Hall/Sellafield, Brown Firth, Sheffield (stainless steel), Jenner Hut, Gloucestershire, MRC Biophysics Unit at King's College (DNA Structure), Soho water pump (cholera)...and Widnes Research Laboratory. What a line-up to be part of. Many other major achievements occurred at Widnes Lab (uranium analysis, the vinyl chloride process, the insecticide Gammexane, the weedkiller Methoxone, Freons and PTFE to name a few) but Halothane revolutionised surgery and greatly improved patient safety when anaesthetics were used. It was also the first drug to be created by molecular design following on from a precise definition of the functional requirements of a new anaesthetic agent, a definition that allowed the necessary clinical response to be translated into chemistry. James Raventos (1905-1982), a Catalan pharmacologist with an exemplary record as an experimentalist, based at ICI Dyestuffs Division at Blackley in north Manchester, defined the key requirement and ICI Research Director John Ferguson (1899-1981) initiated the project. In February 1951 he met with Charles Suckling at his lab bench in Widnes and asked the question "Do you think these two papers of mine (on narcosis) could help a search for an inhalant anaesthetic amongst compounds containing fluorine?" Suckling was able to invent such a molecular compound ($CF_3CHBrCl$) with all the key required properties and it was first prepared in January 1953 and patented in February 1957. Clinical trials were carried out by Michael Johnstone at Manchester Royal Infirmary and an internal ICI report from Raventos and Suckling written on 20 January 1956 stated "Fluothane was used for the first time on human beings this

morning in MRI with results which so far have proved entirely satisfactory". Robert Winston as a doctor would have known and appreciated what a change Halothane brought about for surgeons, anaesthetists and millions of patients alike for several decades after its invention. Today Fluothane is not the anaesthetic of choice in the UK but is still used and was being used in surgery in Malawi just two weeks ago.

The building where it was invented has gone, swept away partially in the decline of the chemical industry in Widnes and finally, just a few months ago, to create the new road system for the Mersey Crossing Gateway bridge that was opened on 14 October 2017. The Widnes Research Lab was built on Victoria Road in 1891 under the direction of the Swiss chemist Ferdinand Hurter when the United Alkali Company (UAC) was created. Its construction set a milestone in the history of the chemical industry, being almost certainly the first laboratory built by a chemical firm in the UK with the purpose of undertaking pure and applied research. A short distance from this building was an administrative block called the Tower Building of ICI. From 1855 it had been part of the enormous Gossage's soap firm on Mersey Road in Widnes which was closed by Unilever in 1933. It was in this building that Sir John Brunner and Ludwig Mond met in the 1860s and also where much of the early work of ICI on narcosis was done, which formed an important part of the scientific basis for the discovery of halothane. Ian Campbell himself spent part of his working career in this building. When the decision was taken to celebrate the invention of halothane by positioning a Royal Society of Chemistry blue plaque on an appropriate building in 2011 it was this latter building which was chosen. The plaque was unveiled by Sir Martyn Poliakoff CBE, FRS, FRSC and Colin Suckling OBE, FRSC and stands proudly on the front face of that building which has, since 1987, been the Catalyst Science Discovery Centre and Museum. Inside Catalyst in its *Birth of an Industry Museum* are artefacts from the production of halothane and a display panel about the story of its invention.

On 28 September 2017 there was a thirtieth anniversary celebration of the creation of the Catalyst Science Discovery Centre and Museum on its current site and in the building so deeply involved with not just halothane but the whole development of the soap and chemical industry in Runcorn and Widnes. Industrial, academic and local people attended and heard a sterling address from Dominic Tildesley, representing the current President of the Royal Society of Chemistry, on the value of everything the Catalyst does in promoting the chemical sciences and STEM to people of all ages. In the *WOW Laboratory* a group of cubs from Widnes did a workshop and were very pleased to show the County Commissioner for Scouts and Deputy Lord Lieutenant of Cheshire what they were learning. Catalyst's determination to continue in its essential work is summed up in its slogan "Preserving the Past and Inspiring the Future". It is run entirely by a Charitable Trust and receives no public funds. Its Trustees are constantly seeking funds to maintain its work. Please visit www.catalyst.org.uk .

Diana Leitch

MEMBERS' PUBLICATIONS

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

Compound Histories: Materials, Governance and Production, 1760-1840, eds. Lissa Roberts and Simon Werrett, (Leiden: Brill: 2017).

This publication offers a new view of the period during which Europe took on its modern character and globally dominant position. By exploring the intertwined realms of production, governance and materials, it places chemists and chemistry at the centre of processes most closely identified with the construction of the modern world. *Compound Histories* explores the place of chemistry in material and knowledge production; the growth and management of consumption; environmental changes, regulation of materials, markets, landscapes and societies; and practices embodied in political economy. Rather than emphasize revolutionary breaks and the primacy of innovation-driven change, the volume highlights the continuities and accumulation of incremental changes that framed historical development.

The publication is available to **download for free** from Brill's open access page and it contains articles by two RSCHG Committee members.
http://booksandjournals.brillonline.com/content/books/9789004325562

Frank A.J.L. James, "The Subversive Humphry Davy: Aristocracy and Establishing Chemical Research Laboratories in Late Eighteenth- and Early Nineteenth-Century England", 269-88.
http://booksandjournals.brillonline.com/content/books/b9789004325562_013

Anna Simmons, "Wholesale Pharmaceutical Manufacturing in London, c.1760 - c.1840: Sites, Production and Networks", 289-310.
http://booksandjournals.brillonline.com/content/books/b9789004325562_014

Chris Cooksey, "Turmeric: Old Spice, New Spice", *Biotechnic & Histochemistry,* 2017, **92**:5, 309–314.
http://dx.doi.org/10.1080/10520295.2017.1310924

The history of chemical investigations into the yellow components of turmeric is traced from 1815. The struggle to identify the chemical structure of curcumin continued for nearly a century and was complicated by the difficulty of purification of the curcumin, and by the presence of two additional yellow components.

Chris Cooksey, "Quirks of Dye Nomenclature. 8. Methylene Blue, Azure and Violet", *Biotechnic & Histochemistry,* 2017, **92**:5, 347–356.
http://dx.doi.org/10.1080/10520295.2017.1315775

Methylene blue was first synthesized in 1877 and soon found application in medicine, staining for microscopy and as an industrial dye and pigment.

The Diversity of Dyes in History and Archaeology (London: Archetype Publications Ltd, 2017), 451 pp.

This collection of about forty papers is mainly drawn from presentations made at the annual Dyes in History and Archaeology meetings which took place between 2003 and 2007. It includes:

Chris Cooksey, "An Appreciation of John Hamilton Edmonds (1931-2009)", 116–7.

John Edmonds was a member of the Historical Group and had interests in ancient and natural dyes, in making gunpowder, and much else.

Chris Cooksey and Alan Dronsfield, "Peter Griess: A Critical Evaluation of his Contribution to Azo Dye Chemistry", 349–60.

Although azobenzene was discovered by Mitscherlich (1834), and related compounds were prepared by Zinin and Hofmann, the potentialities of the class were not realised until Johann Peter Griess (1829-88) began his work. Griess had begun to study the azo compounds while still working with Kolbe and in 1858 discovered that the reaction of aromatic amines with half an equivalent of nitrous acid gave coloured azo compounds, the forerunners of an historic class of fabric and leather dyes. Over the years, Griess published about 140 papers on azo compounds.

Chris Cooksey, "The ABC of Isatans", 390–7.

This paper describes the history of investigations into the indigo precursors contained in woad. The early nineteenth-century supposition that it was *leuco*indigo was disproved by Henry Edward Schunck in the 1850s.

Chris Cooksey, "Quirks of Dye Nomenclature. 9. Fluorescein", *Biotechnic & Histochemistry* 2017, Early Online: 1–7.
http://dx.doi.org/10.1080/10520295.2017.1359751

Adolf Baeyer announced the discovery of fluorescein in 1871 and named it after its most striking property, i.e., fluorescence. The synthesis of fluorescein and the seven molecular species of fluorescein in both the solid state or in solution are described.

W.P. Griffith, "Two Hundred Proud Years – the Bicentenary of Johnson Matthey: Origins of the Company and of Today's Research Activities in Science and Technology", *Johnson Matthey Technol. Rev.*, 2017, **61**, (3), 257
http://www.technology.matthey.com/article/61/3/257-261/

Peter Reed, "John Fletcher Moulton and the Transforming Aftermath of the Chemists' War", *The International Journal for the History of Engineering and Technology*, 2017, **87** (1), 1–19.

In 1917, Richard Pilcher, registrar and secretary of the Royal Institute of Chemistry used the phrase "the chemists' war" to describe the First World War. Pilcher's phrase was to prove prophetic in another way because the war would transform the working and organisation of the British chemical industry. With his background in mathematics, the legal profession and as an MP, John Fletcher Moulton was an unlikely person to play a crucial role in both the war effort and post-war transformation, but the analytical ability and organisational skills developed from his patent court cases proved more important than scientific and technical knowledge.

PUBLICATIONS RECEIVED

SamsonMay Design, *Johnson Matthey – Celebrating 200 Years of Inspiring Science* (Private publication, produced for customers and employees, but may be downloaded at no cost from http://www.matthey.com/file.axd?pointerid=5944192baa66bb284c7beb1c&versionid=5944192baa66bb284c7beb1b&uid=2c6f6d6c-da0e-4f13-ac5c-778b58736f06, 2017). Pp 40.

The title tells us all. This little booklet, handsomely produced, gives a positive chronological account of this well-known London-based firm over the last 200 years. On 1 January 1817, aged twenty-five, the young assayer Percival Norton Johnson both got married and founded the firm that bears his name. The "Matthey" part of the name can be traced back to 1838 when fifteen-year-old George Matthey started as an apprentice. Such was his expertise and commitment, Johnson took him into partnership in 1851. By then the firm had diversified into precious metal extraction and exploitation: gold, platinum and palladium.

Moreover, and to its advantage, the firm sought to capitalise on newer applications of these metals. Its rhodium catalysts continue to be used for hydroformylation. Others find application to limit pollution from vehicles. Presently, one in three cars contains a JM emission control catalyst. A chance observation in 1965 that platinum was having an effect on cell-division led to the anti-cancer drug *carboplatin*, with JM supplying the metal upon which it was based. The booklet will appeal both to readers with an interest in precious metal chemistry and those who have an interest in seeing how a major firm developed over the years. Those wishing to gain a yet deeper

appreciation of JM's activities perhaps should seek out the Wikipedia article on this company and explore some of the references therein.

Alan Dronsfield

PUBLICATIONS OF INTEREST

Ambix: The Journal of the Society for the History of Alchemy and Chemistry

The following issue has been published since the summer 2017 *RSCHG Newsletter*.

Ambix, volume 64, issue 2, May 2017, *The Royal Typographer and the Alchemist: Willem Silvius and John Dee*.

Stephen Clucas, "John Dee, Alchemy and Print Culture".

Peter J. Forshaw, "The Hermetic Frontispiece: Contextualising John Dee's Hieroglyphic Monad".

Stephen Clucas, "The Royal Typographer and the Alchemist: John Dee, Willem Silvius, and the Diagrammatic Alchemy of the *Monas Hieroglyphica"*.

Stephen Vanden Broecke, "The Ideal of a Knowledge Society in Dee's *Monas Hieroglyphica* (1564) and Other Productions by Willem Silvius".

Manuel Mertens, "Willem Silvius: "Typographical Parent" of John Dee's *Monas Hieroglyphica"*.

From January 2018 there will be a new editorial team at *Ambix*. Bruce Moran, University of Nevada, Reno, is taking over from Jennifer Rampling as Editor and Viviane Quirke, Oxford Brookes University, joins Alan Rocke of Case Western Reserve University, as a second Associate Editor. For more information on SHAC and *Ambix* visit www.ambix.org

Patrimoine Industriel de la Chimie

The December 2016 issue, edited by Patrice Bret, Jacques Breysse, Gérard Emptoz and Roger Lamartine is a beautifully illustrated volume on the French Chemical Industry. It features short articles on topics including gunpowder, fertilizer and aspirin production, Leblanc soda, the Grasse perfume industry, the Rum industry in Reunion and the French match industry. The book is in French but abstracts of the articles are provided in both French and English. For further details please see:
http://www.cilac.com/nos-publications/1541-patrimoine-industriel-de-la-chimie.html

NEWS AND UPDATES

Science Museum

#chemglass: Can you help?

Sophie Waring, Curator of Chemistry would like the help of RSCHG Members in identifying some of the objects in the museum's chemistry collection. Please visit
https://blog.sciencemuseum.org.uk/chemglass-can-you-help/ for more information.

Society for the History of Alchemy and Chemistry

2018 Morris Award: Call for Nominations

The Society for the History of Alchemy and Chemistry solicits nominations for the 2018 John and Martha Morris Award for Outstanding Achievement in the History of Modern Chemistry or the History of the Chemical Industry. This award honours the memory of John and Martha Morris, the late parents of Peter Morris, the former editor of *Ambix*, who has contributed the endowment for this award. The recipient chosen to receive the Morris Award will be expected to deliver a lecture at a meeting of SHAC, where the awardee will be presented with an appropriate framed photograph, picture or document and the sum of £300. The award is international in scope, and nominations are invited from anywhere in the world for arrival no later than 1 May 2018. For more details visit http://www.ambix.org/morris-award/

Division of History of the American Chemical Society

The recipient of the 2016 Outstanding Paper Award of the Division of the History of Chemistry of the American Chemical Society is Helge Kragh of the Neils Bohr Institute in Copenhagen. The paper was "From Cosmochemistry to Fuel Cells: Notes on Emil Baur, Physical Chemist" *Bulletin of the History of Chemistry,* 2015, 40(2), 74-85. The award is presented to the author of the best paper published in the *Bulletin for the History of Chemistry* during 2014, 2015, 2016.

Jeffrey I. Seeman of the University of Richmond, Richmond, Virginia is the recipient of the 2017 HIST Award of the Division of the History of Chemistry of the American Chemical Society. It will be presented at the spring national meeting of the American Chemical Society in New Orleans on Tuesday 20 March 2018.

Chemical Heritage Foundation: A New Chapter Begins

The Chemical Heritage Foundation has announced that on 1 February 2018 it will become the Science History Institute. At the end of 2015 the boards of CHF and the San Francisco based Life Sciences Foundation approved a merger of the two organizations. However, the name "Chemical Heritage Foundation" did not fit the new focus studying the history of chemistry, chemical engineering, and the life sciences. The new name, Science History Institute, describes what the institution does today (study the history of the chemical and molecular sciences and accompanying engineering fields) and leaves room to explore emerging fields as they develop. On 1 February 2018, a new website and social media handles will be launched.

