



Chemistry

In Action!

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Dmitri Mendeleev 1834-1907. Father of the Periodic Table.

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Information Page

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Editorial #113

Proceedings ChemEd-Ireland 2018

This issue is the Proceedings issue where we collect the talks from the previous year's ChemEd-Ireland conference. In 2018 it was held very successfully in Trinity College, Dublin. The lead organiser, John O'Donoghue, has kindly organised the collection of the talks. The Proceedings act as an archive of past ChemEd-Ireland conferences and widens the impact by reaching more people than those who attended.

If you were there then I hope the articles will remind you of a good day and if you weren't there, make a date to attend this year's conference at DIT, Kevin Street on October 19th. 2019.

IYPT 2019

You will be aware from the last issue (#112) that 2019 is the International Year of the Periodic Table (IYPT). Please make this an opportunity to promote the Periodic Table and chemistry in your school. We continue to publish articles relating to the Periodic Table, which we hope will inform your teaching this year. Plan to do something in your school to mark IYPT.

LC practical exams cancelled

The introduction of practical exams in the LC science subjects -biology, chemistry and physics – was one of the key elements in the new science specifications, launched in 2008. The Schools Examination Commission (SEC) ran a pilot project in 30 schools and the report was sent to the Minister of Education last year. The report (see p.3) showed that such exams were feasible but that they would be too expensive to run and would be a logistical nightmare. I have made this point in the past in these editorials. Schools would need to be re-equipped and teachers would have to be retrained. Running 90 minute practical exams for all students taking LC biology, chemistry and physics would be enormously expensive and complex. It also means introducing practical exams in science into an education system with no experience in running them. I am

sure that schools and teachers will be relieved that the new exams are off the table for the time being. If it were to be introduced, surely it would make sense to pilot it first in one of the smaller LC sciences, chemistry or physics, for a 2 year cycle?

Ideally the new LC subjects should follow on seamlessly from the new junior cycle courses, and there should be a matching of approach and academic demand to ensure a smooth transition. The new junior cycle science course will complete its first cycle this summer and students should have been able to move into a matching set of LC science subjects. It looks doubtful now that this will be the case. The final specification of the new science courses is still needed and publishers, teachers and schools need time to prepare. There was already a large gap between junior cert science and the existing leaving cert courses, making transition difficult for students; with the new course this gap will be larger and students will be less well prepared to study one of the science courses. For example, in chemistry students will not have met bonding before.

Apart from this problem there is also the question about the subject specifications lacking detail of depth of treatment, so that teachers actually know what they have to teach. In a letter in the *Irish Times* (28/2/19) Professor Aine Hyland makes a good point:

“The current template (of the National Council for Curriculum and Assessment) for designing a new (or revised) curriculum is limited to a statement of topics and a list of learning outcomes – it is simply an outline or a framework for a possible syllabus. No further details are provided – no indication is given of depth of treatment of a topic or theme, nor are teachers’ notes or an examination specification included in the syllabus document – as was available in the past.”

Peter E. Childs

Hon. Editor

In issue #113

Proceedings of ChemEd-Ireland 2018

A major part of this issue is devoted to the Proceedings of ChemEd-Ireland 2018, held in Trinity College, Dublin. The main organiser, Dr John O'Donoghue, has collected as many of the papers as possible, and gives us an introduction to the conference. This was the first time TCD had hosted ChemEd-Ireland and it was a great success. John gives us an overview of TCD's chemistry education activities on p.10.

Sir Martyn Poliakoff was a highlight of the conference as he talked about his video series on the chemical elements. We have an interview with him by Lizzy Ratcliffe which covers most of what he said in Dublin (p.12).

Professor Sylvia Draper (p.15) from TCD spoke about her career and the importance of explaining what one does to a lay audience.

Dr Fiona Desmond (SEC), gave an update on the practical assessment trial and reviewed the 2018 LC chemistry papers (p.17)

Professor Sylvia Draper (p.15) from TCD spoke about her career and the importance of explaining what one does to a lay audience.

There were several workshops and we have short reports on the JCT workshop on ocean acidification (p. 19) and the one on Risky Chemistry (p. 20).

Professor Sylvia Draper (p.15) from TCD spoke about her career and the importance of explaining what one does to a lay audience.



United Nations
Educational, Scientific and
Cultural Organization



International Year
of the Periodic Table
of Chemical Elements

IYPT

IYPT was launched in January at the UNESCO headquarters in Paris and we have a report on the opening ceremony. (p. 23)

Mark Lorch gives us a nice overview of the history of the Periodic Table (p.27).

Some ideas for marking IYPT and resources to use are given on p.34.

We have an article on the history of group 17, the halogens, which was dominated by French chemists (p. 37).

What are the best books on the Periodic Table? Gordon Woods gives us his take on this (p. 41).

There are many video resources on YouTube about the Periodic Table and some of them are given on p. 35.

Other items

Ever wondered what's in your bread or other food that you buy? Dr Jane Essex has an interesting article on bread adulteration on p.47.

Are you teaching chemical myths? You might be as some things that we accept on trust turn out to be wrong. Some chemical myths are given on p.57 but if you know of more, please send them in.

The chemist you should know in this issue is Thomas Graham, famous for his law of effusion and diffusion (see p.50).

Ian Clancy has contributed an interesting article on the change in the definition of SI units, especially the kilogramme, which will take place this May (see p. 54).

Bob Worley has the first of a series of articles on Microscale Chemistry – this one on introducing solubility and precipitation (p. 61).

Cliona O'Geran of Janssen reports on the WiSTEM²D programme sponsored by Johnson & Johnson on p. 64.

Education News and Views

The Editor welcomes contributions and news of interest to chemistry teachers in this section.

Female-only STEM professors

(Irish Times 15/11/18)

In Nov. 2018 Minister of State for Higher Education, Mary Mitchell O'Connor, announced the Government's intention to create up to 45 new posts to boost women's representation in senior academic positions. In Irish universities 50% of lecturers are women but only 24% of professors are women. This initiative, whose details are still to be worked out, aims to redress the balance and break the glass ceiling. The percentage of women in higher academic posts varies between institutions and between disciplines.

Practical exams axed

In Dec. 2018 the Minister of Education, Joe McHugh, announced that the practical exams in the new LC science subjects (biology, chemistry, and physics) as proposed by the NCCA, would be shelved due to cost and logistical problems.

"Instead, he has asked the curriculum advisory body to explore the option of a coursework assessment - such as a project - in biology, chemistry and physics, similar to what happens in some other subjects.

Students would complete the coursework during the school year, under the guidance of teachers, and it would be marked by an examiner appointed by the State Examinations Commission (SEC).

The trials were deemed a success, but the SEC argued strongly against a national roll-out now because of an already crowded sixth year timetable, difficulties recruiting examiners and the need to bring school science labs up to scratch which, while unquantified, could run to hundreds of millions of euro.

The report argued against imposing science practicals on an already over-burdened system without a major review of the organisation of existing orals and practicals.

It is 36 years since science practicals were first mooted, as a way of testing students' application

of their knowledge and skills, while also reducing reliance on the written June exams.

There was an expectation that the trials would lead to the introduction of practicals in the next couple of years, to coincide with the first cohort of students completing the new, more hands-on junior cycle science syllabus and progressing to Leaving Cert.

A spokesperson for Mr McHugh said the Department of Education was keen that Leaving Cert science subjects should incorporate a second assessment component to allow a broader assessment of students' skills."
(Irish Independent 11/12/18)

This follows submission of a report by the Schools Examination Commission (SEC) on the feasibility of practical exams based on a trial in 30 schools, which reported in June 2018.

You can read the report here:

<https://www.examinations.ie/misc-doc/EN-AU-52990956.pdf>

Here is the summary of the report:

Summary

Draft new subject specifications (previously known as syllabuses) for Leaving Certificate Biology, Chemistry and Physics have been prepared by the National Council for Curriculum and Assessment (NCCA). These specifications include a proposal that 30% of the marks in each of these subjects be awarded for a 90-minute, laboratory based, externally assessed, practical examination, with the remaining 70% being for a written examination.

The proposed arrangements were trialled in thirty schools in October 2017. Feedback was systematically gathered from all involved (students, teachers, school management, examiners, task setters, and chief examiners), and detailed quantitative and qualitative analyses were carried out on the feedback, the tasks, the outcomes, and the process. A smaller proof-of-concept trial on the possible use of digital technology in such an assessment was also carried out in three additional schools.

While the feedback from those involved was generally very positive towards the assessment of practical skills in principle, participants expressed concern about aspects of implementing it as a component of the Leaving Certificate examination. The main concerns expressed related to the disruption to the normal life of the school, the amount of work required of teachers to support implementation (and the attendant impact on their other work) and the availability of examiners. While most of those involved agreed that science practical skills were important and should be tested, there was less agreement that that this was the right way to do it. While students strongly agreed that they would pay more attention to practical work if such an assessment were introduced, there were lower levels of agreement with a statement that such an assessment should be introduced, and lower levels of agreement still that the assessment as they experienced it was fair. Notwithstanding this, these statements all attracted more agreement than disagreement.

Technical analysis of the quality of the assessment did not throw up any significant concerns that could not be rectified. Quantitative analyses provided some evidence that the assessment measured a distinct set of skills from those measured by a written examination, but not strong evidence. The lack of strength in the evidence may have been related to the availability of only a weak alternative measure of practical skills with which it could be compared, and the analysis was certainly not such as to undermine an assertion that the assessment measured different competencies from those measured by a written test. Qualitative analyses suggested that the assessment did indeed focus on the skills that had been specified for it.

Nonetheless, it was known from the outset and came into greater relief over the course of the trial that, in an ideal world, an assessment of practical work in a modern science curriculum should, if it were possible, seek to evaluate the students' capacity to apply their knowledge and skills to unrehearsed and less familiar problems. The context of the Leaving Certificate examination as an entirely externally assessed and high-stakes examination prevents that from being achieved with an assessment of this type, so we must remain clear about what this assessment can and cannot do when assessing

the benefits in comparison to the costs (in the broadest sense).

The logistics and costs of a roll-out were interrogated. Total costs of delivery of the assessment itself, excluding certain headquarter costs and costs associated with preparing materials at school level, are of the order of €2.5 million annually. Including all costs would be unlikely to bring this figure above €3 million annually. This is exclusive of any capital and recurring costs that might be required to bring laboratory facilities in schools up to the required standard, to maintain them at that level, or to provide technical support to schools. Auditing science facilities in schools and estimating such costs were beyond the scope of the trial. Leaving aside costs, there are significant concerns about the capacity to deliver a full rollout along the lines of existing models of delivery of oral and practical examinations, which are already under considerable stress. Looming large among those concerns is that of examiner supply. For this and other reasons, if a decision is made to proceed, a major review is required of how all oral and practical assessment is organised, how it integrates with the other needs of the education system, and how it is to be supported by the education community at large.

The implementation challenges identified in the report and the limitations as to what can be adequately tested in an assessment of this type need to be recognised. However, the benefits of proceeding, in terms of impact on the teaching and learning of science, should not be undervalued.

While the report is most coherently read as presented, there may be readers who are not in a position to read the full report, but who nonetheless wish to appreciate fully all of the issues that must be considered when a final decision is being made regarding a national rollout of the proposed form of assessment. Such readers are advised to read Chapter 9 in its entirety, following which they can refer back to other chapters as required.

SFI funds STEM initiatives



Dr Sinéad McNally (DCU), Dr Gráinne Walshe (UL), Prof Merrilyn Goos (UL), Minister Halligan, Margie McCarthy (SFI), Judith Harford (UCD); and Brendan Tangney (TCD).

Thu, 14 Feb 2019

Two UL initiatives aimed at encouraging and supporting women in STEM education were today awarded Science Foundation Ireland funding. Minister for Training, Skills, Innovation, Research and Development, John Halligan TD, announced a national investment of €3.6 million through Science Foundation Ireland's Discover Programme, to fund projects dedicated to educating and engaging the public in science, technology, engineering and maths (STEM).

Science Foundation Ireland, through its SFI Discover Programme, aims to develop a highly-engaged and scientifically-informed public. Through the SFI Discover Awards, it provides funding for projects that inspire and guide the best in STEM education and public engagement.

41 diverse initiatives will be supported by this year's programme, with successful awardees being carefully selected through international peer-review. A further 11 projects that were awarded in 2017, will also have their funding continued for a second year.

Speaking at the SFI Discover Awards event, Minister Halligan said: *"Science Foundation Ireland's work in promoting science, technology, engineering and maths to the public stimulates very important public conversations around scientific research and encourages young people to consider pursuing a career path in these areas. To address the many global*

challenges we face across society and the economy, we must ensure that future generations of problem solvers have the opportunity to be inspired. Ireland continues to act as a hub for excellent research and the initiatives being funded through this year's SFI Discover programme will help to generate enthusiasm for STEM and highlight the individual, societal and economic value of encouraging more people in Ireland to get involved."

A number of the projects receiving funding are specifically targeted towards engaging girls and women in STEM:

- **SOPHia: Science Outreach to Promote Physics to Female Students (UL)** - a project that aims to encourage female students to take up physics as a Leaving Certificate Subject.
- **STEMChAT – Women as catalysts for change in STEM education (UL)** – looks at the recruitment of female undergraduate STEM Champions and industry mentors who will facilitate informal workshops with school students and parents, predominantly in disadvantaged areas.
- **Strength in Science (NUIG)** – The development of cross-curricular resources for science and PE teachers that are linked with the Biology, Physics and PE curricula that will increase girls' interest in both learning science and participating in exercise
- **Engaging Girls in CS - Code Plus (TCD)** – Female-only coding workshops facilitating a cohort of female speakers working in computing, to deliver career talks in girls' schools. Tech companies will host visits for teenage females.
- **Girls in DEIS Schools: Changing Attitudes /Impacting Futures in STEM (UCD)** - Students will engage with STEM by exploring the lives and impact of several female STEM pioneers, both historical and contemporary.
- **Let's talk about STEM: supports for girls' early science engagement (DCU)** - Parents and educators will participate in workshops to consider evidence on the role of language in differentially motivating girls' and boys' interest in and persistence with scientific learning

Speaking about the Programme, Interim Director of Science for Society at Science Foundation Ireland, Margie McCarthy, said: *“The SFI Discover Programme encourages people from all walks of life to become informed about, and engaged with, STEM. Through SFI Discover we harness the creativity of diverse engagement initiatives to motivate more people to explore STEM in meaningful ways, and we aspire to create a brighter future for Ireland together. The projects being announced today are very exciting and I look forward to working with them to inspire our future scientists, engineers and innovators.”*

Science Foundation Ireland has invested in over 240 public engagement projects through the Discover Programme since 2013. This year’s funded initiatives are estimated to reach over two million people.

(<http://www.ul.ie/news-centre/news/2-ul-initiatives-encourage-and-support-women-stem-education-receive-sfi-funding>)

Low literacy levels in Irish graduates

Irish Independent 20/1/19

Literacy levels of Irish graduates (ages 25-64) have declined over the past 20 years according to an OECD survey. The survey conducted in 2012 found that 6% of Irish graduates were functionally illiterate, compared to 7% in the UK, 2% in Finland and 3% in the Netherlands. Numeracy levels were even more worrying – Only 19% of Irish graduates (25-64) reached the highest level of numeracy, compared to 37% in Finland, 35% in the Netherlands and 25% in the UK. A university degree is no guarantee any more of basic levels of literacy and numeracy!

New education campus at Maynooth University

Katherine Donnelly

Irish Independent 21/2/19

“Maynooth University (MU) is celebrating a tradition in teacher training that goes back more than 90 years, with the opening of a new €14m school of education.

From a modest six students on the higher diploma in education at Maynooth in 1926, an average of 600 teachers a year now qualify in Maynooth and it has more than

12,600 graduates on the Teaching Council register

The new building is providing capacity for the rapid growth in student enrolment to the university’s three education departments, where more than 2,000 students are currently pursuing education courses, as well as research activity. Maynooth offers 15 different professional qualification courses covering the full spectrum of teacher education, including early childhood, primary, second level and higher education, guidance counsellors and school leadership.”

ICT action plan

<https://www.education.ie/en/Publications/Policy-Reports/technology-skills-2022.pdf>

“The Minister for Education and Skills Joe McHugh T.D. and Minister for Business, Enterprise and Innovation Heather Humphreys T.D. today (Monday 18 February 2019) have announced targets to deliver more than 47,000 graduates with high level ICT skills by 2022. Technology Skills 2022: Ireland’s Third ICT Skills Action Plan sets out priority actions to meet Ireland’s needs for graduates skilled in computing and electronic and electrical engineering to support and drive economic performance over the coming years.

The plan is informed by research conducted by the Expert Group on Future Skills Needs (EGFSN).

The ambitious targets in the plan will increase the total number of graduates with high-level ICT skills by more than 5,000 every year by 2022.

Before the introduction of this plan it was intended to increase the number of graduates annually, from across the education and training system, to 9,230 by 2022 - an increase of 1,800.

The interventions outlined in Technology Skills 2022 will now provide a further 3,200 graduates every year by 2022 – meaning more than 12,450 people will graduate in high-level ICT Skills areas in 2022.”

<https://www.education.ie/en/Press-Events/Press-Releases/2019-press-releases/PR19-02-18-01.html>

High drop-out rates in tech courses and ITs

“The HEA have produced a major study on An Analysis of Completion in Irish Higher Education: 2007/08 Entrants, which makes for interesting reading. As with many HEA reports there is a lot of detail and mountains of data (this report is 220 pages long!). It does not include the National College of Ireland nor the likes of the Dublin Business School which is a big pity and a major omission in my view.

Out of this report, Katherine Donnelly of the Irish Independent headlines her report today with “Tech courses are toughest to finish in college”. While this may be true, the report digs a lot deeper than a one-liner in the paper. The report divides up the HEA sector into three categories: Colleges (not including NCI), Institutes of Technology, and Universities. Data on levels 6 and 7 for Colleges and Universities is not included - presumably because they don't offer courses under level 8 (honours degree level).

Non-completion (a fancy word for dropout) rates in Colleges are at 6%, in ITs it is 34%, and in Universities it is 17%. The overall non-completion rate at level 8 is 18% (34,059 students in total) - this is a lot lower than the headline figures being given on radio news this morning. The lowest non-completion rate is 3% in St. Patrick's College, Drumcondra (606 students) - while the highest is 39% at IT Tallaght (605 students), clearly an unusual statistic for institutions with an almost identical number of students.”

Check out the interesting graphs at:

<http://www.eugeneoloughlin.com/2019/02/new-data-from-higher-education.html>

SFI Outstanding Contribution to STEM Communication

Nov. 2018

This award recognises an outstanding contribution to the popularisation of science, and recognises an individual who raises public awareness of the value of science to human progress.

Recipient: Dr Niamh Shaw, Blackrock Castle Observatory and Cork Institute of Technology

Dr Niamh Shaw is an Irish engineer, scientist and performer. She presents the human story of science, creating theatre shows, public events and contributions to media with this focus. She has set herself a life's mission to get to space, as artist and explorer. She hopes that by sharing the human story behind such a venture, it will help us better understand our place in the story of space, and the beauty of our planet Earth. She is artist in residence at CIT Blackrock Castle Observatory, working closely with them on their many STEM promotion activities, including Space week. An alumnus of the International Space University's 2015 Space Studies Programme, she was the Humanities co-chair and Core Lectures Assoc Chair in 2018 & 2017 respectively. Her theatre work has toured internationally, and created by through SFI's Discover 2014 & 2017 Programmes in partnership with CIT Blackrock Castle Observatory and supported by European Space Agency, Arts@CERN, Culture Ireland, Arts Council of Ireland. She writes for BBC's Sky at Night magazine.