SHORT ESSAYS

Halothane – The First 'Made-to-Measure' Anaesthetic

Two major advances that revolutionised surgery occurred in the nineteenth century. One was Joseph Lister's 1865 discovery that wound infection and subsequent lethal sepsis could be prevented by the liberal application of chemical germ-killers, notably carbolic acid. He was using, in fact, a 5% solution of phenol and he used it to sterilise the surgical instruments, the area of the incision and even (when used as a spray) the air in the operating theatre. The other advance was to render surgery pain-free. Humphry Davy had speculated in his 1800 book on nitrous oxide "As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place", but this does not connect with anaesthesia as we know it today. Yes, a high concentration of N_2O can render a patient unconscious, but Davy was not using it for this purpose. He was employing it medically, in lower concentrations and also using it recreationally. He noticed that it would temporarily relieve headaches and the pain of toothache. Thus he probably saw it, not as a general anaesthetic, but more as an analgesic. Today it is still used for this purpose in "gas and air" machines [1] to take some of the pain out of childbirth and to provide emergency pain-relief in the case of accidents. On the other hand, Henry Hill Hickman in 1823 began to render animal patients unconscious with carbon dioxide, with a view to performing minor surgery without causing them apparent discomfort. He then allowed them to revive from their induced asphyxia by giving them access to fresh air. He reported his work, but there was no follow-up. He did not elaborate his discovery to human patients.

Anaesthetic	Popular between	Discontinued because….
Diethyl ether	1840s – 1960s	Post-operative vomiting common. Forms explosive mixtures with air and oxygen, with between 1 in 80,000 and 1 in 100,000 operations resulting in explosions
Nitrous oxide	1840s – present time	Still in use for both major and minor operations
Chloroform	1847 – 1950s	Post-operative vomiting common. Noted for causing liver damage: one of the more toxic anaesthetics, leading to unpredictable fatalities
Ethyl chloride	Early 1900s – early 1960s	Flammable; small safety margin
Trichloroethylene	1940s – early 1980s	Relatively weak; slow induction and recovery; cannot be used with soda-lime (CO_2 absorber, which permits recycling of agent)
Cyclopropane	Late 1930s – early 1980s	Forms highly explosive mixtures with air and oxygen; relatively expensive
Divinyl ether	Early 1930s – 1950s	Highly flammable; forms explosive mixtures with air/oxygen; can form explosive peroxides on storage; relatively expensive
Ethylene	Mid 1920s - mid 1950s	Highly flammable; forms explosive mixtures with air/oxygen
Ethyl vinyl ether	Late 1940s – late 1950s	Expensive; highly flammable; forms explosive mixtures with air/oxygen

The first person to give a public and widely reported demonstration of anaesthesia was William Morton, a dentist, in 1846. He used ether vapour to render Edward Gilbert Abbott unconscious whilst a surgeon painlessly removed a tumour from this patient's neck. The realisation that the vapours from volatile liquids might induce unconsciousness, if inspired in a high enough concentration, stimulated a search for other anaesthetic agents. In 1847, James Young Simpson used chloroform, initially for obstetric anaesthesia. With its sweetish odour and smooth inductions, patients preferred it to ether, probably unaware that it was the more dangerous of the two

agents. It caused the death of about 1 in 3,000 patients, in contrast to ether with a death-rate of 1 in 12,000. Until the mid-1950s, the most widely used anaesthetics were chloroform, ether and nitrous oxide, this last being used extensively in dentistry. In the preceding century, chemists, physicians and surgeons sought other agents that might usefully supplant the first two. Improved patient safety was a foremost criterion, and a bonus would be a swift recovery time without the vomiting that was associated with long operations with high anaesthetic dosages. Some, like dichloromethane, only achieved a brief popularity (1867-80) but others survived well into the twentieth century. The more widely used ones are listed in Table 1. None is without disadvantage.

For major abdominal operations the surgeon would require muscle relaxation to help them in their explorations. This would require high doses of chloroform or ether, dangerously close to those that would cause paralysis of the breathing centre in the brain. Before the advent of machines that would take over the breathing process, this put the patient at significant risk. And, of course, recovery would be prolonged, unpleasant and even dangerous (with pneumonia being a possible sequel, a dreaded complication in the pre-antibiotic era).

Enter Fluorine

The French chemist Jean-Baptiste Dumas prepared the first organofluoride, CH_3F, from dimethyl sulfate and KF in 1835, though he was probably unaware of the identity of his product. For this reason, the Russian composer/chemist, Alexander Borodin, is usually credited with synthesising the first compound containing a C-F bond (in benzoyl fluoride, 1862), by treating the chloride with KHF_2. Direct fluorination of a few organic species by F_2 is possible, but the yields are low and the reaction is apt to be explosive. More productive are variations on the Borodin method of chlorine, bromine or iodine replacement using fluorine from SbF_3 or $SbF_3.Cl_2$. Between WW1 and WW2, many air-conditioning systems were constructed in the USA for use in homes and industrial plants. These depended on the use of a liquefied gas as the heat transfer medium, with NH_3, SO_2 and CH_3Cl being the ones most commonly used. Small leaks of the first two were easily detectable from their odours, but even large leaks of (nearly odourless) methyl chloride were undetectable, and the vapour could build up to lethal concentrations. A cluster of CH_3Cl-related deaths in Chicago in 1929 led to a local ban on the use of this material as a refrigerant. Fortunately, alternatives were (almost) to hand. In 1928 General Motors was considering the feasibility of providing air-conditioning in its vehicles. Clearly the use of methyl chloride in such confined spaces would be risky, so Thomas Midgley was asked to put in place a research programme to come up with safer, non-flammable alternatives that were equally effective [2]. The outcome was CCl_2F_2. As an anaesthetic gas this had so many disadvantages so as to render it useless, but the Midgley work was important as it gave a wider community of chemists the techniques to synthesise a range of novel fluoro-halo-hydrocarbons to order. And one of them, some twenty-five years later, would revolutionise anaesthetic practice.

Chemists Harold Booth and May Bixby, working at the Western Reserve University, Ohio, reflected on the potential of this range of products:

> the best probability of finding a new non-combustible anaesthetic gas lay in the field of organic fluoride compounds …There is the indication that, like chlorine, fluorine substitution for hydrogen in organic compounds lessens the inflammability: for example fluoroform burns with difficulty, whilst methane forms explosive mixtures with air. To narrow the field further for an approach to this subject, it was logical to study those organic fluorides which are derivatives of the best known anaesthetics……fluoride derivatives of chloroform [3].

Table 2: Safety and effectiveness of various fluoroalkanes compared with ether and chloroform

Compound	FD50/AD50	Time taken to produce? after exposure to FD50 concentration:		
		anaesthesia	sensibility to pain after 10 min exposure	walking activity after 10 min exposure
$C_2H_5OC_2H_5$	3.5	45sec	3 min	5 min
$CHCl_3$	3.5	45 sec	2-3 min	5 min
$CF_2ClCH_2CH_3$	2.0	30 sec	30 sec	90 sec
CF_3CHBr_2	4.6	20 sec	3 min	10 min
CF_2ClCH_2Br	4.6	20 sec	5 min	10 min

At the time fluoroform could not be prepared in sufficiently large amounts for animal studies, so the researchers had to make do with dichloromonofluoromethane (CCl_2HF) and monochlorodifluoromethane ($CClHF_2$). They found that neither material had anaesthetic potential. Even low doses were accompanied by distress: "1% caused the animal to continuously, vigorously and frantically scratch and bite itself during 1 hr and 45 min….4% (induced) violent tremors….6%, unconsciousness not sufficiently deep for surgical operations". Using CCl_2HF at

20%, despite added oxygen, caused death between five and eleven minutes. The following year (1933) they reported a range of fluoro-chloroethylenes in their search for improved anaesthetics, connecting their work to the parent ethylene, CH_2=CH_2, which was then enjoying a vogue as a well-tolerated (but highly flammable/explosive) anaesthetic. They achieved no medical breakthrough, however, and Booth moved his research into other fields. His observation that within the family of fluorochemicals there might lurk an anaesthetic better than chloroform or ether did not go un-noticed and the Mallinckrodt Pharmaceuticals Company (which already supplied ether and cyclopropane for anaesthetic purposes) commissioned Earl McBee of Purdue University in the mid-1940s to prepare a range of fluorinated halo-hydrocarbons as potential anaesthetics. It must be no coincidence that McBee was also involved with the Manhattan Project, with its significant fluorine chemistry research. Mallinckrodt presented forty-six compounds synthesised by McBee to Benjamin Robbins at Vanderbilt University, Nashville, USA, for testing for anaesthetic potential [4]. His contribution was to devise a "theoretical filter" to narrow down the candidates for clinical evaluation. He focused primarily on the safety aspect using the FD_{50}/AD_{50} ratio. Fatal dose-50 (FD_{50}) was the concentration which caused death in ten minutes of 50% of a mouse population. Anaesthetic dose-50 (AD_{50}) was that required to anaesthetise 50% of a mouse population, again in ten minutes. Thus for safety the FD_{50} figure should be high, and for efficiency as an anaesthetic, the AD_{50} value should be low. To show potential, at least from a safety perspective, the ratio FD_{50}/AD_{50} should be high. Robbins tabulated his data, and included the values for ether and chloroform for comparison purposes. A much shortened version of his table is given below. We include data on a potentially "poor" anaesthetic ($CF_2ClCH_2CH_3$) and two which are potentially "good" (CF_3CHBr_2 and CF_2ClCH_2Br).

Robbins' conclusions were as follows:

- All forty-six of his fluorinated halo-alkanes produced anaesthesia, apart from a butane, which he writes, incorrectly, as C_4HClF_6 (not included in the table)
- Species which had low boiling points were associated with the production of convulsions (fits) in the mice, especially on recovery
- Within a group of related compounds, potency increases with increase in b.p.
- The introduction of a bromine atom increases the safety of an anaesthetic and its potency.

Using his data, Robbins was able to select the eighteen most promising compounds and then tried them out on dogs. His results were equivocal. Yes, all eighteen induced anaesthesia, but all apart from four, induced abnormal cardiac rhythms, and all, to varying degrees, gave rise to falls in blood pressure. He considered those agents which did not affect heart beat rhythm had potential: "The results obtained with four of these compounds ($CF_3CHBrCH_3$, CF_3CHBr_2, $CF_3CHClCH_2Cl$ and $CHF_2CHClCH_3$) are such that we feel further investigations of them as possible anaesthetic agents are indicated". However it was left to others to continue this line of research.

In 1930 the anaesthetic properties of ethyl vinyl ether were discovered, but it took some eighteen years for it to go into clinical practice. Like ether and ethylene, it formed explosive mixtures with air and oxygen, a significant drawback when it came to reducing blood-loss by cautery. It was anticipated that partial halogenation would reduce its flammability and in 1951 trifluoroethyl vinyl ether ($CF_3CH_2.O.CH=CH_2$) was prepared by Julius Shukys, working for *Airco Inc*. of New Jersey, USA. Though it still contained enough hydrogen for it to form explosive mixtures with air and oxygen, it was reasonably well tolerated by patients and it went into clinical practice as the anaesthetic as "Fluoromar" in 1953. It was rapidly eclipsed by the anaesthetic that is the focus of the remainder of this article, but it deserves a place in the history of anaesthesia, because it was the first partially fluorinated anaesthetic seen as a "success" and also because it was the fore-runner of the fluorinated ethers which today reign supreme for inhalational anaesthesia.

Charles Suckling and the Widnes connection

Imperial Chemical Industries (ICI) was formed in 1926 by the merger of several UK chemical firms and by the 1950s operated at a number of sites in the north of England. At Widnes, in Lancashire, it produced low-boiling fluorinated chlorohydrocarbons (which it named Arctons) for use in refrigeration plants. Research chemist Charles Suckling recalls:

> We had at the Widnes laboratories considerable experience in the specialised techniques for the manufacture of the Arcton type of compound and in our desire to make further practical use of these substances, we decided to search among them and other fluorine-containing compounds for an anaesthetic [5].

Foremost in his mind were three factors guiding him to likely candidates:

- The inertness of fluorine in the C-F bond, especially in the CF_3- and CF_2= groups. Apart from their inherent inertness, they also conferred stability to adjacent C-Hal bonds. Thus compounds of the type $CF_3.CHalX_2$ (X = H or Hal) should have high chemical stability and hence low toxicity.
- That the Arctons which had C-H incorporated had a greater margin of safety associated with them, compared to the totally halogenated alkanes. It was believed that the greater polar nature of the former species enabled

them to interact electrostatically with "brain molecules" and thus show anaesthetic effects at lower doses compared to the latter group.

- That John Ferguson, ICI's Research Director, had (in 1939) proposed an index of "Relative Saturation" to assess a molecule's potential for "narcosis" [6]. Ether vapour induces narcosis or anaesthesia at a volume concentration of 3.4%, that is, a partial pressure (p_a) = 3.4x760/100 mmHg. Now the saturated vapour pressure of ether at body temperature (p_s) is 830 mmHg. Ferguson's Relative Saturation (= p_a/p_s) = (3.4x760/100) / 830, namely 0.03.

Table 3: p_a/p_s values for selected fluoroalkanes

Compound	p_a/p_s
$CF_3CHBrCl$	0.03
CF_3CHBr_2*	0.05
$CF_2ClCHCl_2$	0.05
$CF_3CHBrCH_3$	0.07
CF_2BrCF_2Br	0.01
CF_3CCl_3	0.13
$CF_2ClCFCl_2$	0.16

(*Suckling evidently decided that a partial pressure of 5 mmHg was necessary to maintain anaesthesia, not Robbins' value of 0.3 mmHg)

Calculations based on fourteen anaesthetic agents showed that 86% had index values in the range 0.01 to 0.03. Analysis of some of Robbins' fluorinated alkanes showed, with the exception of CF_3CHBr_2, all had p_a/p_s values greater than 0.03. This did not rule out anaesthetic potential of the others, but it made it doubtful. Then Suckling's team reinvestigated a few of Robbins' compounds and added some of its own. The results are shown in Table 3.

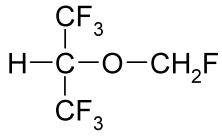
Bearing in mind Suckling's three considerations (presence of a CF_3 group, CF_3 connection to a C-H bond and a p_a/p_s ratio ideally 0.01-0.03) only one member of the list stands out, $CF_3CHBrCl$, 1,1,1-trifluoro-2-bromo-2-chloroethane. *Halothane,* a new anaesthetic agent had been born. Charles Suckling records in his (1957) patent:

> …(it) is a particularly useful non-explosive inhalation anaesthetic capable of producing full surgical anaesthesia over prolonged periods…..(it) gives an exceptionally smooth and rapid induction to full surgical anaesthesia which can be maintained by inhalation of a relatively small amount of vapour in air… Recovery from anaesthesia with our new compound is rapid and smooth and no undesirable effects have been observed… [7].

Halothane (also marketed as "Fluothane") is a liquid, b.p. 50ºC, with a slight, pleasant odour. It is poured into containers integral to anaesthetic machines that allow its vapour to be delivered to the patient alongside nitrous oxide and/or oxygen. Within a few weeks anaesthetists were sharing their experiences of this new agent. Typical is this 1957 report which said that patients were routinely pre-medicated with an oral barbiturate, morphine and hyoscine, sometimes intravenous atropine, and sometimes intravenous thiopentone to start off the general anaesthesia [8]. Mostly, though, induction was by application of the anaesthetic mask supplying, initially, a mixture of nitrous oxide and oxygen. When the patient was lightly asleep, the N_2O was turned off and the halothane vapour added to the oxygen stream [9]. The authors remarked that "although halothane/O_2 induction was not unpleasant, preliminary N_2O/O_2 induction proved to be more agreeable to the majority of patients". Recovery was moderately rapid: for an operation lasting less than an hour, the average time to regain full consciousness was thirty-seven minutes. Broadly, these authors were impressed by halothane's advantages over the other agents commonly in use, but they sounded a note of caution "Generally speaking, we feel that halothane has sufficient desirable properties to justify its inclusion in the anaesthetist's armamentarium, though further work on the possible metabolic effects is needed".

Indeed, Halothane rapidly caught on, displacing ether and chloroform. It had no intrinsic analgesic effect, so it was routinely used alongside potent opioid intravenous painkillers. It had no muscular relaxant properties so it was employed in conjunction with curare, or synthetic muscle relaxants, both with the necessary artificial ventilation. This combination of drugs meant that patients only needed to be lightly put asleep for the operation, with the consequence that after-effects were slight and recovery swift. It enjoyed a thirty-year popularity until the mid-1980s. The fact that it is no longer routinely used in the hospitals of developed countries is due to two considerations, the first of which is connected with the above note of caution: a few patients were rendered very ill by the anaesthetic, and some died. From the mid-1960s, warning bells were beginning to ring about the role of halothane in post-operative liver dysfunction in general and "halothane hepatitis" in particular, especially after repeated exposures to the agent. About 15-20% of the halothane administered is broken down in the liver to trifluoroacetic acid and bromide and chloride ions, and/or bromine and chlorine radicals. In the face of increasing concern - was the liver being damaged by toxic metabolites, by hypoxia due to altered liver blood flow, or by an

immunologically-mediated injury with some patients perhaps genetically predisposed to hepatotoxicity? - it became evident that the concept of a "safe period" between administrations had to be questioned, and the search for an ideal, and even safer, anaesthetic was not yet over. The second consideration that led to Halothane's demise was that work was being undertaken on another range of fluorinated compounds to assess their potentials as anaesthetic agents. The *Airco Inc*. company was naturally disappointed that its Fluromar anaesthetic was so rapidly eclipsed by Halothane, however it did not lose faith with the idea that another partially-fluorinated ether anaesthetic, even better than Halothane, might still be waiting to be discovered. And discovered it was – one of four commercial products, "Enflurane", "Isoflurane", "Desfluorane" and "Sevoflurane".



Sevoflurane

Of the four, the last, Sevoflurane, now reigns supreme in the anaesthetist's armoury. These ethers are more expensive than Halothane, with Sevoflurane being significantly so. But "price per ml of anaesthetic used" can be misleading. Patients recover rapidly from Sevoflurane anaesthesia and can sometimes be in a fit state to return home (under supervision) at the end of the day, whereas with Halothane, even with its relatively rapid recovery time, such a plan could be seen as fool-hardy.

In the twenty-first century, should Halothane be written off and confined to books and articles on the history of anaesthesia? Its use in UK hospitals had all but disappeared by 1990, but it is still used, on account of its cheapness, for veterinary anaesthesia. Even so, it is losing out to the fluorinated ethers. Some argue that because of its cheapness it should be used (in appropriate cases) in third world hospitals, thus freeing up funds for other medical purposes. But we conclude with an extract from a controversial 2015 paper:

> Developing nations rarely have the personnel and equipment to provide safe anaesthesia. Anaesthesia is most commonly delivered by non-physicians who have little or no formal training. Cardiac monitors, pulse-oximeters, supplemental oxygen and endotracheal intubation are rarely available and anaesthesia is delivered using drawover techniques. Halothane, still the most common inhalation anaesthetic in the developing world, is a potent agent and, without monitoring equipment and trained providers, can lead to significant patient morbidity and mortality. Ether, on the other hand is nontoxic to the cardiovascular system and it does not depress respiratory activity. It is safe to use by anaesthetists who have not received formal training and without complicated monitoring, supplemental oxygen and endotracheal intubation. Ether has the added benefit of providing surgical analgesia [10].

So there it is. William Morton's ether of 1846 might be making a come-back!

Acknowledgements

Some of the technical details in this article have been reproduced from our earlier paper on this topic which appeared in both *Education in Chemistry* [11] and *Proceedings of the History of Anaesthesia Society* [11]. We are grateful to the current editors for granting permissions for reproduction. Readers interested in the history of anaesthesia should consider joining the History of Anaesthesia Society, annual subscription £20. Details at: http://www.histansoc.org.uk/

References and Notes

1. Actually, the machines deliver a mixture of nitrous oxide and oxygen.

2. J.W. Elkins in *The Chapman and Hall Encyclopaedia of Environmental Science*, eds., D.E. Alexander and R.W. Fairbridge (Boston MA: Kluwer Academic, 1999).

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5. C.W. Suckling, "Some Chemical and Physical Factors in the Development of Fluothane", *Brit. J. Anaesthesia*, 1957, **29**, 466.

6. J. Ferguson, "The Use of Chemical Potentials as Indices of Toxicity", *Proc. Royal Soc. B,* 1939, **127**, 387.

7. W. Suckling, Brit. Pat. 767779, 1957 and U.S. Pat. 2,849,502, 1958.

8. J. Chang, H.H. Macartney and H.B. Graves. "Clinical Experience with Fluothane (Halothane)", *Canadian Anaesth. Soc. J*. 1957, **4**, 187-206. Available at https://link.springer.com/content/pdf/10.1007%2FBF03014419.pdf

9. In contrast, one of us (JP) in clinical practice used to maintain a flow of N_2O alongside the administration of the Halothane vapour.

10. C.Y. Chang *et al*, "Ether in the Developing World: Rethinking an Abandoned Agent", *BioMed Central Anesthesiology*, 2015, **15**, 149. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4608178/

11. A. Dronsfield, M. Hill and J. Pring, "Halothane – the first designer anaesthetic", *Ed. Chem.*, 2002, **39**, 131 and *Proc. Hist. Anaesth. Soc.*, 2002, **31**, 57. Available at http://www.histansoc.org.uk/uploads/9/5/5/2/9552670/volume_31.pdf

Alan Dronsfield, Margaret Hill and John Pring

Mauveine – The Final Word? (5)

The last Final Word appeared in the summer 2014 *RSCHG Newsletter*. It was a good year for thin layer chromatography (TLC) studies of mauveine – there were three of them. The first was mentioned in the last article. John Plater described the dichromate oxidation of a mixture of *N-tert*-butyl-*p*-toluidine/aniline/*o*-toluidine (1 : 1.5 : 1.8), followed by de-*tert*-butylation with acid to give a mixture of mainly mauveine A and B as shown by TLC [1]. The structures of mauveines are shown in Figure 1. Next up, in a Spanish – United States collaboration, the mauveine product was synthesised according to Perkin's 1856 recipe [2]. TLC on silica gel using 6:1:3 *iso*butanol/acetic acid/ethyl acetate mixture as eluent revealed four purple spots and one red one. These were identified as pseudo-mauveine, red, R_f 0.32, mauveine A (0.56), B2 (0.63), B (0.70) and C (0.78). The Raman spectra of the separated components were obtained from the developed TLC plate using silver nanoparticles to elicit the surface-enhanced Raman spectra (SERS). SERS is a powerful extension of Raman spectroscopy which provides molecular vibrational data from exceedingly small samples. Chandrasekhara Venkata Raman (1888–1970) would have been astounded. The assignment of the normal vibrational modes of mauveine was aided by performing density functional theory calculations. Finally in November that year, Plater and Harrison disclose an improved synthesis of *N-tert*-butyl-*p*-toluidine hydrochloride which was then used to prepare the mixture of mauveine A and B in 6% yield as above [3]. This product was shown by TLC, illustrated, on silica gel eluting with 60:30:9.5:0.5 *sec*-butanol/ethyl acetate/water/acetic acid to be similar to an historic sample of mauveine obtained from the Manchester Museum of Science and Industry, MOSI (illustrated here [4]). The mauveine product from the dichromate oxidation of a mixture of aniline and toluidines was shown by TLC, illustrated, to be different, *viz.* the major components were mauveine A and B2 and the minor products B and C.

In a step-up in the analytical technique, the next John Plater paper employed HPLC [5]. A 15 cm C_{18} reverse phase column with detection at 550 nm separated the mauveines in the opposite order to that found by TLC, i.e., pseudo-mauveine is eluted first. The results showed that more mauveine isomers were present in the synthetic sample prepared in [3] and the major components were estimated to have quite different concentrations compared to those in the MOSI sample. It was found that by changing the ratio of reactants, *N-tert*-butyl-*p*-toluidine/aniline/*o*-toluidine, to 1:1.5:1.5 it gave a product which was a close match to the MOSI sample.

A major advance was achieved on two fronts with the publication of the first X-ray crystallographic structure of a mauveine species and the first successful calculation of the UV-VIS absorption spectra of pseudo-mauveine and mauveine A [6]. Salts of pseudo-mauveine were deemed by Perkin to be uncrystallisable [7]. Half a century ago, picric acid was a popular reagent which was used to prepare crystalline derivatives.

These days it is deeply unfashionable to prepare derivatives or to employ picric acid, which will detonate if provoked. However, pseudo-mauveine picrate crystals were successfully prepared and the structure was determined by X-ray crystallography, as shown in Figure 2, which was generated by using data available from the Cambridge Crystallographic Data Centre [8]. Time-dependent density functional theory was successfully used to predict the UV-VIS absorption spectrum of pseudo-mauveine and mauveine A. A good match between the calculated and measured UV-VIS spectra was obtained, provided that ethanol molecules were added and the contribution of rotamers of the 3-aminophenyl substituent of the pseudo-mauveine were considered. The presence of rotamers made the accurate prediction of λ_{max} exceedingly difficult, in that they do influence the position of λ_{max}. Even the methyl groups have a contribution to, for example, the HOMO-LUMO.

Apart from contemporary syntheses and mauveine samples in museums around the world, another source of the dye was investigated using HPLC-MS – Victorian 6 d postage stamps printed between 1865 and 1869 [9]. On these stamps, the plate numbers are incorporated in their design. Fifteen stamps were analysed and it was found that the earliest (plate 5) were not printed using mauveine, about half from plate 6 used mauveine and all with plate 8 or 9 used mauveine. The range of mauveines which were found in stamps was more similar to those found in the MOSI museum sample compared to the composition of mauveine from a preparation using Perkin's procedure. One 6 d stamp (plate 6) was found to contain a high pseudo-mauveine content which is associated with Heinrich Caro's mauveine synthesis which used copper chloride as the oxidant. Thirty 1 d lilac stamps from 1881 did not contain mauveine and were previously shown by others to be coloured with an iron lake prepared from the insect dye, cochineal [10]. The conclusion drawn was that the manufacturing process disclosed by Perkin in his 1856 patent was different to that used to prepare the pigment used on stamps or that now available at MOSI. Philip Ball has summarised this work in one page in *Chemistry World* [11].

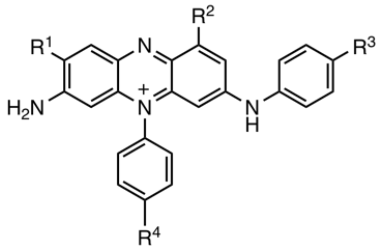

Figure 1. The structures of the mauveine cations.

	Mauveines of known and unknown structure					
Mauveine	Number of carbons	FW	R^1	R^2	R^3	R^4
A	26	391	CH_3	H	CH_3	H
B	27	405	CH_3	CH_3	CH_3	H
B2	27	405	CH_3	H	CH_3	CH_3
C	28	419	CH_3	CH_3	CH_3	CH_3
Pseudo	24	363	H	H	H	H
C25a	25	377	CH_3	H	H	H
C25b	25	377	H	H	CH_3	H
C25c	25	377				
B3	27	405				
B4	27	405				
C1	28	419				
D	29	433				
E	30	447				

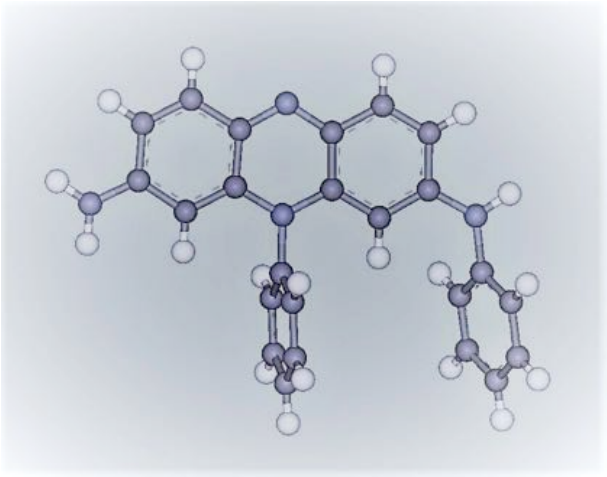

Figure 2: The structure of the pseudo-mauveine cation as determined by X-Ray Crystallography [6]

Finally, an investigation suggests that Perkin was not the first to make mauveine [12]. There are three likely candidates. In 1834, Friedlieb Ferdinand Runge (1795–1867) found that adding aniline from coal tar to a solution of bleaching powder gave a deep purple colour. For many years this was a popular test for aniline – "Bleaching-

powder Test for Aniline. A few drops of aniline are agitated with water, and the solution separated from undissolved amine by passing it through a moist filter. A small quantity of a clear solution of bleaching-powder gives a deep-violet coloration with the filtrate" [13]. In 1840, Carl Julius Fritsche (1808–1871) treated aniline with dilute chromic acid and obtained a dark precipitate. This reaction is summarised by Holleman in his *Organic Chemistry for Beginners* book: "Potassium-dichromate Test for Aniline. 2 or 3 drops of aniline are dissolved in dilute sulphuric acid. On addition of potassium-dichromate solution, a precipitate green, blue, or black according to the concentration is obtained. The black precipitate is called aniline-black" [13]. Then in 1853, F. Beissenhirtz noted that adding sulfuric acid and potassium dichromate to aniline or a salt of aniline gave a clear or pure blue colour. The experimental results reported here [12] used LC-MS to show that calcium hypochlorite oxidation of aniline gave mainly pseudo-mauveine (0.2% yield) and of an aniline-toluidine mixture gave a complex mixture of about twenty mauveines (0.5% yield). The dichromate oxidation of aniline gave pseudo-mauveine in 0.2% yield and the dichromate oxidation of an aniline-toluidine mixture was reported in previous papers.