Recipient: Dr John O'Donoghue, RSC Chemistry Education Coordinator at the School of Chemistry, Trinity College Dublin

Dr John O'Donoghue develops and empowers third level students to engage with schools and the general public. He has directly worked with thousands of secondary school chemistry students and their teachers nationwide as well as designing and expanding new initiatives for education and public engagement. His Spectroscopy in a Suitcase programme has visited schools in every county, showing the real-world applications of chemistry, and his career events have provided students with dozens of valuable science role models.

Chemistry Demonstration Workshop 2019

The annual residential Chemistry Demonstration Workshop at the University of Limerick will run from **25-27 June 2019**. For details and booking contact Aimee.stapleton@ul.ie. The fee of €125 includes 2 nights B&B and all meals for 3 days plus tuition and materials.

Goods Exports and Imports

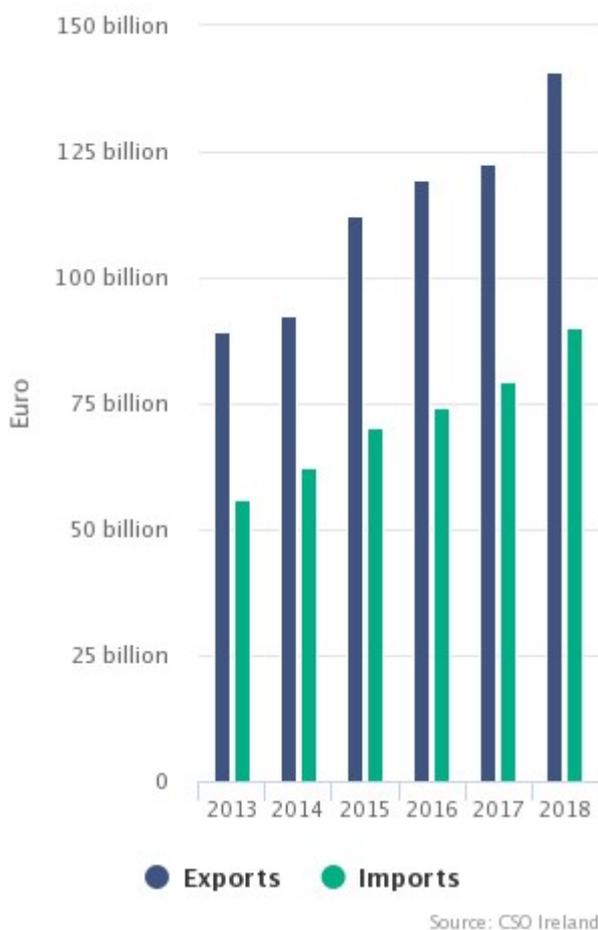
<https://www.cso.ie/en/statistics/externaltrade/goodsexportsandimports/>

The Irish trade figures for 2018 were very good and the economy is showing strong growth, led by the chemicals and pharmaceuticals sector.

December 2018

	€ million		
	Exports	Imports	Surplus
Jan-Dec 2017	122,711	79,271	43,440
Jan-Dec 2018	140,835	90,175	50,659
% change	+ 14.8	+ 13.8	+ 16.6

Figure 1 Goods Exports and Imports



Of the total of €140,835 million exports, €86,100 million were chemicals, 61.1%. The net trade balance in chemicals was €66,280 million. The chemicals export figure has grown from €66,385 million to €86,100 million since 2016 alone, a rise of 29.7%.

This is good news for chemistry and for chemistry graduates.

Ireland's leading exporter

Chemicals, referred to here as the pharmaceutical sector, plays a pivotal role in the Irish economy. It accounts for over 60% of goods exported from the country. It employs more than 30,000 people, and supports a further 26,000 indirect jobs. More than half our workforce are university graduates.

Dominated by pharmaceuticals

In Ireland the industry is dominated by pharmaceutical companies engaged in either Active Pharmaceutical Ingredient (API) manufacture or and also dosage form manufacture (hence the term pharmaceutical). As a centre for manufacturing biopharmaceuticals Ireland is second only to the United States. Recent investments amount to just under €4 billion – the majority from US-based companies including Bristol Myers Squibb, Alexion, Regeneron and Eli Lilly.

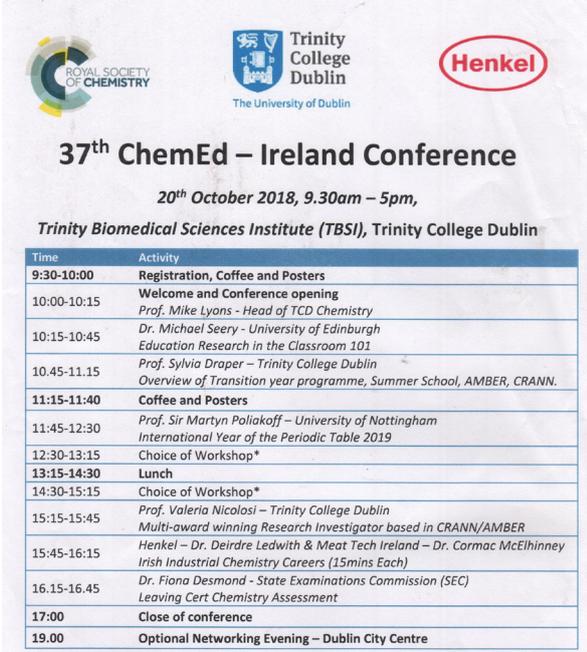
Matt Moran

BioPharmaChem Ireland

<https://www.chemlandscape.cefic.org/country/ireland/>

Proceedings ChemEd-Ireland 2018

The programme for the 2018 ChemEd-Ireland conference at TCD is given below. This had a capacity crowd and an excellent programme.



Time	Activity
9:30-10:00	Registration, Coffee and Posters
10:00-10:15	Welcome and Conference opening Prof. Mike Lyons - Head of TCD Chemistry
10:15-10:45	Dr. Michael Seery - University of Edinburgh Education Research in the Classroom 101
10:45-11:15	Prof. Sylvia Draper - Trinity College Dublin Overview of Transition year programme, Summer School, AMBER, CRANN.
11:15-11:40	Coffee and Posters
11:45-12:30	Prof. Sir Martyn Poliakoff - University of Nottingham International Year of the Periodic Table 2019
12:30-13:15	Choice of Workshop*
13:15-14:30	Lunch
14:30-15:15	Choice of Workshop*
15:15-15:45	Prof. Valeria Nicolosi - Trinity College Dublin Multi-award winning Research Investigator based in CRANN/AMBER
15:45-16:15	Henkel - Dr. Deirdre Ledwith & Meat Tech Ireland - Dr. Cormac McElhinney Irish Industrial Chemistry Careers (15mins Each)
16:15-16:45	Dr. Fiona Desmond - State Examinations Commission (SEC) Leaving Cert Chemistry Assessment
17:00	Close of conference
19:00	Optional Networking Evening - Dublin City Centre

In this issue we have collected a number of the talks and details of the workshops. This is no substitute for the buzz of being there. Chemistry at Trinity College has a long history. TCD is the oldest university in Ireland and not surprisingly the TCD chemistry department is the oldest in the country. One of its distinguished professors of chemistry was Wesley Cocker and he wrote a history of chemistry at TCD from 1711 until 1946 (Wesley Cocker, (1978), 'A history of the university chemical laboratory, Trinity College, Dublin, 1711-1946', *Hermathena*, **124**, 58-76.) This makes an interesting read but of course a lot has happened since then. In 1979 Peter Start from UCD organised the 5th International Conference on Chemical Education (ICCE) and it was held in Trinity College.

John O'Donoghue the organiser of ChemEd-Ireland, with his team from TCD, has put together an article on chemical education activities at TCD, which serve to introduce the Proceedings.

Trinity College Dublin ChemEd Group

John O'Donoghue

RSC Education Coordinator, Trinity College, Dublin

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The TCD ChemEd group formed in 2017 with the purpose of expanding and coordinating the education and public engagement activities of the School of Chemistry at Trinity College Dublin. It is formed from 8 members from across the School of Chemistry who meet on a monthly basis, with a wealth of combined experience. Previously members of this group have organised numerous highly successfully large-scale events, as well as coordinating ongoing weekly activities throughout the last number of years. It is currently led by Dr. John O'Donoghue - RSC Education Coordinator, who is joined by Dr. Niamh McGoldrick - Global Relations Officer, Prof. Sylvia Draper - Professor and TCD Fellow, Dr. Noelle Scully - Fresh Coordinator, Tom Conroy - Physical Chemistry Technical Officer, Dr.

Carl Poree - Teaching Fellow, Dr. Steffi Thomas - Teaching Fellow and Shelley Stafford - PhD Student and Broad Curriculum Coordinator.



John O'Donoghue at the Careers in Chemistry event

The group currently organise many annual in-reach events on campus, such as the Careers in Chemistry day during Science week in November, where over 400 Leaving Cert Chemistry students join us on campus from more than a dozen schools around Leinster. Speakers on the day are a mixture of TCD School of Chemistry Alumni and others from partner organisations who chat informally to the students about their career path to-date. For the 2017 event it was headlined by Kate O'Connell, who is a TD for South Dublin and a pharmacist. For the 2018 event we had the all-star Cork Camogie player Julia White and the Clare footballer Laurie Ryan, who are also both chemists.

Other in-reach events run on campus include the annual Salters Festival of Chemistry in May, which provides hands-on experiments with over 50 Junior Cycle students in the TCD Chemistry labs. The annual Broad Curriculum final also takes place in March every year and sees the second year undergraduate Chemistry students generate innovative and informative presentations, which illustrate the relevance of Chemistry to Life. Previous topics have included 'Chemical Warfare', the 'Chemistry of Bees' and 'The Chemistry of Transmutation'. With each passing year the standard of these students' presentations has increased and the selection of the best one has become a lively event in the TCD School of Chemistry calendar.



David Grayson (TCD) and Deidre Ledwith (Henkel) with the 2017 Broad Curriculum finalists.

Since 2009 members of the group have also developed and hosted 60 transition year students annually in a week-long programme in April. The students are introduced to the

three main disciplines of chemistry through lectures and workshops, which illustrate the importance of chemistry to society i.e. advancements in new materials, drug design and delivery, renewable energy, etc. They gain hands-on experience by carrying out experimental work in the teaching laboratory. The programme also involves tours of the Schools' research and teaching facilities, as well as a visit to the Sports centre. The activities for the week are devised in order to give the students and insight to what college life is like. Similarly the Trinity Access Programme (TAP) Chemistry summer school in June also invites in about 20 transition year students from DEIS schools around Dublin for 5 days of hands-on experiments in the TCD Chemistry labs.

As well as in-reach events, the group also help coordinate Trinity College Dublin's involvement with one of the most successful chemistry out-reach projects in Ireland. The RSC Spectroscopy in a Suitcase programme visits over 150 secondary schools annually through a partnership with UCC, IT Sligo, CIT, UCD and UL, to deliver workshops for Leaving Cert Chemistry students. The TCD team specifically visits about 1,000 students in 50 schools around the Leinster region annually and the postgrad students who run the workshops offer advice about going to university as well as talk about their research.

And finally, in October 2018, the TCD ChemEd group were privileged to organise the national ChemEd-Ireland conference, which saw over 100 secondary school chemistry teachers join us in Trinity College Dublin, together with local and international speakers. This was the first time in the 37 year history of the conference that it was held in TCD and to-date we have received very positive feedback.

This year, 2019, has been designated the International Year of the Periodic Table (IYPT) and the TCD ChemEd group have already started preparations for a new partnership, for a Chemistry Summer camp and a large-scale public lecture about the Chemical Elements in July. More details will be available at a later date.

□

A video for every element

RSC Chemical News 10 January 2019

Sir Martyn Poliakoff is an iconic figure in the world of chemistry – perhaps most recognisable from his role in the YouTube phenomenon *The Periodic Table of Videos*. We caught up with him about the creation of the series, his early life, and the people who have inspired him.

Sir Martyn Poliakoff says he never decided to be a scientist.

"My father decided I would be a scientist, so I had no choice. My father and grandfather were physicists, so I thought I would be a physicist too. It turns out my maths wasn't good enough, but I had a very good memory, so I became a chemist."

"I knew I was going to be a scientist from when I was really quite small, but if I hadn't been I would have liked to have made TV adverts, which in a way I sort of have!"



Picture: © University of Nottingham

He is referring to his Periodic Table of Videos – a set of YouTube videos describing every single element in turn (plus many more videos about chemistry). He appeared in the original set of videos in 2008, and has been featuring in them ever since.

He became involved in the project as a result of the University of Nottingham's work with a talented video maker, Brady Haran. They hired Brady to make YouTube videos about scientists at work, and the channel – [Nottingham Science](#) – is still going strong today.

"After Nottingham Science had been going for not quite a year, I went to a meeting organised

by the Engineering and Physical Sciences Research Council at Nottingham, and I was told to attend a session called 'corporate communication' where they showed the trailer of Brady's videos. I got really excited and wrote to lots of people how wonderful the videos were. The upshot was that I was asked to make some videos with Brady."

They made videos, on topics such as supercritical fluids and green chemistry. "It was a very bad day for me! It was in May just before the exams so I'd had five hours of teaching, and at the end of the day I was videoed for another two hours and we made eight videos."

A bonkers idea

Despite this gruelling experience, Martyn and Brady hit it off, and a few weeks later Brady came to Martyn with a new idea.

"He thought it would be really good to make one video about each of the elements in the periodic table. I told him he was bonkers."

"It's easy to make a video about sodium or hydrogen – they do exciting things like explode – but, at that time, element 117 had not been synthesised – there wasn't even a single atom – so how could you make a video about that? Brady eventually persuaded me, and I found some money – but the money was time-limited. So we began the first video on 8 June 2008 and, with the help of three colleagues and our technician Neil Barnes, we had made 120 videos by 17 July (all 118 elements plus trailer and introduction).

"Because there isn't much news in the summer, we attracted really quite a lot of press excitement. By modern standards it wasn't very much – I think we got a total of about half a million views, which is still small. But we got press coverage from the BBC Turkish

service, from newspapers in Russia, in Israel, all sorts of places.

"We thought we'd finished, but the viewers wanted us to continue and ten years and 650 videos on we're still going."



Picture: © University of Nottingham

No script

The team's main focus at the moment is remaking some of the original videos, since they were done at such speed. In the original series, Martyn spoke ad lib. This led to some entertaining results.

"Because we were in such a hurry, I made a hugely arrogant decision that there wasn't time to look anything up. When I got to element 108 – Hassium – I was videoed without my knowledge saying 'I don't know anything about element 108, should we make something up?' It made it into the final cut and has become one of my favourite videos.

"There is no script, and there are no lesson plans or educational objectives. The first time I see most videos is when they appear on YouTube."

Iconic image of chemistry

Martyn reflects that there is no definitive 'correct' form of the periodic table.

"Obviously the elements have to be in the right order and so on, but there are various unconventional versions that have sprung up, such as spiral ones. I've got a tetrahedral one in my office. I've even got one shaped like a Christmas tree from Canada. The point is that none of these are the correct periodic table in the sense that they're all equally valid for different purposes. I think the new EuChemS version of the periodic table is a really good use of Mendeleev's fundamental idea, but with

a strong message around the idea of sustainability.

"Mendeleev invented something which is scientifically incredible, but it's also the most incredible marketing tool. Did you see how many books were for sale last Christmas on the periodic table of wine or football and so on? It's a very good way of classifying things, and also it's the iconic image of chemistry."

Warm memories

His favourite element is sodium, with the chemical symbol Na. A soft, silvery metal, many people will remember sodium as something that creates an exciting explosion when added to water. Martyn's reasons however are entirely personal and not what you might expect.

"My mother's first name was Ina. As a little girl she used to abbreviate it to 'Na, and when our children were born and she became a grandmother she decided that her grandchildren should call her 'Na. So now every time I see a chemical formula with a sodium salt I get a sort of warm motherly feeling."

Early influences

Martyn has several role models, including the American chemist George Pimentel, who invented the chemical laser and recorded one of the first infrared spectra of Mars, and the late Alec Campbell who rose from technician to academic at Newcastle and taught the entire foundation year including lab demonstrating. But perhaps his earliest role model was his school chemistry teacher.

"Like most chemists I had a very good chemistry teacher. My original chemistry teacher took two years sabbatical, so I had a very young replacement teacher called Tony Roberts, who I think was only 5 years older than me, or perhaps slightly more, but he really inspired me. I think I was the pupil from hell, because I had a very good memory and I read a lot of chemistry books.

"I've always been an obsessive buyer of second hand books – even at that age – so I bought a lot of second hand chemistry books and read them too. So I would talk all the time in class but could answer any question. Except one – I forget what the question was – which I failed to answer and I've never seen anybody

looking so happy as Tony did. I'm still in touch with him and we've appeared in a [YouTube video together](#)."

Challenges and proud moments

Martyn attended King's College Cambridge as an undergraduate, but he did badly in his final exams. "I got very worried before the exams and, in those days, the way to treat worried students was to dose them with Valium – which was really effective! I felt happy, I could see disaster looming. But I didn't care!"

Fortunately the college went on to pay for him to do his PhD, after which he went on to Newcastle University. In 1979 he was appointed a lecturer at the University of Nottingham, where he has remained ever since. In 1991 he was promoted to professor, and in 2015 he was knighted in the New Year Honours for services to the chemical sciences.

Martyn is now 71 years old, and still working at the University of Nottingham as a researcher and teacher, an achievement of which he is proud. His daughter, Ellen Poliakoff, is a senior lecturer in psychology at The University of Manchester and his son, Simon, is head of physics at Dame Alice Owen's School.

"I think in the end the thing that many people are most proud of is their children and grandchildren. When my youngest grandson was four, we were having lunch and I asked him what his chips were made of, and he answered 'molecules'. I hadn't taught him that, but it was a gratifying moment."

This article first appeared in RSC Chemical News (Jan. 2019) and was written by Lizzy Ratcliffe. Used by permission.



Sir Martyn Poliakoff speaking at ChemEd-Ireland in TCD (Photo: John O'Donoghue)

Biography

Professor Sir Martyn Poliakoff CBE FRS FREng studied at King's College, Cambridge, B.A (1969) and Ph.D. (1973) under the supervision of J. J. Turner FRS on the Matrix Isolation of Large Molecules. In 1972, he was appointed Research/Senior Research Officer in the Department of Inorganic Chemistry of the University of Newcastle upon Tyne. In 1979, he moved to a Lectureship in the Department of Chemistry at the University of Nottingham. Promotion to Reader in Inorganic Chemistry and then to Professor of Chemistry followed in 1985 and 1991 respectively. In addition, he is Honorary Professor of Chemistry at Moscow State University. Watch the Periodic Table live at:

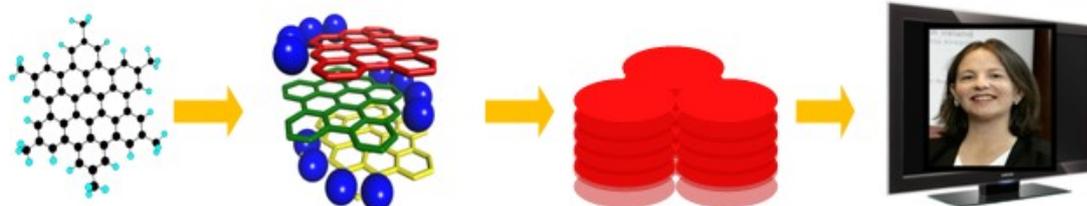
www.periodicvideos.com

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Connect, Communicate and Convert

Sylvia Draper

School of Chemistry, Trinity College Dublin Sylvia.draper@tcd.ie



Having been brought up surrounded by non-chemists, Prof. Sylvia Draper has spent a lifetime explaining what she does and why she finds chemistry interesting [1, 2]. In this paper she shared her experience of what works best when trying to connect and communicate with diverse audiences and how she attempts to tackle complex chemical topics [3, 4, 5]. In essence she believes that you need to understand your audience and that the listener needs to enjoy the learning experience in order to gain something from it.