The inescapable conclusion is that Perkin was not the first to see mauveine; that was probably Runge. But Perkin was the first to hold it in his hand.

In most of his chemical papers, John Plater does not explicitly discuss the implications of his chemical research on mauveine for our understanding of William Henry Perkin's manufacture of mauve, but it is clear that Plater believes that Perkin could have only made his mass-produced dye in the 1860s (what Plater calls "authentic mauveine") using a *N*-alkylated *p*-toluidine [1, p. 167]. Plater's approach to Perkin's manufacture of mauveine is governed by two assumptions, first that the patented synthesis of mauve is very difficult to carry out successfully and that it produces an inferior shade of mauve, and second that there must have been a change in the manufacturing process to produce only isomers A and B of mauveine and not the isomers B_2 and C as well. However—according to Plater—the "authentic" mauveine contains small amounts of mauveine B_x and mauveine C_x of unknown structure, which he argues are not the same as the previously recognised mauveine B and mauveine C. In a review paper Plater makes his historical conclusions clear [4]. In order to produce a mauve which contains only mauveine A and mauveine B (along with small amounts of B_x and C_x), Perkin must have used the *N-tert*-butylated version of *p*-toluidine then removing the *tert*-butyl group from the final product. Crucially Perkin must have used the *tert*-butylated toluidine, Plater argues, as this is the only alkyl substituent which has the desired effect and is easily removed afterwards [4, pp. 254–255].

This bold hypothesis has an immediate problem: how would Perkin have got hold of *tert*-butanol in the early 1860s? Plater himself admits that *tert*-butanol was first prepared by Alexander Butlerov in 1863 and on a larger scale in 1869 [4, p. 257]. Even the larger scale synthesis would have been expensive as it started from 1-iodo-2-methylpropane. Plater is thus left clutching at the straw that surely it would have been possible to have made *tert*-butanol from coal distillation, given that fusel oil (usually a by-product of fermentation rather than coal distillation) contains isobutanol. However, no evidence for any such synthesis is presented. But even if *tert*-butanol had been available in the early 1860s, why would anyone making mauve have used it? No chemist at the time, and certainly not Perkin, had any concept of the mechanism of organic chemical reactions and hence had no idea that a substituent would have this effect (as opposed to producing a different dye). Nor would they have conceived the idea of adding a substituent and then removing it at a later stage.

While Plater has created an intriguing possibility through his chemical research, in practice as a historical interpretation of Perkin's manufacture of mauve his ideas cannot be considered likely. In addition to the problems of obtaining *tert*-butanol in the first place, no *tert*-butylated derivatives of mauveine have ever been detected in historical samples of mauve or mauveine. It seems unlikely that the dealkylation step would have worked 100% each time. Nor, as Plater admits, was there any *tert*-butanol in the inventory of the factory's contents in 1873 [4, p. 257]. Furthermore, is it likely that this process would have remained hidden for so long? While there would have been a competitive advantage in keeping the use of *tert*-butanol secret at the time, the manufacture of mauve ceased in the 1870s and thereafter there was no need for any secrecy. Indeed Perkin would have surely wanted to enjoy the kudos of inventing such a brilliant process. He gave lectures on mauveine after his early retirement and yet the use of *tert*-butanol is never mentioned [7]. The mauve celebrations in 1906 would have been the ideal time for such a dramatic revelation, but no such disclosure was made [14]. Perkin would have given his successors at Greenford Green details of the actual manufacturing process (rather than just the patent) and yet they never revealed the process either. Finally, the adoption of this alleged process would have required an understanding of the mechanism of the mauveine-forming reaction which was completely lacking in the nineteenth century. Nor is it likely that any organic chemist in this period, even a gifted one like Perkin, would have thought of adding a group and then removing it at the end of the process.

But if *tert*-butylation cannot be the explanation for the change in the relative composition of the mauveine isomers, what is the explanation? Plater says that many will find it easier to believe the standard explanation "somehow", implying that no such explanation is possible [4, p. 257]. This is partly because he found it impossible to remove the other two isomers by washing [1, p. 166]. Although Plater makes no reference to this, it is well-known that Perkin changed his method of making mauve in 1863 [15, p. 8508]. The original process used the patented method and produced a paste containing mauveine sulphate which did not dye very well. Perkin switched to a new method which produced mauveine acetate crystals. This switch can also be detected in fabrics of the period [15, pp. 8510–8511]. Crucially Plater's "authentic mauveine" is in this latter form which explains why it is not the same as the

material produced by Plater using the patented method. In any event, Plater makes too much of the difference between the two mauve dyes. The earliest samples using the patented method (which are all fabrics as no dye paste from this period has survived) can be distinguished from the later dye whether fabrics or crystals, but even the later dye contains significant amounts of mauveine B2 and C [15, pp. 8509–8511].

The authors would like to thank Alan Dronsfield and Henry S. Rzepa for valuable comments and suggestions.

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Chris Cooksey and Peter J. T. Morris

The *Conversations* of Jane Marcet and Delvalle Lowry

Jane Marcet was a major populariser of science, history and economics. Her most widely recognised book in scientific circles is her first, *Conversations on Chemistry* [1], which was published in sixteen editions between 1806 and 1852 and revised throughout this period. This was just one of many *Conversations* she wrote, which covered a range of topics, including natural philosophy, political economy, botany and various historical and religious subjects [2]. The most widely read of all was *Conversations on Political Economy* which stimulated an interest in economics in many politicians and in people such as Harriet Martineau. Jane believed that women could understand the new sciences as well as men. In most of her work she expounded her material in the form of conversations between three female participants, a tutor, Mrs B, and two pupils, Emily and Caroline. Three *Conversations*, on chemistry, natural philosophy and political economy had appeared prior to 1822, which was also the year in which her husband Alexander died, but also when another woman, Delvalle Lowry (1800-1859), published *Conversations on Mineralogy* [3], a subject which Jane Marcet had not treated. Lowry's format closely mirrors Jane's format, but Lowry's tutor is not Marcet's Mrs B but Mrs L, and the students are called Lucy and Mary.

In the preface to her book, Delvalle Lowry makes clear that Jane Marcet's books on chemistry, political economy and natural philosophy had certainly stimulated her to copy their style, but nowhere does she mention Jane Marcet by name, describing the writer simply as the "authoress". That Marcet's books were written by a lady and directed primarily at women was stated in the preface to the first edition of *Conversations on Chemistry* of 1806. Marcet's name as author first appeared in the thirteenth edition of *Conversations on Chemistry* in 1837. Yet it is evident that Delvalle Lowry must have been very aware of Jane's authorship, though no correspondence that she and Marcet

exchanged has come to light. However, in her preface Lowry also mentions her interest in published introductions to botany and algebra, not specifically identified. The first seems to be a reference to the Fitton sisters' botany book of 1817, but the second is currently unidentifiable.

The title page of Lowry's 1822 edition of *Mineralogy* states that the many engravings were produced by Mr and Miss Lowry. The preface also states that she wishes to encourage young readers to learn about mineralogy. She mentions places where relevant lectures could be heard, where samples could be purchased, where wooden models of crystals were available for purchase, and where private instruction might be experienced, particularly from a Mrs Lowry, who had a great collection of minerals. Mrs Lowry provided personal instruction in mineralogy, "more particularly to ladies", and she worked from a house in Titchfield Street. Mrs Lowry was Delvalle Lowry's mother and that her father, Wilson Lowry, died in a house he owned in Great Titchfield Street [4]. These houses must have been one and the same, the Lowry family house.

Jane Marcet's own drawings for her chemistry book were engraved by Wilson Lowry, who was perhaps the foremost engraver of the period [4]. The advertisements for *Conversations on Chemistry* often cited Lowry as the engraver of the illustrations, which also carry this name. Wilson Lowry (1762-1824) was born in Cumberland and came to London at the age of eighteen. His initial training was as a house painter in both London and Arundel, but he had received some instruction in engraving in Cumberland. He also studied for four years to become a surgeon, but engraving became his major interest. He worked as an engraver for various masters and developed a number of instruments and techniques to assist in his work, including a machine for striking elliptical curves, the use of diamonds for marking, and of acid for etching lines on steels. He was particularly recognised for engravings of buildings and machinery and his work appeared in the *Philosophical Magazine*, the *Journal of the Society of Arts*, and for plates in books such as *Nicholson's Architectural Dictionary* (1819) and *Crabb's Technical Dictionary* (1823). Lowry's entry [4] in the *Oxford Dictionary of National Biography* emphasises his genuine interest in science and mechanics, with a focus on mineralogy and geology. He was a Fellow of the Royal Society of London, an original member of the Geological Society and on intimate terms with the leading scientific men of his day. Evidently, he moved in the same circles as Jane's husband Alexander, also an original member of the Geological Society and a Fellow of the Royal Society [5]. Given Lowry' familiarity with Jane's work, it is inconceivable that he never discussed it with his daughter.

Wilson Lowry's second wife was Rebecca Delvalle, an accomplished mineralogist of Spanish extraction. Delvalle Lowry was their daughter. Wilson Lowry must have had privileged access to Jane's work from about 1805 and his daughter must have been aware of it. Delvalle copied Jane's style and format, but also took the opportunity to advertise her mother's expertise and business interests. The Mrs L of her *Conversations on Mineralogy* was undoubtedly her own mother.

1. Anon., *Conversations on Chemistry, in which the Elements of that Science are Familiarly Explained and Illustrated by Experiments* (London: Longman, Hurst, Rees, and Orme, 1806).

2. B. Polkinghorn, *Jane Marcet, An Uncommon Woman* (Aldermaston: Forestwood Publications, 1993).

3. D. Lowry, *Conversations on Mineralogy* (London: Longman, Hurst, Rees, Orme and Brown, 1822). A facsimile edition from Kessinger Publishing, Tennessee, of a US copy published by Uriah Hunt in Philadelphia in 1822 was used in this research.

4. Entry for Wilson Lowry, *ODNB*.

5. Entry for Alexander John Gaspard Marcet, *ODNB*.

G. Jeffery Leigh

ESSAY REVIEW

Jim Baggott, *Mass: The Quest to Understand Matter from Greek Atoms to Quantum Fields* (Oxford: Oxford University Press, 2017). Pp. xviii + 346. ISBN 978-0-19-875971-3. £20/$27.95 (hardback).

This book is a popular science book which takes a historical approach. It assumes no more than rusty GCSE mathematics and science, but can be appreciated by the scientifically more educated. The author is a former lecturer in chemistry at the University of Reading. Most members of the RSC History Group, to whom this review is addressed, are graduate chemists with an interest in history of science. Because the book ranges so widely, we chemists (the reviewer includes himself, despite being also an Institute of Physics member), will not have studied many of the scientific and historical topics in the book, even at the level of the works listed in the bibliography. Accordingly, this book can act as a stimulus to undertake further reading.

In his preface, Baggott quotes the advice given to Stephen Hawking that each equation halves the sales of a popular science book (implying that no equations should be used other than possibly $E = mc^2$, which is so well known that it scarcely counts). He rightly disregards this advice, but imposes on himself the constraint that, in the main text (the endnotes are more mathematical), equations should have "two or at most three variables plus a [single] constant". Thus, equations such as $F = ma$, $E = mc^2$, and $E = h\nu$ appear, but $F = Gm_1m_2/r^2$ appears only in fragmented form at page 40, so that the reviewer found himself mentally reconstructing this familiar equation from somewhat circumlocutory text [1].

The book is very clearly structured and has a glossary, so "dipping" is facilitated. The author condenses and combines sources as listed in his bibliography (history and philosophy of science books, scientific biographies, other popular science texts, and some professional science texts). The index has apparently comprehensive name entries. However subject entries in the index are somewhat patchy; for instance, pages 101-102 on the bending of light by gravity are only findable from the index if one knows of Eddington, and pages 157-8 on the periodic table only if one knows of Pauli.

The core of the book comprises four parts, each of four chapters and each totalling fifty to seventy pages. Each part begins with one or two sentences indicating what the part will cover, and each chapter ends with "Five things we have learned". Parts II to IV each have 6 to 8 Figures illustrating the science, but Part I has only one Figure, not scientific (a map showing where Greek philosophers lived).

Part I. This part includes the following topics: – (a) The philosophy of matter from the ancient Greeks' speculations on the subdivisibility of matter to Locke, Berkeley, and Hume (Locke's distinction between primary and secondary qualities, introduced here, is implicitly referred to again at the very end of Part IV). (b) Newtonian mechanics. (c) The use of experimental evidence to investigate the atomic hypothesis up to 1908, by when each element was known to comprise similar atoms which survive chemical reactions [2], and the Avogadro constant L had been determined remarkably accurately.

The reviewer's main criticism of the book relates to the treatment of Newtonian Mechanics in Part I, admittedly only a small part of the book as a whole. The treatment focuses, sometimes misleadingly for the general reader, on what Newtonian mechanics does *not* do: "Try as we might, there's no way out ..... But it doesn't take us any further forward ..... And it gets worse....." A more positive account, with figures, would have been better. The discussion of the distinction between weight and mass and of $F = ma$ is inadequate. The importance of treating friction (or "resistance") as a force is ignored. The criticism by Ernst Mach (1838-1916) of Newton's definition of mass in terms of "density" and "bulk" is given undue prominence [3]. Mach's prescription for comparing two masses (consistent with Newton's laws) is summarised at page 37, and Newton himself used both inertial and gravitational methods [4], but the text of the second of "Five things we have learned" at page 43 would imply to the general reader that Newtonian mechanics does not allow such comparisons to be made.

In treating topic *(c)* of Part I, the author emphasises the experiment in which Daniel Sennert (1572-1637) dissolved silver in metallic form and then reextracted it in the same form. He notes that Boyle and Newton, though atomists, themselves had only rather general atomic notions (Newton's corpuscular theory of light apart). He describes the familiar line of chemical thought from the late eighteenth to the mid-nineteenth century (Priestley – Lavoisier – Dalton – Gay Lussac – Avogadro – Berzelius – Cannizzaro), which arrived at still-accepted molecular formulae such as H_2, O_2, and H_2O. The author describes the chronologically overlapping line of more physical thought (Bernoulli – Clausius – Maxwell – Boltzmann – Einstein – Perrin), which arrived at values for the Avogadro constant L close to the modern accepted value. Obviously in the space available, the author could not have set out the chemical or physical lines of thought much more fully; but the reviewer is sorry that space was not found in the description of the chemical line to give credit to Davy for his identification of important elements such as sodium and chlorine.

Part II. This part includes the following topics: – (a) Maxwell's electromagnetism. (b) Einstein's special relativity. (c) (By way of confirmation of $E = mc^2$) the work of Hahn, Meitner, and Strassmann on nuclear fission, and the atomic bomb. (d) Einstein's theory of general relativity and its confirmation, *inter alia*, by (i) Eddington's observation in 1919 of the bending of light grazing the sun during a lunar eclipse [5], (ii) the indirect observation of black holes predicted from the theory by Schwarzschild, and (iii) the observation in 2015 of gravitational waves by the Large Interferometry Gravitational-wave Observatory (LIGO) in the USA. (e) The introduction of the cosmological constant, dark matter, and dark energy to reconcile general relativity with astronomical observations.