Two examples were presented. In the first, a photonic process known as upconversion was explained [6]. In this process materials are designed and used in tandem so that they can emit light of higher energy than they absorb. This is an upconverting energy transfer process. It uses a photosensitiser with a long-lived, triplet excited-state lifetime to excite acceptor molecules that can then emit higher energy (usually blue) light.

There are two main reasons for her being interested in this research and these were used to show how the work could be presented in two different ways depending on the audience. The process has the capacity to improve (i) the application of photodynamic therapies and (ii) the efficiency of solar cells.

In the first set of slides the upconversion process was explained and then it was shown how it can trigger the death of cancer cells that lie deep under the skin (i.e. extend the application of photodynamic therapies for the treatment of cancer).

In the second set of slides the scientific facts surrounding the energy crisis were presented first and then used to justify the need to create

solar cells that can efficiently absorb sunlight, particularly in the low energy region of the spectrum.

Prof. Draper explained how you can ‘prime’ the audience (depending on their interests) and connect these with chemical learning. She showed how to draw on topical news items or events that help to anchor ideas e.g. responding to the energy crisis can have parallels with raising awareness of suicide prevention (particularly when your talk happens to coincide with walking ‘from darkness into light’).

Prof. Draper also explained how Chemistry has everything. It is logical, mathematical, descriptive, kinetic, tactile and fun. It rewards anyone who is curious. She provided links to her participation in debates [7], media items [8] and podcasts [9] and gave a musical rendition (so that the audience would remember why they should have a go!).

She also made it clear how important it is to connect to your audience/students on a personal level so that they have some understanding of who you are and what matters to you. The take home message was to think outside the box, to embrace the task of converting the world (so that everyone can think chemically) and to bring some magic into the classroom and beyond.....



References

- [1] <https://www.rte.ie/eile/brainstorm/2018/1121/1012336-the-chemistry-of-equality/>
- [2] <http://duscisoc.ie/trinity-talks-science-008-a-luminous-future/>
- [3] <https://www.rte.ie/eile/brainstorm/2018/0709/977366-our-nose-can-distinguish-and-identify-10-000-different-smells/>
- [4] <https://www.rte.ie/eile/brainstorm/2018/0823/986971-the-science-of-water-chemistry-h2o/>

Career talks



Henkel, Ireland was represented on the day by Justine O’Sullivan, a research chemist at the company. Justine spoke passionately about her “Career in Chemistry” beginning with the educational path she pursued upon entering third level education. This path led to a role as a research chemist in Henkel R&D, based in Tallaght, Dublin.

Henkel is a German company with three core business units: Adhesive Technologies, Laundry & Homecare and Beauty Care. Dublin is a technological hub for the adhesive technologies sector, with manufacturing, research and development and packaging facilities all based strategically close to each other, in Ballyfermot and Tallaght.

[5] <https://www.rte.ie/eile/brainstorm/2018/0725/980942-in-full-colour-the-chemistry-of-hair-dye/>

[6] <https://www.irishtimes.com/news/science/lighting-up-chemistry-research-through-upconversion-1.3482773>

[7] <http://www.universitytimes.ie/2016/10/annual-liferaft-debate-sees-lecturers-successfully-plea-for-the-survival-of-the-hamilton/>

[8] <https://www.youtube.com/watch?v=Lni3mImREKk>

[9] https://www.youtube.com/watch?v=dmO8K_JJbS0

□

The “day-to-day” life of an early stage research chemist at Henkel was described in detail to give the teachers in attendance an idea of an industrial role that their students could potentially enjoy if they were to pursue a chemistry career. The design and implementation of laboratory experiments was described, with visual examples of equipment and devices that are used, which teachers could relate to their classroom teachings. Finally, Justine spoke about the opportunities within Henkel for travel and also the promotion of science by Henkel employees in schools to spark children’s interest in science from a young age.

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Leaving Certificate Chemistry Assessment 2018

Fiona Desmond

Schools Examinations Commission

An overview of the role of the State Examinations Commission (SEC) in Irish education was given. The SEC is an independent agency under the aegis of the Department of Education & Skills (DES) and the sole provider of state assessment and certification at the middle and end of Irish second level education. The SEC acts as an implementation agency and operates closely with the National Council for Curriculum and Assessment (NCCA) the advisory agency of the DES, and with the Department of Education inspectorate, the regulatory body.

When the invitation to present at ChemEd-Ireland 2018 was made to the SEC Chief Examiner for Chemistry in Autumn 2017, it was hoped that the presentation might be able to include a preview of the introduction of a new mode of practical assessment in Leaving Certificate Chemistry in addition to the written paper. At ChemEd-Ireland 2018 the Chief Examiner was able to give a brief update on the SEC trial in practical assessment in Leaving Certificate Chemistry, Physics and Biology that had taken place in October 2017.* The practical skills that cannot be tested in a written examination were the focus of the trial. The SEC report on the science trial, had been submitted in May 2018 to the then Minister for Education & Skills, Mr Richard Bruton, and it had been under consideration during summer 2018. The fact that a new Minister for Education, Mr Joe McHugh had taken up office only four days prior to ChemEd 2018 suggested that a decision on whether a new mode of practical assessment in Leaving Certificate sciences in addition to the written papers, and based on the Science Trial outcomes, would be likely to have to wait until the Minister had had an opportunity to be briefed on the trial by his department officials and had had a chance to read the report. So all that could be said at ChemEd-Ireland was that the trial had been successfully conducted, had received a very great deal of interest from schools all around

the country, had been given very positive support through the participation of students, participation of science teachers as examiners and science teachers as organisers of the trial in participating schools, buy-in from parents and school management and it had provided a wealth of information for the decision makers in the Department.

The focus therefore remains on the current LC Chemistry syllabus and associated circulars.

For a full set of statistics on participation rates and performance, readers are referred to the Statistics section of the SEC website www.examinations.ie.

The overall LC candidature (established LC and LCVP but not including LCA) in 2018 was 54,440, about 2.4% lower than in 2017. The participation rates in all of the science subjects at Leaving Certificate were compared, Chemistry being the second most popular after Biology which was taken by more than half the candidates. Approximately equal numbers of boys and girls sit Chemistry in Leaving Certificate examinations.

The total LC Chemistry candidature in 2018 was 9,167 (7,943 Higher Level and 1,224 Ordinary Level) compared to 9,468 in 2017 (8,162 Higher Level and 1,306 Ordinary Level). This shows a very slight decrease from 17.0 to 16.8% in the uptake of Chemistry – the first decrease in uptake during the current syllabus but the percentage uptake was always expected to plateau. In future years the post-primary school population is expected to increase again and it is therefore likely that the Chemistry cohort size at Leaving Certificate will increase again because of that. However, the percentage uptake of Chemistry will be affected by the introduction of new subjects to the curriculum, namely, Politics & Society, P.E. and Computer Studies which will give future students a broader choice.

There has been a continued drift towards Higher Level from Ordinary Level again in

2018 with the percentage sitting Ordinary Level down to 13.4% compared with 13.8% in 2017. This is partly attributed to the attraction of CAO points for results between 30 and 40% at Higher Level, not available previous to 2017. Performance at Ordinary Level, a small cohort, fluctuates a little from year to year but the results are in good alignment with recent years and the mean grade was 4.8, identical to that of 2017.

The combined H7 and H8 grades at Higher Level are higher than in previous years – this is associated with the drift of Ordinary Level students to Higher Level and also perhaps with CAO points available for results between 30 and 40% dis-incentivising some candidates from aiming to achieve at least 40% in their preparation for the examination. Performance across the other grades is maintained with slightly lower rates at H3 and H5 than in previous years. The mean grade was 4.0, identical to that of 2017.

The Chief Examiner outlined, using examples from the Higher and Ordinary LC 2018 examination papers how candidate engagement with and attainment of key syllabus objectives in terms of (i) knowledge and understanding, (ii) application and analysis, and (iii) synthesis and evaluation, were assessed.

The popularity and average scores in the questions on both Higher Level and Ordinary level 2018 papers were described.

The Chief Examiner gave some advice for teachers and their students in relation to

preparing for the LC Chemistry written papers of the future.

In conclusion, the Chief Examiner referred to the presentation given earlier in the day of ChemEd-Ireland 2018 proceedings by Dr Michael Seery. Dr Seery had, when explaining what made chemistry difficult for students, referred to Johnstone's Triangle and the cognitive load imposed upon novice chemists in navigating between macroscopic phenomena, symbolic representations and sub-microscopic models. Students need to build patterns between the individual facts presented in class and in textbooks and good teaching helps students build such patterns. Good examinations can help reinforce the creation of patterns rather than the rote learning of disconnected facts.

Biography

Dr Fiona Desmond is the State Examinations Commission Chief Examiner for Leaving Certificate subjects Chemistry and Physics & Chemistry. Prior to joining the SEC Fiona was a teacher of Leaving Certificate Chemistry, Maths and Physics and of post-Leaving Certificate vocational courses in the Cork College of Commerce.

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***Note: this talk has been overtaken by events as the Minister of Education has decided not to proceed with the practical assessment of the new LC science syllabi. The report by the SEC on practical assessment trial has been published (see p.**).**

PDST workshop on Ocean Acidification

Margaret Cooney and Aine Boland
JCT Science team

The JCT Science team facilitated a workshop at the ChemEd-Ireland 2018 conference on cross-cutting chemistry concepts using solubility and carbon sinks as our vehicle.

We began by discussing coral reefs and the role of the chemist in their survival. We discussed topics such as:

- what is happening to coral globally?
- do changes in ocean pH have the same impact on warm and cold water coral?

Some key science topics we explored in this area included the following:

The building of skeletons in marine creatures is particularly sensitive to acidity. One of the molecules that hydrogen ions bond with is carbonate (CO_3^{2-}), a key component of calcium carbonate (CaCO_3) shells. To make calcium carbonate, shell-building marine animals such as corals and oysters combine a calcium ion (Ca^{+2}) with carbonate (CO_3^{2-}) from calcium hydrogencarbonate ($\text{Ca}(\text{HCO}_3)_2$) surrounding seawater, releasing carbon dioxide and water in the process.



Teachers at work during the workshop (Photo: P.E. Childs)

Carbon dioxide can have a major impact on sea-water. In the past 200 years alone, ocean water has become 30 percent more acidic - faster than any known change in ocean chemistry in the last 50 million years. When carbon dioxide dissolves in seawater, the water becomes more acidic and the ocean's pH (a measure of how acidic or basic the ocean is) drops. Scientists formerly didn't worry about this process because they always assumed that rivers carried enough dissolved chemicals

from rocks to the ocean to keep the ocean's pH stable. (Scientists call this stabilizing effect "buffering.") But so much carbon dioxide is dissolving into the ocean so quickly that this natural buffering hasn't been able to keep up, resulting in relatively rapidly dropping pH in surface waters. As those surface layers gradually mix into deep water, the entire ocean is affected. (<https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification>)



Teachers learning about ocean acidification by doing. (Photo: P.E. Childs)

This led to a discussion about what is causing the oceans to become acidified, and why and how some parts of the ocean are more acidic than others. Before we could begin with acid/base chemistry we needed to talk about solubility. The Junior Cycle Science Chemical World learning outcome 6 states that:

"Students should be able to investigate the properties of different materials including solubilities, conductivity, melting points and boiling points"

This learning became our focus in the workshop.

The concept of a gas dissolving isn't one Junior Cycle students are overly familiar with. We engineered a number of activities to allow teachers to explore this concept including graphing the solubility of a gas, a computer simulation on the carbon cycle, an investigation to mimic a carbon sink, which looked at the solubility of CO_2 in warm and cold water, and teachers conducted a sip test to ascertain fizziness and CO_2 levels in water at different temperatures. Teachers gathered lots of evidence from these investigations and

shared their learning through a placemat activity. Questions arose such as:

- What information does this give us about warm and cold-water areas of the ocean and CO₂ solubility?
- What part of the ocean might act as a more efficient carbon sink?
- How will the acidification of the ocean affect food chains and habitats?
- Will animals and plants adapt?

Teachers were given an opportunity to engage collaboratively with the Junior Cycle learning outcomes and identify which ones they had engaged with across the Science specification.

The workshop ended by looking at the bigger picture in terms of the need to collaborate on coral reef and ocean acidification research. Biological organisms need chemists, physicists and geologists to engineer solutions. Ecologists, who are thinking about phytoplankton, need environmentalists researching alternative carbon sinks.

Teachers were supplied with multimedia resources to take back to class with them on ocean acidification including a TED talk by an Irish scientist Triona McGrath. The workshop

slides and accompanying resources are available to teachers on our website <https://www.jct.ie/science/science> under CPD workshops /elective workshops as shown below.



Biography:

Margaret Cooney is a Science Advisor with Junior Cycle for Teachers. She works in Kinsale Community School where she teaches Science, Biology and Mathematics.

Aine Boland is a Science Advisor with Junior Cycle for Teachers. She works in Marist College, Athlone where she teaches Science, Agricultural Science and Chemistry.

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Risky Chemistry workshop

Tom Conroy

Technical Officer, School of Chemistry, Trinity College, Dublin

This workshop was a basic introduction to risk assessment. Through group discussions, as well as questions based on individual scenarios, everyone learned something new and had ideas to take away with them. The concept that a risk assessment should be unique to each lab and experimental environment was new to a lot of people.

Risk assessment is about assessing the risks associated with carrying out the experiment in the laboratory. In addition to the chemicals involved, the laboratory layout, equipment and practical components should all be considered when assessing any and all associated risk.

Control Measures

1. Eliminate the hazard
2. Substitute the hazard with a lesser risk
3. Isolate the hazard
4. Engineering controls
5. Administrative controls
6. Personal protective equipment (PPE)

(www.hsa.ie)

One important note is that, of all the steps involved for controlling risk, PPE is the last one to be considered and, as such, is known as a last line of defence. All other control measures should be explored first and attempts made to reduce the associated risk.

The RAMP acronym was used as a good example of the steps to remember and address when considering a risk assessment.

- R** Recognize the hazards
- A** Assess the risks of the hazards
- M** Minimize the risks of the hazards
- P** Prepare for emergencies from uncontrolled hazards

(American Chemical Society - www.acs.org)

Biography

Tom Conroy is a Technical Officer in the Physical Chemistry teaching labs at the School of Chemistry in Trinity College Dublin.

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Research Poster: Looking at Variables in Chemical Reactions Hilary Lynch

Looking at Variables in Chemical Reactions.
Hilary Lynch. Clonakilty Community College.(HLynch@clonakiltycc.ie)

Introduction:
Four second year science teachers wondered how best to teach chemical reactions to students. The aim was to maximise our time usage in introducing variables to students. A practical approach was preferred. Student tabulation, discussion and graphical analysis was to be incorporated.

The Classroom-based Approach:
96 second year students and 14 fifth year students worked on experiments involving variables. This was carried out on a rotational basis in two science rooms over four double classes. 5 teachers supervised and ensured that all safety precautions were taken. Second year students were divided into groups of six per station. Learning outcomes were :
Strand 1: 2.2,2.3 and 2.4
Strand 3: 1.1 and 1.7

What worked well:
2nd year-5th year student interaction worked well. Variables were identified easily and discussions and experimental outcomes were predicted enthusiastically. 2nd year students helped to measure results. They tabulated ,graphed and analysed their results.

Conclusions :
All students' understanding of variables, scientific measurement and analysis improved. Team work was seen at its best. Science experimentation was enjoyed by all.

References: "Chemistry Live" by Declan Kennedy," Essential Science" by Declan Kennedy, Rose Lawlor and Seán Finn. New Junior Cert Learning Outcomes.

Science teachers came together in a quandary last year when faced with the teaching of Chemical Reactions to second year students. The degree of depth required was unclear, despite learning outcomes and reassurance at our JCT cluster meeting. We wondered how best to teach a number of chemical reactions with inbuilt variation to students. The aim was to maximise our time usage in introducing variables. A practical approach was preferred.

Ninety- six second year students and fourteen fifth year students worked on experiments involving variables. This was carried out on a rotational basis in two science rooms over four double classes. Six teachers supervised and ensured that all safety precautions were adhered to. Two science teachers prepared the required chemicals (over two lunch-breaks). Second year students were divided into groups of six per station.

The fifth years had been studying Rates of Reaction themselves around this time so the lab session gave them a chance to revise and gave them a greater understanding of variables.

The learning outcomes used were:

Strand 1: 2.2, 2.3 and 2.4

Strand 3: 1.1 and 2.7

The student interaction worked well. Variables were identified easily and discussions and experimental outcomes were predicted enthusiastically. They measured, tabulated, graphed and analysed their results.

The supervising non-science teachers learnt science through observation, science teachers learnt to mentor students, fifth year students learnt to teach and second year students saw what fifth years knew and learnt from their peers. It would be true to say that all parties learnt from doing.

All students' understanding of variables, scientific measurement and analysis improved. Teamwork was seen at its best and science experimentation was enjoyed by all.

It is our intention to approach this section of the course in a similar fashion this year.

It is hoped that the approach to the teaching will be developed this year. The experiments

would be carried out again but greater emphasis would be placed on:

(a) the introductory class to variables in Chemistry and

(b) on student and teacher follow-up and feedback.

Questionnaires/interviews and testing might be used to see what the students learnt and their self-analysis of their learning would be encouraged.

The main aims of the research would be the development of the school's community of learners, the students' greater ownership of what they are learning and the promotion of a particular culture of learning through practical investigation.

References:

Chemistry Live by Declan Kennedy

Essential Science by Declan Kennedy, Rose

Lawlor and Seán Finn. New

Junior Cert Science Learning Outcomes. □



United Nations
Educational, Scientific and
Cultural Organization



International Year
of the Periodic Table
of Chemical Elements

facebook.com/IYPT2019
twitter.com/IYPT2019
instagram.com/IYPT2019

2019 is the International Year of the Periodic Table and the opening ceremony was held in Paris on January 28th at the UNESCO HQ. You can view the launch at www.iypt2019.org/opening-ceremony followed by a launch in Russia on Feb. 8th. In this issue we will have a number of items relating to the Periodic Table (see also the last issue, #112).

Report from the International Year of the Periodic Table (IYPT) Opening Ceremony Paris – 29th January 2019

John O'Donoghue

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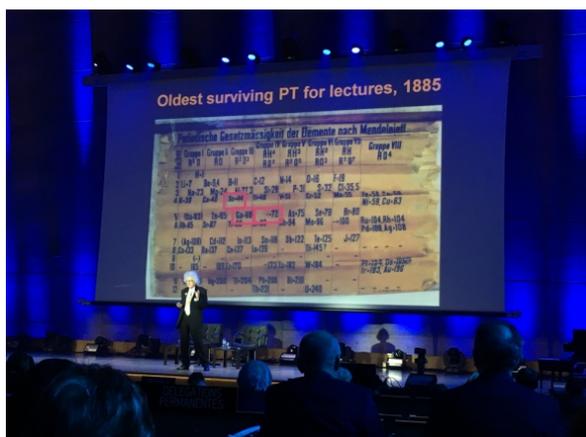


Furniture and other items from Mendeleev's office as well as a signed copy of an early version of the Periodic Table.

The festivities have now officially begun, with the International Year of the Periodic Table 2019 officially launched at the UNESCO building in Paris in January celebrating 150 years since Dmitri Mendeleev published his periodic system. This day long ceremony was joined by numerous high profile guests including the 2016 Noble Prize winner Ben Feringa and the only living person with an element named after them; Yuri Oganessian. Various chemical societies and professional bodies were also present on the day including

the Mendeleev Russian Chemical Society, the American Chemical Society, the International Union of Pure and Applied Chemistry (IUPAC) and the Royal Society of Chemistry among others.

The ceremony began with a dazzling 3D light display and musical performance by Mira Yevtich showcasing the elements and the Periodic Table. Speakers from across the world contributed pieces in French, Russian and English through talks, discussions and demonstrations. A particularly favourite section of mine was the round table discussion about the "Origins of the Elements" which had speakers giving lively presentations about meteorites, elements in outer space and how the elements are formed in stars.