Part III. This part includes the following topics: – (a) Rutherford's nuclear atom and the old quantum theory from Planck to Bohr. (b) The non-relativistic quantum mechanics of Heisenberg and Schrödinger. (c) The Pauli exclusion principle and the periodic table. (d) The relativistic quantum mechanics of Dirac and antimatter. (e) The Copenhagen interpretation and the Einstein-Podolsky-Rosen thought experiment. (f) Electron spin.

Topics (a), (b), (c) and (f) in Part III are familiar to chemists. *(f)* – and more particularly the Landé g factor for the spin magnetism of an electron – is encountered by chemistry undergraduates in relation to atomic spectra, magnetic susceptibility measurements, and electron paramagnetic resonance [6]; and g is a taking-off point for deeper physics. According to Dirac's relativistic quantum mechanics g should be exactly 2 [7]. The experimental value of g is 0.116 % greater than 2, and this small discrepancy points to the deeper physics. The fifth "thing" in "Five things we have learned" in the last chapter of Part III (at page 192) reads, "Mass took another step towards obscurity. The mass of an electron is, in part, derived from the energy of the virtual photons that dress it".

Part IV. This part proceeds to the even deeper physics associated with the names of Yang and Mills and of Higgs, and with the Large Hadron Collider (LHC) in Geneva. With Part IV, the author arrives at the destination prefigured in the title. According to Baggott's final summary at pages 253-4, "Five things we have learned", "..... We now know that protons and neutrons are composed of up and down quarks, but the masses of these elementary particles account for only one per cent of their host particles. Most of the mass ... is derived from the energies of

interactions between quarks and massless gluons and between quarks and other quarks that take place inside these particles..... [The] masses of the quarks are derived from interaction between otherwise massless particles and the Higgs field. We conclude that mass is a secondary quality....."

Notes and references

1. *a* acceleration, *c* the speed of light, *E* energy, *F* force, *G* the gravitational constant, *m*, m_1, and m_2 masses, *h* the Planck constant, *r* distance between two masses m_1 and m_2, and *n* frequency.

2. "Similar" is used by the reviewer to allow for isotopic mixtures, first suggested by Soddy in 1910.

3. See Isaac Newton, *The Principia – Mathematical Principles of Natural Philosophy*, translated by I. Bernard Cohen and Anne Whitman assisted by Julia Bordenz, preceded by *A Guide to Newton's Principia* by I Bernard Cohen (Berkeley and Los Angeles: University of California Press, 1999), 89-92.

4. Newton/Cohen, *op. cit* at 93-94. For example, use of a lever arm balance allows masses to be compared despite differences between between terrestrial locations in the acceleration of free fall, *g*, and therefore of weight. (*g* is 0.527 % less at the equator than at the poles.) Newton was aware of the variation in *g* and indeed he provided a qualitatively correct explanation of it, *op. cit.* at pages 826-832.

5. Newtonian particles of mass *m* travelling at speed *c* grazing the sun (mass $M >> m$) would follow a hyperbolic orbit, but one only very slightly curved even when close to the sun (more precisely, the orbit has very high eccentricity). The overall deflection (i.e. the angle between the asymptotes to the incoming and outgoing paths) is 0.87 seconds of arc. General relativity predicts *twice* this deflection, as confirmed approximately by Eddington and more accurately by subsequent observers.

6. In particular, the chemist may remember the following approximate formula for the magnetic moment *m* of of an octahedrally-coordinated first transition series metal ion with *n* unpaired electrons (each of spin 1/2) and therefore with atomic spin $S = n/2$, namely $\mu = 2\sqrt{(S(S+1))}\ \mu_B$, in which μ_B is the Bohr magneton and "2" is the Dirac value for *g*. For Mn^{2+} and Fe^{3+} in aqueous solution ($n = 5$) the formula gives $\mu = 2\sqrt{(2.5(2.5+1))}\ \mu_B = \sqrt{(5x7)}\ \mu_B = 5.92\ \mu_B$ in good agreement with bulk magnetic susceptibility determinations. See Linus Pauling, *Nature of the Chemical Bond* (Ithaca: Cornell University Press, 3rd edition, 1960), 162-164. (IUPAC now give *g* a negative sign, not included by Baggott, by the reviewer, or by Païs referred to in the next footnote.)

7. Even before Dirac, there was experimental evidence that *g* was nearer to 2 than 1. See Abraham Païs, *Subtle is the Lord – The Life and Science of Albert Einstein* (Oxford: Oxford University Press, 1982), 245-249.

Michael Jewess
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MEETING AND CONFERENCE REPORTS

Rutherford's Chemists, Glasgow, 15-16 July 2017

This was the second recent joint meeting between the RSC Historical Group and the History Group of the Institute of Physics; our previous collaboration being the meeting on Moseley held in London in October 2016. The middle of July was chosen as the time, as university lecture rooms were available and university accommodation was reasonably priced, but unfortunately attendance was low. The meeting served as a reminder of the crucial contributions chemists made in the first half of the twentieth century in the new areas of science opened up by the discovery of radioactivity. As well as the formal presentations, the symposium heard an informal talk by John Faithfull on some Soddy artefacts held at the Hunterian Museum, and we were conducted on a guided walk to view some interesting local sites. These included the building in which the term *isotope* was supposedly coined during a dinner party, and Ramsay's birthplace, both of which are close to the university. Thanks are due to Neil Todd of the Institute of Physics for organising an excellent meeting.

Marie and Pierre Curie and the Discovery of Radioactivity
Pierre Radvanyi (Institut de Physique Nucléaire, Orsay, France)

Prompted by the discovery of X-rays by W.C. Röntgen, H. Becquerel investigated whether a very phosphorescent uranium salt also emitted X-rays. In these experiments, in March 1896, Becquerel discovered what he called "uranic rays". In the autumn of 1897, Marie Curie Sklodowska commenced working towards a PhD at the Sorbonne (she would become the first woman in Paris to obtain such a degree). She decided to investigate if other chemical elements also emitted such "uranic rays". Her husband Pierre Curie constructed the necessary apparatus. She also looked at uranium minerals and found surprisingly that these were more active than pure uranium. Marie and Pierre continued their searches together. In July 1898 they discovered polonium and in December 1898 radium, using a new physico-chemical method. The term "radio-activity" was coined by Marie Curie. A number of questions were immediately raised by these discoveries. What were the properties of the rays emitted? Where does their energy come from? At this point Ernest Rutherford initially working alone, and then with Frederick Soddy, started working to answer these questions. In the ensuing years, Pierre devoted himself to the physical properties of radium, and launched the first medical applications of radioactivity, but died in a street accident in 1906. Marie succeeded in separating pure radium and in 1910 measured its atomic weight.

Frederick Soddy - Transmutation in Science and Society
Linda Richards (Oregon State University, Corvallis, USA)

It is fitting Sir Ernest Rutherford and Frederick Soddy first met in a public debate over atomic matter, because Soddy was consumed by what mattered most about atomic energy, for good or ill. While it was Rutherford who received fame for the two men's 1901-3 collaboration on disintegration theory, Soddy reached far beyond chemical and physical science to frame transmutation as a new kind of alchemy for mankind. Soddy felt imbued with a special responsibility, having been given a glimpse of how the atomic and chemical structure of the universe was determined. Unlike Rutherford, Soddy correctly anticipated (or perhaps he actually inspired?) a public concern that nuclear forces placed society at the precipice of abundance or destruction. Soddy began to abandon his nuclear research by 1919 and turned to the underpinnings of social structure, in the hopes of intervening in the economy in order to protect human rights and to end war. What mattered most to Soddy about atomic matter went far beyond chemistry and directed Soddy's trajectory into economics. Today Soddy is being resurrected as a de-growth economist with his anti-nuclear war clarion call. Similar in some ways to Linus Pauling's ideas about the responsibility of the scientist, Soddy's life can be a discursive rhetorical tool to help decipher the relationship between science and society.

Frederick Soddy - The Glasgow Years
David Sanderson (University of Glasgow, Glasgow, UK)

Frederick Soddy was born in Eastbourne in 1877 and educated at Eastbourne College. After a year in Aberystwyth, he studied chemistry at Merton College, Oxford, graduating with first class honours in 1899. Travelling to Canada he was appointed demonstrator in Chemistry at McGill University (1900-1903), where, working in collaboration with Rutherford, he developed the transmutation theory of radioactive decay. In London at UCL with William Ramsay (1903-1904) he showed that helium was produced from the radioactive decay of radium. Following a Commonwealth Universities lecture tour of Australia, he moved to Glasgow as Lecturer in Inorganic Chemistry and Radioactivity. His time in Glasgow (1904-1914) was highly productive and happy. He published twenty-four papers comprising original research and annual reviews of radioactivity for the Chemical Society. He was an eloquent lecturer, giving vividly illustrated public lectures on radioactivity, but also speaking publicly on broader scientific and social questions. During this period the nature of the radioactive decay series, displacement laws, the re-organisation of the periodic table of the elements from atomic mass to atomic number, were clarified. The term isotope was introduced to scientific vocabulary in 1913 by Soddy and was recognised in the citation of his 1921 Nobel Prize for Chemistry. Soddy returned to Glasgow to lecture to student societies in the early 1950s, and his contributions have been commemorated in the University by events in 1953, 1958, 1963, and in the isotope centenary year in 2013. This presentation looked at some aspects of the Glasgow legacy of Frederick Soddy, including the so-called Soddy Box, and also his work on the atomic weight of lead derived from the decay of thorium.

Sir William Ramsay: Chemical Nobility
Finlay Stuart (Isotope Geosciences Unit, SUERC, East Kilbride, UK)

William Ramsay was born in Glasgow in 1852, and grew up in the shadow of the University. Although destined for a career in the church, his interest in chemistry developed while convalescing with a broken leg acquired playing football. This led to entry to the University of Glasgow aged fourteen. After a PhD in organic chemistry at University of Tübingen with Wilhelm Fittig, he returned to Glasgow University as assistant to the Professor of Chemistry in 1874. In 1880 he took a Chair in Chemistry at University College, Bristol. Here he established himself as one of the leading physical chemists of his generation as well as an expert in the design and use of apparatus for handling minute volumes of gases. In 1887 he was appointed head of General Chemistry at University College London, where he worked until his death in 1916. A meeting with the physicist R.W. Strutt (Lord Rayleigh) at the Royal Society in 1894 proved pivotal in Ramsay's career. Within a year he had showed that sequential removal of nitrogen from air produced a progressively denser gas, eventually leading to the isolation of the inert gas argon, and the recognition that Mendeleev's Periodic Table needed an extra column for the inert gases. Subsequent work led to the discovery of helium. In Summer 1898 his team undertook the mammoth effort of fractional distillation of 120 tons of liquified air, sequentially isolating and identifying the remaining noble gases; neon, krypton and xenon. At the turn of the century Rutherford and Soddy discovered that thorium produced minute quantities of a radioactive, inert gas. In 1903 Ramsay invited Soddy to UCL where they refined analysis techniques, then went on to demonstrate that helium is a product of the spontaneous disintegration of radioactive substances - incontrovertible proof of the transmutation of elements. In late 1910 Ramsay's group measured the atomic weight of radon, completing column 8 of the Periodic Table.

Radioactive Contamination in the Notebooks of Frederick Soddy and William Ramsay
Neil Todd (University of Exeter, Exeter, UK)

This paper gave an account of a radiological survey and gamma ray analysis of the laboratory notebooks of Sir William Ramsay, held in the University College London archives, and of Frederick Soddy held in the Bodleian Library at Oxford. The Ramsay notebooks had previously been surveyed and four had been identified as being contaminated and were held in a box separated from other material. Within the Soddy papers forty-six notebooks were surveyed. The notebooks were initially scanned for residual radioactivity with a sensitive Geiger counter and

the activities recorded. Selected items from both sets were further analysed by means of a NaI gamma-ray spectrometer for the purpose of radioisotope identification. Both the Ramsay and Soddy notebooks show significant contamination from the summer of 1903 when they were working together at UCL on the production of helium from radium. Both also show later significant (>100 cps) contamination events, Soddy's in 1905 and Ramsay in 1910. Within the Soddy papers documents which were not used to record experimental laboratory data did not show any contamination, with one exception (some press cuttings from *The Times* from 1903). The gamma-ray analysis indicated that all of the contamination was due to radium (Ra226). It was argued that in conjunction with radiological data from buildings and apparatus, these data, as well as data from other surveys, provide an insight into some key events in the history of science. Of particular interest is the transfer of technology developed by Ramsay and Soddy for the manipulation of radium emanation to the Rutherford school at Manchester and the propensity for these methods to give rise to radioactive contamination.

Bertram Borden Boltwood (1870 – 1927): Radiometric Dating and the Age of the Earth
Edward Davis (University of Cambridge, Cambridge, UK)

Extensive correspondence between Boltwood (at Yale) and Rutherford (at Manchester) started in 1904 and continued for twenty years. The letters reveal much about the man known to his friends as "Bolty'. He was clearly a very accomplished radiochemist and, as such, could supply Rutherford with experimental information and chemical insights that physicists were unable to do. In addition, he is revealed as a kind and generous man, albeit with a wicked sense of humour. Historically he is known for his discovery of ionium, an element that was later shown to be an isotope of thorium (Th230). He is also credited with recognising that lead was the stable endpoint of uranium decay, which led him to suggest an important way of dating rocks by measuring the amount of lead they contained. Initial estimates for the age of the Earth based on this idea were on the scale of billions of years, in contrast to the millions of years proposed earlier by Lord Kelvin. Current values of the Earth's age are obtained using an advanced version of this method involving measurements of the ratios of radiogenic lead isotopes in ocean sediments and basalts. Further investigation reveals that Boltwood's contributions to science were considerably greater than these two achievements alone. Some of these were identified, and insights were provided into his character, which possibly suggested why his life ended so tragically with suicide.

Otto Hahn: From New (radio)Elements to New Energy
Dieter Hoffmann (Max Planck Institute, Berlin, Germany)

In 1905 Otto Hahn went to work as a young postdoc with Rutherford in Montreal, after a very successful year working with Ramsay. There he had discovered a new radioactive element, radiothorium. This discovery, which was questioned by Rutherford and especially by Boltwood, was the basis for his work in Montreal and the starting point of a very successful career as a radiochemist. This led to the discovery in Montreal of more radioelements – among them radioactinium. These discoveries not only established Hahn's reputation, but formed the basis for a life-long friendship with Rutherford. Decades later his competence in the field enabled him to carry out his revolutionary experiments on nuclear fission during the winter of 1938 to 1939. Among the many chemists who joined Rutherford was the physical chemist Paul Harteck. He was one of the last, arriving in 1933 as a postdoc from Berlin. His aim was to learn about nuclear physics, following his belief that "in the foreseeable future nuclear physics should open interesting and fundamental fields for a physical chemist".

Georg de Hevesy – Radioactivity and X-Rays in Manchester
Siegfried Niese (Radiation Protection, Analytics & Disposal Inc Wilsdruff, Germany)

The Nobel laureate Georg de Hevesy (1885-1966) studied physics and chemistry in Budapest, Berlin, and Freiburg where he defended his PhD thesis on the electrolysis of sodium hydroxide. This was followed by three years as an assistant in Zurich and Karlsruhe, because he had planned to contribute to the development of modern industry in Hungary. In 1912 he spent one year in Manchester with Rutherford to learn something about radioactivity. In the very creative atmosphere he learned new techniques and ideas, became interested in research work, and formed friendships with Moseley and Born. The year in Manchester was the starting point of his long and successful scientific life, with important discoveries in physics, chemistry, geology, physiology and medicine. After training in radioactivity by Rutherford's assistant Geiger, he determined the solubility of very short-lived actinium-emanation in liquids and the valences of radio-elements. When Rutherford asked him to separate Radium D (RaD, later discovered to be the radioactive isotope Pb-210) from inactive lead, Hevesy, like other chemists before him, was unsuccessful, and he concluded that this radioactive element can be used as an indicator for non-separable inactive lead in chemical processes. This he demonstrated in 1913 during a short stay with Paneth in Vienna. Later he applied the indicator method in physical chemistry, and after the discovery of artificial radio-nuclides he applied the technique in biology, physiology and medicine.

John Hudson

Chemistry and Anaesthesia – Some Historical Perspectives

Royal Society of Chemistry, Burlington House, 18 October 2017

We invited members of the History of Anaesthesia Society to attend this conference as our guests and over twenty took up the invitation, adding to the attendance of some fifty Historical Group members. Most, but not all, of the

speakers were former consultant anaesthetists with an interest in the historical/chemical aspects of their speciality. David Wilkinson, representing the President of the Royal College of Anaesthetists, "topped and tailed" the conference. The day was judged to have been a success, with several of our guests expressing a wish to attend our next whole-day conference on "World War 1 – Some Chemical Outcomes".

Alan Dronsfield

Anaesthesia Ignored: Why Doesn't Chemistry Give us the Answers?
David J. Wilkinson (Retired Consultant Anaesthetist, St. Bartholomew's Hospital)

Mankind has been using combinations of plant extracts for centuries in the hope of treating a variety of ailments. It is not surprising that the relief of pain and/or the creation of an unconscious state so that traumatic injuries could be treated more humanely would prove to be a feature of many early herbal manuscripts. The creation of a 'soporific sponge' and 'dwale' are two examples of this type of product and were undoubtedly used effectively for centuries. Using combinations of powerful alkaloids, the difference between therapeutic and harmful dosages would have been very difficult to determine especially as there were no standard preparations of each plant.

In Japan in the late-eighteenth century, Seishu Hanoaka produced a duplicatable product which was a combination of six plants after some thirty years of experimentation. Mafutsusan was an effective orally administered general anaesthetic and its preparation and use were taught throughout Japan during the early part of the nineteenth century. It was not until Western influences and the speed and simplicity demonstrated by ether inhalation to create a similar state that the practice disappeared.

With the demonstration in the USA that ether could create an anaesthetic state and the subsequent development of chloroform anaesthesia in the UK, the search was on for other potential anaesthetic agents. The only requirement for the trial of such agents was that they should be a volatile liquid! Innumerable products were tried, sometimes on animals first but often they were given to patients without any preliminary trials. Although several agents proved to be effective there were also series of cases that experienced very unpleasant side-effects.

By the start of the 1930s there were a series of gases and volatile liquids that were recognised as effective anaesthetic agents and chemists started to manufacture more potential agents. Halogenated hydrocarbons and ethers were the predominant agents and the ability to fluorinate such products that developed in the late 1940s changed the face of inhalational anaesthesia.

However, before chemists are blamed for not providing what anaesthesia would like to have, it should be recognised that the understanding of the receptors involved in anaesthesia is still at a rudimentary level and so it is very difficult to develop agents for indeterminate endpoints! The structural differences between complex ethers, hydrocarbons, and noble gases, all of which create an anaesthesia state, does little to solve this problem. It is to be expected that as soon as anaesthesia can determine exactly what it wants then a chemist should be able to manufacture it for our use. Until then we await research outcomes and in the meantime, seek to minimise adverse effects from the agents available for our use.

Davy, Nitrous Oxide and Bristol
Frank James (Royal Institution of Great Britain, London)

Frank James began by noting that his talk continued where his Wheeler Lecture of 2015 had finished. In this lecture he had discussed the fundraising endeavours of Thomas Beddoes and others in the mid-1790s to establish the Medical Pneumatic Institution (MPI) in Bristol. In the MPI the therapeutic effects (or otherwise) of various gases (mostly discovered during the eighteenth century) would be investigated for a whole range of diseases, but with a pronounced focus on consumption. Despite significant political opposition, due to Beddoes's radical political views (as a Jacobin and supporter of the French Revolution), by 1798 he had raised about £2,000 which was deemed sufficient to acquire a building and appoint staff, including the nineteen-year-old Humphry Davy as the MPI's Superintendent. James outlined briefly Davy's life, education, apprenticeship (as an apothecary) and networks up to October 1798 when he moved from Penzance to Bristol. There he assumed the running of the MPI, including completing negotiations for the building in which it was to be housed and then arranging its conversion to meet the needs of the MPI, including a laboratory and facilities for both in- and out-patients. This took time, so Davy occupied himself with other things, for example examining the strontian mineral vein on the River Severn to the north of Bristol. James pointed out that despite the MPI's name, it was not only medical experiments on gases that were performed. Other therapeutic agents were tested, particularly foxglove (digitalis). Although Davy was directly involved in medical trials of the gases, from mid-April 1799, he devoted ever increasing time to his discovery of the physiological properties of nitrous oxide, which resulted in his first book. He experimented on himself (sometimes inhaling eighteen litres), on one occasion writing "Davy & Newton" in large letters in his notebook, suggesting his vaunting ambition. He also experimented on friends in Bristol such as Samuel Coleridge, Peter Roget and Robert Southey, but it proved impossible to produce precisely the same reaction in different individuals. Although Davy in his book suggested that since nitrous oxide was "capable of destroying physical pain, it may be used during surgical operations", this was not taken up in medicine for about four decades. While explaining why something did not happen can be problematic, the delay in using nitrous oxide as an anaesthetic has been ascribed to its association with amusement and radical politics. James concluded that an additional reason might be connected with the lack of replicability of experimental outcomes.

Nitrous Oxide in Anaesthetic Practice: Some Reflections

John Pring (Retired Consultant Anaesthetist, West Cornwall Hospital, Penzance)

If only Davy, instead of saying "As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place" had declared "Hey, lads, this nitrous oxide will make a good anaesthetic – let's investigate!" he would have ended up twice as famous as he is now, and we would not have had to wait another forty years for anaesthesia!

Nitrous oxide is a colourless, slightly sweet-smelling gas, which boils at –88ºC, and is produced by the thermal decomposition of ammonium nitrate above 250ºC. Once impurities have been removed nitrous oxide is stored in French-blue cylinders pressurized to 44 bar. Its critical temperature (the temperature above which a gas cannot be compressed to the liquid state by pressure alone) is 36.5ºC, and its filling ratio (the weight of the fluid in the cylinder divided by the weight of water required to fill the cylinder) is 0.75 in the UK, but in hotter climates the filling ratio needs to be 0.67, to avoid cylinder explosion.

Whereas oxygen is supplied in cylinders at 137 bar and obeys Boyle's Law, a full cylinder of nitrous oxide, containing a mixture of liquid and gaseous nitrous oxide, shows approximately 44 bar, and this saturated vapour pressure remains effectively constant until all the liquid nitrous oxide vaporizes, whereupon Boyle's Law would apply. SVP changes only with temperature, so if the gas is used at a constant rate during a case the pressure will fall slightly. Nitrous oxide extracts its latent heat of vaporisation initially from itself (the bulk of liquid N_2O) and then its surroundings so you could often see ice forming on the outside of the cylinders. Between cases the cylinder would rewarm, the SVP would rise to its previous level again, the ice would disappear, and there would be a small puddle of water on the floor under the cylinder.

Nitrous oxide has a low blood/gas solubility coefficient (the lower the B/G partition coefficient the more rapid are both the induction of and the emergence from inhalational anaesthesia with that agent) but a high MAC (minimum alveolar concentration of a gas or vapour that is needed to prevent movement in 50% of subjects in response to surgical stimulus) whereas some modern agents have both low B/G SC and MACs.

N_2O will support combustion but is neither inflammable nor explosive, unlike old agents like cyclopropane (the explosive equivalent of modern volatile agent sevoflurane in terms of pleasant speed of induction). In 1934, Harold R. Griffith commented "My conception of anaesthesia with the older agents (nitrous oxide and ethylene) is that we administered the gas plus enough oxygen to keep the patient alive; with cyclopropane, on the other hand, we administer oxygen with just enough of the anaesthetic gas to keep the patient asleep".

Despite a MAC of 105%, N_2O is a central nervous system depressant and in concentrations of 80% will cause loss of consciousness in most subjects. It is forty times as soluble as nitrogen, and can pass from the blood into a gas-filled cavity faster than nitrogen can diffuse out, thus expanding the cavity, so is to be avoided in patients with bowel obstruction, middle ear and sinus disease, certain types of eye surgery when a bubble of inert gas may be left in the eye, and for patients with a pneumothorax.

The success of nitrous oxide as a sole anaesthetic was dependent on using as little oxygen as possible. Patients were frequently induced with 100% nitrous oxide for short dental operations until they showed signs of acute hypoxia - cyanosis, stertorous breathing, jactitations and muscle spasm. The gas was then withdrawn and the patient allowed to breathe air, or bursts of oxygen or air.

Cyanosis was an accepted occurrence during anaesthesia. In R.J. Minnitt and John Gillies *Textbook of Anaesthetics* (1945) one of the signs of fully developed nitrous oxide anaesthesia is "a colour of the skin definitely blue, but not blackish blue".

Safety features prominently nowadays and each cylinder is labelled, colour coded, and bar coded so they can be traced, and have a tamper-proof plastic wrapper around the valve. Importantly on the yoke on the rear of an anaesthetic machine is a pin index system to prevent the wrong cylinder being connected to the yoke, and thus the wrong gas from being delivered to the patient. Nowadays one cannot just turn the nitrous oxide on and deliver hypoxic mixtures as there is an interlock which automatically turns on at least 25% oxygen.

Hospitals now rely on bulk storage of oxygen but nitrous oxide cylinders are connected to a manifold, and both are piped to wherever needed; the pipes are colour-coded and have Schrader connectors which will only fit the appropriate gas socket.

McKesson in America was using gas and air, with 70% gas, for self-administered obstetric analgesia pre-1933, but in 1961 Tunstall described the introduction of *Entonox*, a 50:50 mixture of nitrous oxide with oxygen, produced using the Poynting effect, the dissolution of gaseous O_2 when bubbled through liquid N_2O, with vaporisation of the liquid to form a gaseous mixture with a pseudocritical temperature of -6ºC. If a cylinder has been exposed to cold below -6ºC it should be rewarmed and inverted three times before use, lest 'layering' occurs (oxygen above liquid nitrous oxide) which would result as the cylinder empties in an initial oxygen-rich mixture and then an oxygen-poor one. *Entonox* is also used for home deliveries, and by ambulance personnel for pain relief in transferring patients with broken bones. Laughing gas parties were popular in the 1820s and 1830s but its recreational use and abuse continues.

Surgical Relaxation: Crum Brown to the Present Day
Ann Ferguson (Retired Consultant Anaesthetist, Broadstairs)

"Relaxation" a term widely used in surgery and anaesthesia incorrectly implies that the subject still has control of their voluntary muscles. A more accurate term is *pharmacological paralysis*, and it is carried out, under very controlled conditions, by anaesthetists, not surgeons. How and why we do this, depends very much on the surgery.

The drug that everyone has heard about is curare, brought to Europe in 1744. It acts on the junction between a motor nerve and the muscle, causing flaccid paralysis. Neuromuscular blocking drugs, as exemplified by curare are unusual and perhaps unique in that knowledge of their mechanism of action and their use as tools in physiological experiments preceded their widespread clinical use by almost a century. Many physiological discoveries concerning cholinergic transmission have depended on the use of curare or tubocurarine. Claude Bernard showed, working with frogs, that curare paralyses motor nerves, but has no effect on the nerves of sensation. Alexander Crum Brown, doctor, chemist (eventually professor in Edinburgh) together with Dr Thomas Fraser, together won the Macdougall Brisbane Prize of the Royal Society of Edinburgh in 1868 for their paper "On the Connection between Chemical constitution and physiological action. Part one on the physiological action of the salts of ammonium bases derived from strychnia, brucia, thebaia, codeia, morphia and nicotia". This paper has considerable historical importance, as it constitutes one of the earliest attempts to make a systematic study of the relationship between the chemical structure and the pharmacological action of a drug. They showed that strychnine kills, but the same dose of methylated strychnine causes paralysis. It would be a mistake to suppose that they were trying to synthesize drugs which would cause neuromuscular blockade; they were merely trying to see how a change in the chemical structure of a substance changed its physiological action.

In the nineteenth and twentieth centuries, curare was tried as a cure for tetanus and there were attempts to use it in anaesthesia. John Newport Langley used it experimentally to elucidate the action of the neuromuscular junction in 1906 and Dale, Feldberg and Vogt used it in 1936 to demonstrate that acetyl choline was the transmitter at the neuromuscular junction. It was absolutely invaluable to both these sets of workers. In the 1930s there were unsuccessful attempts to use it in spastic states, and Gill, after suffering from multiple sclerosis, collected curare from Ecuador, which Bennett later used to prevent bone-breaking spasms in metrazol convulsion therapy. Curare had at last found a use in clinical practice.

Lewis Wright, an anaesthetist working for Squibb Pharmaceuticals, realised that curare had a possible application in anaesthesia, and he persuaded Harry Griffith, of Montreal to try it, which he did in January 1942, for an appendicectomy. This was a success, and Griffith continued to use it, wrote it up, and established its long-term use in North America. He used low doses by modern standards, and had described one thousand cases by 1945. John Halton heard of Griffith's use of curare, obtained some, and shared this with Liverpool anaesthetist Cecil Gray. They correctly realised its potential, and continued to use it. Unlike in America, Gray used high doses of curare and ventilated the patients, and reversed the curare at the end of the procedure.