Prof. Sir Martyn Poliakoff speaking about the oldest Periodic Table used for teaching that was found at St. Andrews University in Scotland and dating from 1885

There was a very welcome focus on sustainable development and education throughout the day with one of the highlights being Prof. Sir Martyn Poliakoff's keynote talk entitled "Mendeleev's Gift to Education". A new education initiative was launched during the day as well called "1001 inventions: Journeys from Alchemy to Chemistry". Development and Education from an African context was also discussed with a hugely diverse range of speakers representing cultures from around the world.



The Chemistry Bar where Fruit Juice cocktails were provided and chilled with Liquid Nitrogen

The exhibition area was full of ideas, demonstrations and of course numerous periodic tables. One of the most popular one for selfies during the day was the Periodic Table of Stamps, which consisted of postage stamps celebrating every element from over 100 countries. There was also a real periodic table on display with samples of every element in sealed containers where possible, including some of the more "exotic" ones such as Uranium, Radon and Plutonium.



Gas discharge tubes with gases trapped and excited by a Tesla Coil (NEON)

The demonstrations were appropriately provided by Mendeleev University from Moscow and consisted of fantastic gas discharge tubes, superconducting magnets, flame tests, electrolysis and lots more. One of the more intriguing exhibitions was a virtual reality headset which allowed you to explore Mendeleev's original office and perform some simple chemistry experiments virtually. But the most popular part of the exhibition space was definitely the Chemistry Bar, which provided all attendees with liquid nitrogen cooled juice cocktails throughout the day.

The IYPT Closing ceremony will take place in Tokyo Japan on the 5th of December.

□

poor mechanical condition. To make the chart safe for access and use it received a full conservation treatment. The University's Special Collections was awarded a funding grant from the National Manuscripts Conservation Trust (NMCT) for the conservation of the chart in collaboration with private conservator Richard Hawkes (Artworks Conservation). Treatment to the chart included: brushing to remove loose surface dirt and debris, separating the chart from its heavy linen backing, washing the chart in de-ionised water adjusted to a neutral pH with calcium hydroxide to remove the soluble discolouration and some of the acidity, and finally a 'de-acidification' treatment by immersion in a bath of magnesium hydrogen carbonate to deposit an alkaline reserve in the paper and finally repairing tears and losses using a Japanese kozo paper and wheat starch paste. The funding also allowed production of a full-size facsimile which is now on display in the School of Chemistry. The original periodic table has been rehoused in conservation grade material and is stored in Special Collections' climate-controlled stores in the University.

A researcher at the University, M Pilar Gil from Special Collections, found an entry in the financial transaction records in the St Andrews archives recording the purchase of an 1885 table by Thomas Purdie from the German catalogue of C Gerhardt (Bonn) for the sum of 3 Marks in October 1888. This was paid from the Class Account and included in the Chemistry Class Expenses for the session 1888-1889. This entry and evidence of purchase by mail order appears to define the provenance of the St Andrews periodic table. It was produced in Vienna in 1885 and was purchased by Purdie in 1888. Purdie was professor of Chemistry from 1884 until his retirement in 1909. This in

itself is not so remarkable, a new professor setting up in a new position would want the latest research and teaching materials. Purdie's appointment was a step-change in experimental research at St Andrews. The previous incumbents had been mineralogists, whereas Purdie had been influenced by the substantial growth that was taking place in organic chemistry at that time. What is remarkable however is that this table appears to be the only surviving one from this period across Europe. We are very keen to know if there are others out there that are close in age or even predate the St Andrews table.

Professor David O'Hagan, recent ex-Head of Chemistry at the University of St Andrews, said: "The discovery of the world's oldest classroom periodic table at the University of St Andrews is remarkable. The table will be available for research and display at the University and we have a number of events planned in 2019, which has been designated international year of the periodic table by the United Nations, to coincide with the 150th anniversary of the table's creation by Dmitri Mendeleev."

Gabriel Sewell, Head of Special Collections, University of St Andrews, added: "We are delighted that we now know when the oldest known periodic table chart came to St Andrews to be used in teaching. Thanks to the generosity of the National Manuscripts Conservation Trust, the table has been preserved for current and future generations to enjoy and we look forward to making it accessible to all."

Read more at:

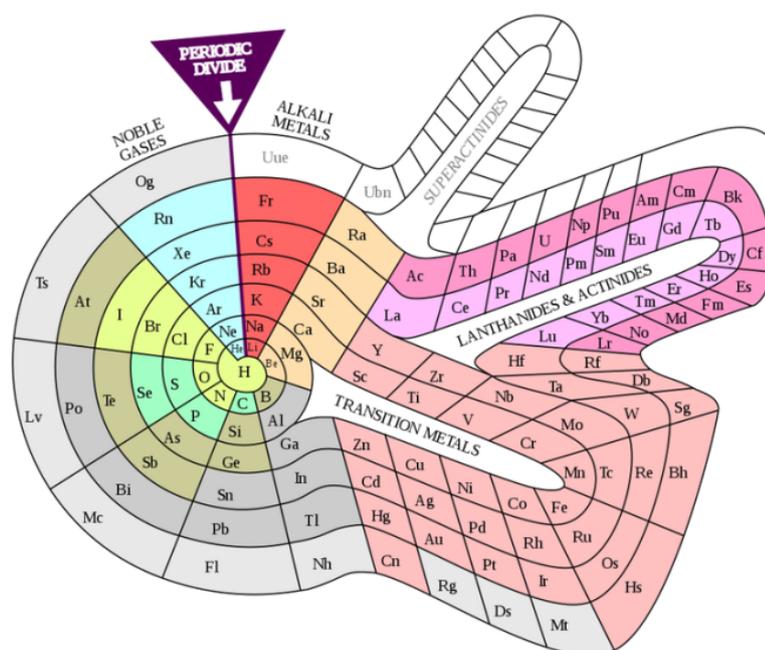
<https://phys.org/news/2019-01-world-oldest-periodic-table-st.html>

<https://www.chemistryworld.com/opinion/is-this-the-worlds-oldest-classroom-periodic-table/3009960.article>

□

The periodic table might have looked very different indeed

The United Nations has declared 2019 the International Year of the Periodic Table. Mark Lorch from the UK's University of Hull explains.



Theodor Benfey's spiral table (1964). DePiep/Wikipedia Mark Lorch, *University of Hull*

The [periodic table](#) stares down from the walls of just about every chemistry lab. The credit for its creation generally goes to [Dimitri Mendeleev](#), a Russian chemist who in 1869 wrote out the known elements (of which there were 63 at the time) on cards and then arranged them in columns and rows according to their chemical and physical properties. To celebrate the 150th anniversary of this pivotal moment in science, the UN has proclaimed 2019 to be the [International year of the Periodic Table](#).

ELEMENTS		
Hydrogen 1	Strontian 46	
Nitrogen 5	Barites 68	
Carbon 6	Iron 50	
Oxygen 7	Zinc 56	
Phosphorus 9	Copper 56	
Sulphur 13	Lead 90	
Magnesia 20	Silver 190	
Lime 24	Gold 190	
Soda 28	Platina 190	
Potash 42	Mercury 167	

John Dalton's element list. [Wikimedia Commons](#)

But the periodic table didn't actually start with Mendeleev.

Many had tinkered with arranging the elements. Decades before, chemist John Dalton tried to [create a table](#) as well as some rather interesting symbols for the elements (they didn't catch on). And just a few years before Mendeleev sat down with his deck of homemade cards, [John Newlands](#) also created a table sorting the elements by their properties.

Mendeleev's genius was in what he left out of his table. He recognised that certain elements were missing, yet to be discovered. So where Dalton, Newlands and others had laid out what was known, Mendeleev left space for the unknown. Even more amazingly, he accurately predicted the properties of the missing elements.

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104,4	Pt = 197,4
			Fe = 56	Ru = 104,4	Ir = 196
		Ni =	Co = 59	Pd = 106,6	Os = 199
			Cu = 63,4	Ag = 108	Hg = 200
H = 1			Zn = 65,2	Cd = 112	
	Be = 9,4	Mg = 24	? = 68	Ur = 116	An = 197?
	B = 11	Al = 27,4	? = 70	Su = 118	
	C = 12	Si = 28	As = 75	Sb = 122	Bi = 210?
	N = 14	P = 31	Se = 79,4	Te = 128?	
	O = 16	S = 32	Br = 80	J = 127	
	F = 19	Cl = 35,5	Rb = 85,4	Cs = 133	Tl = 204
Li = 7	Na = 23	K = 39	Sr = 87,6	Ba = 137	Pb = 207
		Ca = 40	Ce = 92		
		? = 45	La = 94		
		?Er = 56	Di = 95		
		?Yt = 60	Th = 118?		
		?In = 75,6			

Dimitry Mendeleev's table complete with missing elements. Wikimedia Commons

Notice the question marks in his table above? For example, next to Al (aluminium) there's space for an unknown metal. Mendeleev foretold it would have an atomic mass of 68, a density of six grams per cubic centimetre and a very low melting point. Six years later [Paul Émile Lecoq de Boisbaudran](#), isolated [gallium](#) and sure enough it slotted right into the gap with an atomic mass of 69.7, a density of 5.9g/cm³ and a melting point so low that [it becomes liquid in your hand](#). Mendeleev did the same for [scandium](#), [germanium](#) and [technetium](#) (which wasn't discovered until 1937, 30 years after his death).

At first glance Mendeleev's table doesn't look much like the one we are familiar with. For one thing, the modern table has a bunch of elements that Mendeleev overlooked (and failed to leave room for), most notably the noble gases (such as helium, neon, argon). And the table is oriented differently to our modern version, with elements we now place together in columns arranged in rows.

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	* 104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				* 58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
				* 90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Today's periodic table. Offnfopt/Wikipedia

Heinrich Werner's modern incarnation. Reprinted (adapted) with permission from Types of graphic classifications of the elements. I. Introduction and short tables, G. N. Quam, Mary Battell Quam. Copyright (1934) American Chemical Society.