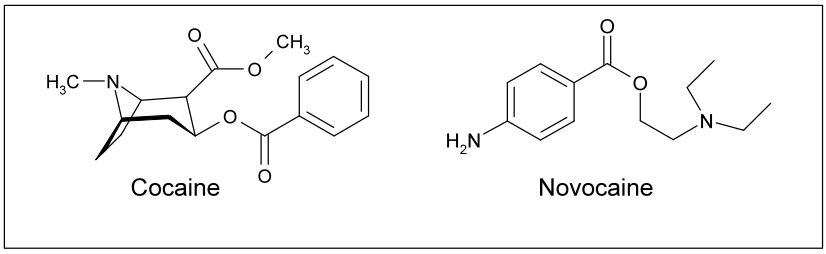
This was a great advance for surgery and anaesthesia, as it meant lower doses of anaesthetic agents could be used. Essentially, it increased the scope of surgery and decreased morbidity. For years curare was the gold standard, but other drugs were required, with a fast onset time, that could be easily reversed, have little or no effect on blood pressure and pulse, be safe in sick patients, worked independent of renal and hepatic function and provoked no histamine release. *Gallamine* (1947), *Alcuronium* (1961), *Fazadinium* (1974) and *Mivacron* have all been tried and eventually abandoned. *Pancuronium* (1968), *Atracurium* (1983), *Vecuronium* (1984) and *Rocuronium* (1994) are all still in use. The problem with all these drugs is that they have to be reversed, which is a somewhat cumbersome pharmacological process. The great advantage of the newest drug, *Rocuronium*, is that there is a specific reversal agent for it, *Sugamadex*. This should be the way forward for all new paralyzing drugs.

Details of all of the drugs mentioned, with their formulae, can be found in D.R. Bevan, J.C. Bevan and F. Donati, *Muscle relaxants in Anesthesia*, (Chicago, London: Year Book Medical Publishers Inc, 1988).

A Chemical, Medical and Social History of Cocaine
Alan Dronsfield (University of Derby)

Cocaine occurs in small amounts in the coca plant, *Erythroxylum Coca*, a shrub indigenous to South America. Chewing the leaves produces a "lift" apparently not unlike that associated with drinking strong cups of coffee. Europe began to take an interest in the leaves and their effects from about 1870 when the advent of refrigerated ships meant that the leaves could be imported in a reasonably fresh condition. Angelo Mariani, a chemist, found that the cocaine could be leached out by steeping them in cheap wine and his product *Vin Mariani* was endorsed by many celebrities who enthused over its restorative powers. An alcohol-free product was also marketed from 1886 as a refreshing drink and brain-tonic, *Coca Cola*, although its cocaine content was soon replaced by caffeine. In the final quarter of the nineteenth century cocaine was thought to be harmless and was used, orally, to boost energy and to act as an appetite suppressant. The ophthalmologist, Carl Koller, noticed it had a numbing effect on the tongue and tried it, successfully, as local anaesthetic eye-drops (1884). Within weeks it was reported that it also exerted a local anaesthetic effect if injected and immediately this found application in dentistry, both for "painless" extractions and for fillings. It was later found that it could "block" a nerve stopping the transmission of pain sensation, something that was later employed in spinal and epidural anaesthesia.

But cocaine had a number of drawbacks and chemists and physicians searched for an alternative. They were informed by a knowledge of the main structural features of cocaine, the correct structure being announced by Richard Willstätter in 1894. Several products were marketed, the most successful being *Novocaine*. This was used widely over the period 1905-1955. It was non-addictive and, unlike cocaine, was reliable in its action with virtually no cases of patient-collapse being reported.



At the start of the twentieth century it began to be realised that cocaine was not as harmless as was once thought. From 1908 it was only available from chemists on signing the Poisons Register and from 1915 newspaper reports of "cocaine parties" incapacitating soldiers on leave led to the *Defence of the Realm Act* (1916) which restricted its use only to medical procedures. In the USA, the demonization of the drug had racial overtones, with newspaper reports of it causing havoc in the coloured community. From 1919 the *National Prohibition Act* had attempted to limit the consumption of alcohol, but the law was unpopular and increasingly half-heartedly applied. In 1930 Henry Anslinger joined the Bureau and soon changed its focus from alcohol to drugs, especially marijuana and to a lesser extent, cocaine. Ever increasing draconian penalties spawned the "underground" production and dissemination of these drugs. He exported his policies to countries dependent on post-war US aid, and it is arguable that the present UK policies derive form this dependency.

The talk concluded by looking at the research findings of Dr David Nutt. In 2007 he produced a chart attempting to rank drugs and other substances in order of the harm that they do. His findings, with heroin being the most harmful, followed by (in order) alcohol, cocaine, tobacco, LSD and cannabis met with Governmental disapproval and he was very quickly dismissed from his role of "drugs czar".

Local Anaesthetics after the First World War: Early Structure-Activity Relationships
J.A.W. Wildsmith (Retired Consultant Anaesthetist and Professor Emeritus, University of Dundee)

Understanding the structure/activity relationships of local anaesthetic drugs requires an understanding of the two 'activities' which the drugs must possess. The first is obvious: the ability to impair transmission of impulses in peripheral nerve axons. The nerve action potential is caused by a wave of depolarization, a phased change in membrane permeability, first to sodium and then to potassium, meaning that the trans-membrane potential changes from about -70mV to +30mV (due to an inward move of sodium ions) and then returns to baseline (due to outward movement of potassium ions) in 1-2msec. Drugs might block any phase of the process, but most act by preventing the initial inward movement of sodium by blocking the channels by which it passes through the cell membrane. This is a non-specific action which many different classes of compounds possess when studied in laboratory preparations, but few of them act as local anaesthetics in the clinical setting. The reason is an interaction between the structure of peripheral nerve trunks and the impact of ionisation on the water and lipid solubility of the agents.

Like all anaesthetics local agents are lipid soluble, so to enable them to be presented in aqueous solutions suitable for injection they are compounded as hydrochloride salts is acid solution. After injection tissue buffers raise the local pH, the agent is converted to the un-ionised, lipid soluble version of the molecule. This is able to diffuse through the very significant amount of lipid connective tissue which surrounds the axons, and also the final diffusion barrier, the axonal membrane. In the intracellular fluid some of the molecules will re-ionise and it is this ionised form which diffuses into, blocks the trans-membrane channel for sodium, prevents depolarization and stops the onward transmission of impulses. Thus, the key properties of an agent are its lipid solubility and its pKa. Because of the need for a double change in ionisation status the ideal pKa is physiological pH, 7.4.

Cocaine is an effective topical agent, but diffuses poorly, is only weakly effective by injection and has significant systemic toxicity. These problems were quickly recognized after Koller's 1884 description of its use, but no real progress was made until after it was recognised to be a benzoic acid ester, this leading to the introduction of *procaine* in 1904. An improvement, its effectiveness is limited by low lipid solubility and a high pKa (8.9). Rapid hydrolysis of the ester link means that systemic toxicity is low, but also that it cannot be stored in aqueous solution, and that a breakdown product (para-amino benoic acid) is allergenic. After the First World War two new agents were produced: *tetracaine* (1928) and *dibucaine* (1925). The former is procaine with a butane group added so it is more lipid soluble, and thus more potent, but shares procaine's other problems. Dibucaine is chemically very different, being much more lipid soluble, and having an amide link making it stable in aqueous solution and producing a lower pKa (7.9). However, it was not the success which it should have been, primarily because of a major marketing error. Its original trade name was *Percaine*, and this led to confusion with procaine, and the use of excessive doses of dibucaine (which is much more potent) and thus cases of severe systemic toxicity. Such was the problem that the name was changed, to *Nupercaine*.

All of these developments took place in Germany, but the next major development was in Stockholm in the late 1930s. Attempts to synthetize an alkaloid, gramine, resulted in production of an isomer which was found to have local anaesthetic activity. A few analogues were produced, but none was better than procaine so the project stalled. However, one of the undergraduates who had helped, Nils Lofgren, returned to the subject for his PhD thesis, producing many homologous series of compounds as an exercise in structure activity relationships, then a 'new' subject. However, one of his own students, Bengt Lundqvist, was keen to try an agent clinically and was given compound 'LL30', one which Lofgren had produced to study the influence of electron theory on chemical structure. Like dibucaine it has an amide linkage, and an even lower pKa (7.7), but was not introduced with a confusing trade name! The studies earned Lofgren high marks for his thesis and 'proved' the validity of structure/activity studies. The agent became *lidocaine (Xylocaine),* turned a small pharmaceutical company (Astra) into a corporate giant, and made Lofgren and Lindqvist rich men. Sadly, they did not live long to enjoy the money; Lundqvist died very young, and Lofgren took his own life. *Lidocaine* remains the standard drug, and has resulted in the introduction of a range of related drugs.

For further information see: J.A.W. Wildsmith, J-R Jansson, "From Cocaine to Lidocaine: Great Progress with a Tragic Ending", *European Journal of Anaesthesiology,* 2015; 32:143-6.

Carbon Dioxide: The First Anaesthetic Gas

Adrian Padfield (Retired Consultant Anaesthetist, Royal Hallamshire Hospital, Sheffield)

Henry Hill Hickman was a general practitioner (then called a 'surgeon') who practised in Ludlow from 1820 to 1824 when he departed to Shifnal somewhat precipitately. He had been apprenticed to local surgeons, attended lectures in Edinburgh and passed the membership examination of the Royal College of Surgeons in May 1820. He seemed to be a sensitive young man and was concerned about the pain suffered by patients who needed surgery. He experimented on animals using asphyxia, 'carbonic acid gas' and his own exhaled breath to produce insensibility or suspended animation. He may have known about Benjamin Brodie at St George's Hospital in London who had made a guinea pig insensible using carbon dioxide in 1821 and he would have heard about the Grotto del Cane near Naples filled with carbon dioxide, where many tourists observed dogs dragged out unconscious and then revived. The concept of anaesthesia was not then known or accepted but the notion that people seemingly dead by suffocation or drowning were not dead, was. The Humane Society had started in 1773 and became Royal in 1788 so it was recognised that it was possible to resuscitate the 'apparently dead'. The Edinburgh Clinical Guide for medical students stated in 1801: "Accidents frequently occur from suffocation, drowning and strangulation which give immediate check to …life but do not… extinguish it".

Hickman wrote to an eminent local landowner, T.A. Knight, FRS, in February 1824, describing his experiments and why he used carbon dioxide: "I have never known of a case of a person dying after inhaling Carbonic Acid Gas…and suspended animation may be continued…for any surgical operation". Hickman looked for support from Knight and in August he published a twenty-eight-page pamphlet directed at the public entitled *A Letter on Suspended Animation* but addressed to Knight. There is a line deleted on the title page: "and read before [the Royal Society] by Sir Humphry Davy"! The pamphlet was printed in Ironbridge because Hickman was now living nearby in Shifnal. It seems he left Ludlow in 1824; there was an auction of his furniture, &c. and of his collection of stuffed animals in May 1824 but why? Perhaps because of an increasing public reaction against cruelty to animals? The RSPCA was founded in 1824. A year later his pamphlet was reproduced in the local newspaper and there were two known public responses: dismissive in *The Gentlemen's Magazine* in early 1825, and in *The Lancet*, February 1826, which was vituperative. Hickman continued to practise in Shifnal until 1828; he was described as a physician in a local directory.

In April 1828 he went to Paris to petition the French King, Charles X. His letter was passed on to the *Académie Royale de Médecine* where it was discussed in October 1828 and regarded as sensational and contemptible. By this time Hickman's wife had joined him and he bought her a jewelled bracelet in November so his finances must have been secure. However, he returned to Tenbury, not Shifnal, practising there from at least as early as July 1829 until his death on 2 April 1830. Early in 1847 a local doctor wrote to *The Lancet* claiming priority for Hickman over the recent introduction of inhalational anaesthesia using ether. It was another sixty-five years before Hickman's name was cited in the *British Medical Journal* by the curator of the Wellcome Museum and then after the Great War he was referred to again as the centenary of his death approached. This was celebrated and a medal struck to be awarded every three years by the Section of Anaesthetics of the Royal Society of Medicine.

In modern general anaesthesia, accumulation of CO_2 stimulates breathing and raises the blood pressure to the detriment of the patient. In the first part of the twentieth century, techniques were devised so that CO_2 was absorbed by passing the patient's expired breath through canisters containing soda lime either by to and fro breathing or more commonly via a circle system with valves to maintain the flow. CO_2 was also used to stimulate breathing during inhalational induction to deepen anaesthesia more rapidly and for the purpose of passing an endotracheal tube via the nose (blind nasal intubation). In the same way it was used to make the patient breathe oxygen more deeply at the end of a short operation and so awaken more quickly.

Anaesthesia: Present and Future: The Chemist's Challenges
David J. Wilkinson (Retired Consultant Anaesthetist, St. Bartholomew's Hospital)

In the decade following 1960, American chemists Ross Terrell and Louise Croix synthesised hundreds of fluorinated hydrocarbons for Ohio Medical Products in a search for more effective anaesthetic agents. This was a carefully orchestrated search for compounds which were needed to be volatile, stable in the presence of soda lime, non-flammable and relatively cheap to produce. Out of the hundreds created and initially assessed on animal models only four were taken forward.

Enflurane was #347 in their series and this proved to be a useful replacement for halothane as it was less cardiovascularly depressant and did not appear to cause any hepatic problems after multiple exposures. *Isoflurane* (#469) was a structural isomer of enflurane but a very different drug. It was more potent with a faster onset and recovery phases. After initial concerns over its higher cost declined, the drug effectively replaced enflurane in clinical practice. *Desflurane* (#653) had an even faster onset and offset but was much more irritant to the respiratory tract. With a boiling point of 23.5C it required a completely new form of vaporiser to deliver the drug. *Sevoflurane* was made in the 1970s by Travenol Laboratories and was a fluorinated ether. Initial concerns over a by-product of its exposure to soda lime limited its initial acceptance, but after extensive use in Japan these concerns were put in context and it became probably the most popular inhalational anaesthetic agent.

A completely different approach emerged with the use of Xenon, one of the noble gases, as an anaesthetic. Initially trialled in the 1950s there were problems with costs and availability. Produced from fractional distillation of air it could not be manufactured and it was not until the early 1990s that effective scavenging and re-use systems were developed. It remains a very effective and interesting agent, but its widespread use is limited by its cost and availability.

Although chemists continue to manufacture new induction agents, muscle relaxants and local anaesthetics there seems to be very little in the pipeline with respect to new inhalational drugs. The main difficulty is obviously the huge costs involved in bringing a new agent into clinical practice and the relatively small usage compared to the large volumes of antibiotics, anti-hypertensive agents etc. The problem for the future remains the need to determine the exact receptors which modulate anaesthesia which, once proven, could determine much more effective targeting of specifically designed drugs.

Symposium Commemorating the 150th Anniversary of the Gesellschaft Deutscher Chemiker

Burlington House, Wednesday 25 October 2017

After registration and coffee, the seventy-five participants were welcomed by Sarah Thomas of the RSC who introduced the current RSC President, Sir John Holman and the President of the German Chemical Society, Gesellschaft Deutscher Chemiker Thisbe Lindhorst. They reminded us of the long histories of the two Societies and of the many links between them. The Symposium was split into three sections and a named lecture. Here we cover in depth only the first section (a Common History) and the historical exhibits.

Bill Brock speaks on "Anglo-German Chemistry, 1821-1914"

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A Common History

The two talks on *A Common History*, opening the main proceedings, were chaired in turn by the CEO of the RSC, Robert Parker, and the Executive Director of the GDCh, Wolfram Koch. First, Bill Brock (University of Leicester) spoke on "Anglo-German Chemistry 1821-1914". The Anglo-German chemical connection stems in considerable part from succession of the Elector of Hanover to the British throne in 1714 as George I. The personal link was broken only in 1837 when Queen Victoria inherited the British throne but could not inherit the throne of Hanover under Salic law. Hanover was annexed by Prussia in 1866.

George II founded the University of Göttingen in 1734 and this attracted British students. Edward Turner, a future professor of chemistry at University College London, studied there under Friedrich Stromeyer (1766-1835). A galaxy of later British chemists studied under Liebig at Giessen, Bunsen at Marburg and Heidelberg, Wöhler at Göttingen, and Hofmann in Berlin, and elsewhere in Germany. Among these were Williamson, Frankland, Tyndall, Dewar, and Ramsay. Germany had good laboratories and offered the PhD degree (introduced in England only in 1919). Germany was cheaper than England to live in, and had superb countryside. Germans also travelled to England, most famously Hofmann to establish the Royal College of Chemistry in 1845, with laboratories opened in 1846 facing onto Oxford Street, and the industrialist Ludwig Mond. A rift was caused by the Great War and particular the 1914 letter signed by ninety-three German intellectuals including Baeyer, Fischer, Haber, and Ostwald. The rift began to heal after 1929. The PhD now being available in Britain, Germany became more of a destination for post-doctoral workers such as Todd.

The next talk was given by Brigitte Osterath a science journalist from Bonn and contributor to *Nachrichten aus der Chemie*, who spoke on "Searching for Traces of August Wilhelm von Hofmann". August Wilhelm von Hofmann co-founded the German Chemical Society in Berlin in 1867 and became its first president, and its father figure. The idea for establishing a chemical society in Germany was brought back by Hofmann from London where he had lived and taught at the Royal College of Chemistry (RCC) for twenty years. Early on he became involved in the Chemical Society of London of which he was President from 1861 to 1863. In London, numerous sites associated with Hofmann remain today, including his home in 9 Fitzroy Square and the former site of the RCC at 299 Oxford Street, both with plaques. In Berlin, though, almost all memories of him were destroyed in WWII or demolished later on. Even at the site where the German Chemical Society was founded in 1867, little of its former glory remains: the building was demolished when a railway line embankment was built in 1876 – nowadays, the homeless reside under the underpass. Beside it, in front of the university library of the Humboldt University of Berlin, the German Chemical Society (GDCh) has now installed a Historic Chemical Landmark plaque.

Delegates listening to Brigitte Osterath's talk on "Searching for Traces of August Wilhelm von Hofmann".

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Chemistry and Global Challenges

The next four talks came under the heading of *Chemistry and Global Challenges*, alternately chaired by Neville Compton (Wiley-VCH) and Anna Simpson (RSC). Philipp Adelhelm (University of Jena) spoke on "The role of

chemistry in the development of materials for efficient, safe and low-cost rechargeable batteries", and this was followed by Elise Cartmell (Scottish Water) on "The role of chemistry in sustainable wastewater treatment".

After lunch, the Global Challenges section was continued by Monika Pischetsrieder (Erlangen-Nürnberg University) on "Novel developments in food chemistry to ensure safe, healthy and pure food". Finally, in this section Pete Licence (University of Nottingham) spoke on "Chemistry: Towards a more sustainable future?"

Alexander Todd-Hans Krebs Lecture

The Alexander Todd-Hans Krebs Lecture "DNA Bases beyond Watson and Crick" was delivered by Thomas Carell (Ludwig Maximilians University Munich), chaired by Sir John Holman and Prof. Lindhorst, who also presented the Todd-Krebs award to the speaker.

Future of the Chemical Sciences

The final session, *Future of the Chemical Sciences* took the form of a panel discussion with Sir John Holman, Thisbe Lindhorst, Pilar Goya (Vice-president, EuCheMS), Matthias Urmann (Sanofi-Aventis) and Elizabeth Rowsell (Johnson Matthey), chaired by Adam Brownsell (RSC).

Renewal of Memorandum of Understanding

Thisbe Lindhorst and Sir John Holman renew the Memorandum of Understanding

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Robert Parker and Wolfram Koch made closing remarks and thanked the speakers; the RSCHG was also thanked for the help it had given. A reception followed during which the Memorandum of Understanding between the two Societies was renewed and signed by the two Presidents. His Excellency the German Ambassador attended this ceremony and made a short speech in which he praised the contributions of the two Societies to Anglo-German cooperation. The text of his speech follows:

Speech of the German Ambassador, His Excellency Dr Peter Ammon

Professor Lindhorst, Professor Sir John Holman, Professor Koch, Dr Parker, Ladies and Gentlemen, thank you for including me on this special occasion. We are here to celebrate the 150th anniversary of the Gesellschaft Deutscher Chemiker (GDCh) and its long-standing relationship with the Royal Society of Chemistry. Let me confess that, when entering University, I started off as a student of chemistry myself. I found it, however, too challenging for me, and after one semester, decided to look for something easier, like diplomacy.

Founded twenty-five years after The Royal Society [of Chemistry], the Gesellschaft Deutscher Chemiker and its British counterpart have maintained close links ever since. Their long, shared history is personified by August Wilhelm von Hofmann, an outstanding chemist of the nineteenth century, who was president of the Chemical Society of London before becoming the founding President of the GDCh's predecessor society, the Deutscher Chemische Gesellschaft, in 1867. Celebrating this event together highlights the strong bond between both institutions that has existed over such a long period of time. However, science by its nature looks forward rather

that back. And of course, we are all very proud to say that 150 years after its founding, the Gesellschaft Deutscher Chemiker is now the largest chemical society in continental Europe, building on the success of the Royal Society [of Chemistry].

In a fast-changing world, chemistry is vital for human prosperity, and the work of scientists is becoming more important than ever. Our joint celebration tonight underlines that science knows no borders. Think of Professor Hofmann, who was called to London because of his excellent reputation and later brought his experience back to Germany, becoming one of the fathers of the Deutsche Chemische Gesellschaft. Science was and is truly transnational. I think it is important that politics, and we diplomats, don't get in the way when you scientists are building bridges between our two countries. Despite what all the doomsayers and preachers of Brexit say, I firmly believe that Germany and the UK will remain close partners, in particular in scientific cooperation.

We cannot let the enormous potential that lies in our cooperation go to waste. Let your voice be heard, within but also beyond scientific circles. In this spirit, I am very proud that this celebration highlights the flourishing relations between the scientists of our two countries. May this splendid anniversary be just the start of even stronger and closer cooperation. I wish you all a most enjoyable evening.

Historical Exhibits

Exhibits and Placards in the Council Chamber

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The day's proceedings were in a sense presided over by the RSC's marble bust of Hofmann, normally located in the entrance hall but for this occasion garlanded in the manner of Sir Henry Wood at the Proms and put in the front of the library lecture hall.

The Council Chamber housed numerous historical exhibits and placards. There were essays by Bill Brock on the Albert Medal, on Hofmann's celebrated Friday evening discourse at the Royal Institution on 11 April 1862, concerning colouring matters from coal, and on Hofmann's molecular models, several of which were displayed. Roland Jackson wrote about John Tyndall and Robert Bunsen and Frank James's contribution focussed on Michael Faraday and German-speaking chemists. Anna Simmons discussed Robert Warington, Justus von Liebig and the Chemical Society. Also exhibited was the new RSC Landmark blue plaque (see below) which it is intended should replace the old and tarnished steel one at 299 Oxford Street (site of the laboratories of the Royal College of Chemistry from 1846). A firm date for the installation of the new plaque is awaited.

Bill Griffith and Michael Jewess

11th International Conference on the History of Chemistry

Trondheim, Norway, 29 August-2 September, 2017

The 11th International Conference on History of Chemistry (11 ICHC) of the Working Party on the History of Chemistry (EuCheMS) was held in Trondheim, Norway, from 29 August to 2 September, 2017. The local host of the conference was the Department of Teacher Education, NTNU – Norwegian University of Science and Technology, in collaboration with the Norwegian Chemical Society. The main sponsors were the NTNU, the Research Council of Norway, the Chemical Heritage Foundation, Sintef Materials and Chemistry, Ineos/Inovyn, the Society for the History of Alchemy and Chemistry and the division for history of chemistry of the Norwegian Chemical Society.

The 11th ICHC was attended by 111 participants, making it one of the highest attended conferences in the history of the ICHC. Participants came from Australia, Taiwan, Japan, China, Mexico, Canada, USA and most European countries. Historians and philosophers of science, professional chemists, current-and prospective science teachers, came together to present and discuss ongoing research in the history of chemistry.

The programme consisted of three plenary lectures, seventeen parallel sessions with seventy-three oral presentations, one film screening, and a concluding discussion panel, in addition to a social programme with excursions. In contrast to previous ICHC conferences there was no call for contributions on a specific theme. Instead, the three key note lectures were meant to inspire panel and individual submissions from a range of areas within the history of chemistry. Hasok Chang from the University of Cambridge spoke about "What history tells us about the nature of chemistry", Maria Rentetzi from the National Technical University of Athens gave a lecture on "Living with radiation: What historians of chemistry have to do with science diplomacy and international organizations", while Anders Lundgren from the University of Uppsala presented on "Science in chemical industry – what did it do?".

The seventeen parallel sessions covered the following topics: Chemists and the IUPAC: Taking responsibility and taking actions; Chemical innovation systems in the Third Reich; Elements and the structure of matter; Alchemy and early chemistry; Women in chemistry; Dyes and pigments in history; Recent chemistry: new methodological approaches; Toxic products: communicating toxicity; Toxic products: toxic risks; Science teaching: historical approaches; Chemistry teaching: new approaches; Boundary work: chemistry and economy; Relating chemistry: translating chemistry across linguistics, disciplinary and physical boundaries; Biographical approaches; and Polymers and plastics. Finally, a round table entitled "What future for the history of recent chemistry and

molecular sciences? New challenges in the history of chemistry and the molecular sciences", concluded the conference.

Group photo in Bymarka recreation ground, where the 11ICHC conference dinner took place.
Photo credit: Mentz Indergaard, NTNU

The social programme included demonstration of a fifteenth century distillation furnace at the University Museum, an excursion to Sverresborg Open Air Museum, an organ concert at the Nidaros Cathedral, a conference dinner, a stroll along the Trondheim fjord, and a full-day excursion to the UNESCO World Heritage Site of Røros, a seventeenth-century mining town.

To add a personal note, I was pleased that the ICHC was well attended after a couple of conferences where attendance had been declining. Once again, however, British attendance was low, only six in total including Hasok Chang as a keynote speaker and myself. This was doubtless partly a result of the high cost of living in Norway, which seems to become more and more eye-wateringly expensive every time I go. And there were no British chemists (rather than professional historians of chemistry). Perhaps with Maastricht being nearer the UK and the cost of living being more reasonable, the situation will change when the Netherlands hosts the ICHC on 6-9 August 2019.

Peter Morris

Dyes in History and Archaeology Meeting Report

The thirty-sixth annual meeting of Dyes in History and Archaeology took place in October 2017 at Hampton Court Palace. It was hosted by the Royal School of Needlework, with oral presentations and poster displays held in the Clore Centre. About seventy delegates attended, from twenty countries. Of the twenty-two oral presentations most came from Italy (five), possibly because the last DHA meeting was held in Pisa, closely followed by England (three), Scotland (three) and the United States (two).

The topics covered were diverse. The identification of dyes on historic textile samples using a wide array of spectroscopic techniques received significant attention. The current understanding of the chemistry associated with historic dyes such as Cornelis Drebbel's scarlet, Turkey red, madder root and iron gall inks was revealed. Recently discovered documentary data on John Crutchley (the eighteenth-century Southwark dyer), on the Leeds dye manufacturer, Wood and Bedford (later to become Yorkshire Chemicals) and on Edward Bancroft were described. The traditional accompaniments to a DHA meeting did not disappoint. The Wednesday evening reception was held at the Royal School of Needlework. The Thursday conference dinner was held in the Mitre Hotel, overlooking the River Thames. The Saturday outing went first to the Dennis Severs house near Liverpool Street station. Then, travel to Braintree, with a picnic on the train, to visit the Warner textile archive located in Warner & Sons' original Grade II listed textile mill and which contains about 100,000 items. There were tea and cakes as well. More details can be found at http://dha36.org.uk/.

Chris Cooksey

FORTHCOMING RSCHG MEETINGS

Royal Society of Chemistry Historical Group Autumn Meeting
Wednesday 17 October 2018, Royal Society of Chemistry, Burlington House, London

This meeting will explore historical perspectives of dyes and dyeing The Group's AGM will also be held. The programme will appear in the summer 2018 *Newsletter*.

OTHER MEETINGS OF INTEREST

Society for the History of Alchemy and Chemistry Spring Meeting and AGM

Alchemy and Print Culture
Saturday 30 June, UCL Institute of Education (IOE), London

Details of the programme and how to register will be available on the SHAC website in due course: www.ambix.org.

History of Anaesthesia Society: Annual Meeting,
29-30 June 2018, Royal College of Surgeons of Edinburgh

For further details please see: http://www.histansoc.org.uk/events.html

Institute of Physics Public Lecture: The Newtonian Moment
Wednesday 21 March 2018, Franklin Room, Institute of Physics, London, 6.30 pm

Fabian Pailluson, a physicist and Anna Marie Roos, a historian of science, will shed light on the discovery of Newton's laws, some of the most famous and important in physics. The lecture will feature a poetry reading by Andrew Wynn Owen, an examination fellow from All Souls College, Oxford.

Institute of Physics: History Group

The next event will be a one-day meeting on the history of MRI, to be held in Nottingham on 18 April 2018. Details will be available nearer the time from: http://www.iop.org/activity/groups/subject/hp/index.html

FORTHCOMING CONFERENCES

European Society for the History of Science Conference
14-17 September 2018, London

The next ESHS conference will take place in London at the Institute of Education on 14-17 September 2018. The conference theme is *Unity and Disunity*. This can be interpreted very broadly, to address, amongst other topics, unity and disunity within and across diverse sciences, nations, periods, and historiographies; unity and disunity as ideals and realities; and unity and disunity as characterizing relations between the sciences and politics, technology, economics, and the arts. Submissions, including an abstract no longer than 300 words in either English or French, should be made, via the conference website http://eshs2018.uk by 23.59 GMT on 28 February 2018.