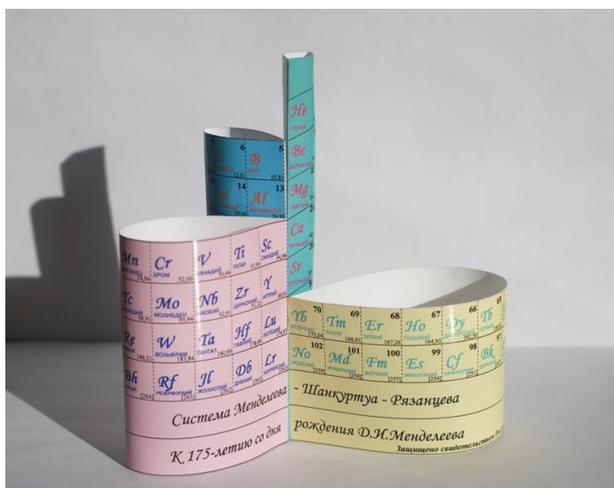
Despite this rather modern looking table, there was still a bit of rearranging to be done. Particularly influential was Charles Janet's version. He took a physicist's approach to the table and used a newly discovered quantum theory to create a layout based on electron configurations. The resulting "left step" table is still preferred by many physicists. Interestingly, Janet also provided space for elements right up to number 120 despite only 92 being known at the time (we're only at 118 now).

Charles Janet's left-step table. Wikipedia, CC BY-SA

Settling on a design

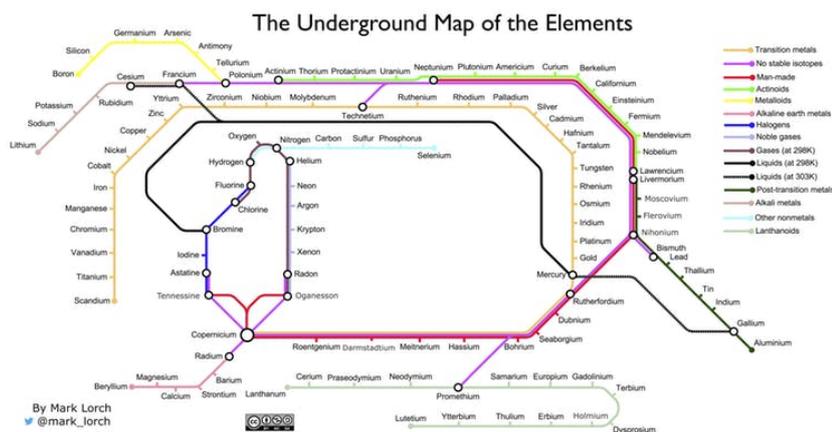
The modern table is actually a direct evolution of Janet's version. The alkali metals (the group topped by lithium) and the alkaline earth metals (topped by beryllium) got shifted from far right to the far left to create a very wide looking (long form) periodic table. The problem with this format is that it doesn't fit nicely on a page or poster, so largely for aesthetic reasons the f-block elements are usually cut out and deposited below the main table. That's how we arrived at the table we recognise today.

That's not to say folks haven't tinkered with layouts, often as an attempt to highlight correlations between elements that aren't readily apparent in the conventional table. There are literally hundreds of variations (check out Mark Leach's database) with spirals and 3D versions being particularly popular, not to mention more tongue-in-cheek variants.



3D 'Mendeleev flower' version of the table. Тимохова Ольга/Wikipedia, CC BY-SA

How about my own fusion of two iconic graphics, Mendeleev's table and Henry Beck's London Underground map below?



The author's underground map of the elements. Mark Lorch, Author provided

Or the dizzy array of imitations that aim to give a science feel to categorising everything from beer to Disney characters, and my particular favourite “irrational nonsense”. All of which go to show how the periodic table of elements has become the iconic symbol of science.

Mark Lorch, Professor of Science Communication and Chemistry, [University of Hull](#)

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Mark Lorch is Professor of Science Communication at the University of Hull. He trained as a protein chemist, studying protein folding and function. His research now focuses on the chemistry of a broad range of biological systems including lipids, proteins and even plant spores.

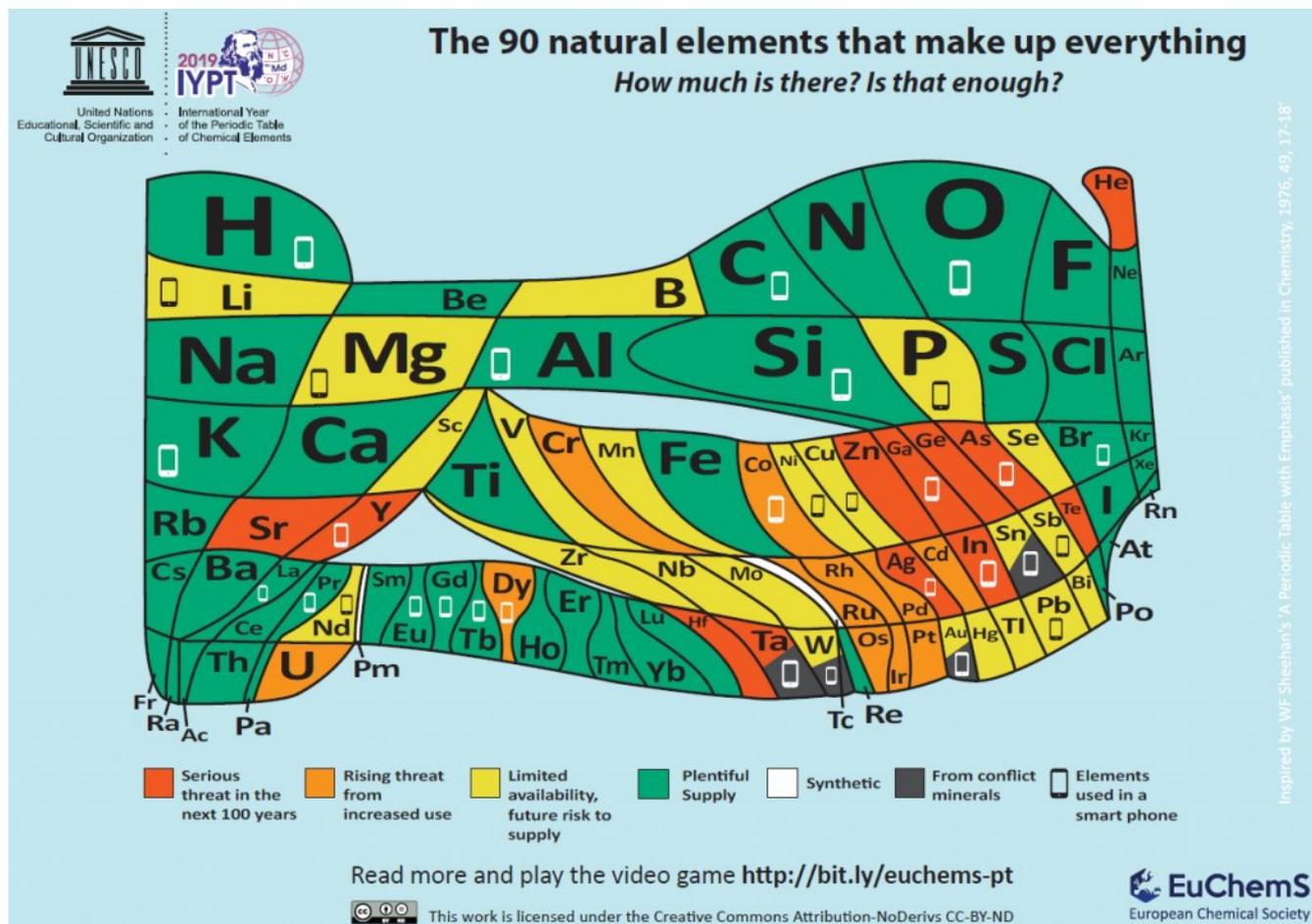
You can find more of his writing at [www.chemistry-blog.com](#), the Guardian and in his The New Humanist and BBC Focus columns. You might also like to check out his book 'The Secret Science of Superheroes'.

As well as his written out puts he gives regular talks to schools, the public and conferences (sometimes all at once, at science festivals or TEDx) and he occasionally pops up on the radio and TV explaining science and technology to a public audience.

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The new EuChemS Periodic Table showing availability of the elements

(<https://www.euchems.eu/euchems-periodic-table/>)



The smartphone you may be using right now to look at this unique Periodic Table is made up of some 30 elements – over half of which may give cause for concern in the years to come because of increasing scarcity. The issue of element scarcity cannot be stressed enough. With some 10 million smartphones being discarded or replaced every month in the European Union alone, we need to carefully look at our tendencies to waste and improperly recycle such items. Unless solutions are provided, we risk seeing many of the natural elements that make up the world around us run out – whether because of limited supplies, their location in conflict areas, or our incapacity to fully recycle them.

Protecting endangered elements needs to be achieved on a number of levels. As individuals, we need to question whether upgrades to our phones and other electronic devices are truly necessary, and we need to make sure that we recycle correctly to avoid old electronics don't end up in landfill sites or polluting the environment. On a political level, we need to see a greater recognition of the risk element scarcity poses, and moves need to be made to support better recycling practices and an efficient circular economy. Moreover, transparency and ethical issues need to be considered to avoid the abuse of human rights, as well as to allow citizens to make informed choices when purchasing smartphones or other electronics – as many of the elements we

require in our electronics are imported from conflict zones.

2019 has been pronounced the International Year of the Periodic Table (IYPT2019), and EuChemS, the European Chemical Society, hopes that this unique and thought-provoking Periodic Table will lead to reflection and ultimately, action. Over the next year, we will provide featured articles on specific elements, their endangered status, and the consequences this will have on the world around us.

The Periodic Table is available for free download. Please note that the work is

licensed under the **Creative Commons Attribution NoDerivs CC BY-ND.**

Support notes, which explain in more detail how the Periodic Table has been designed are available for download here.

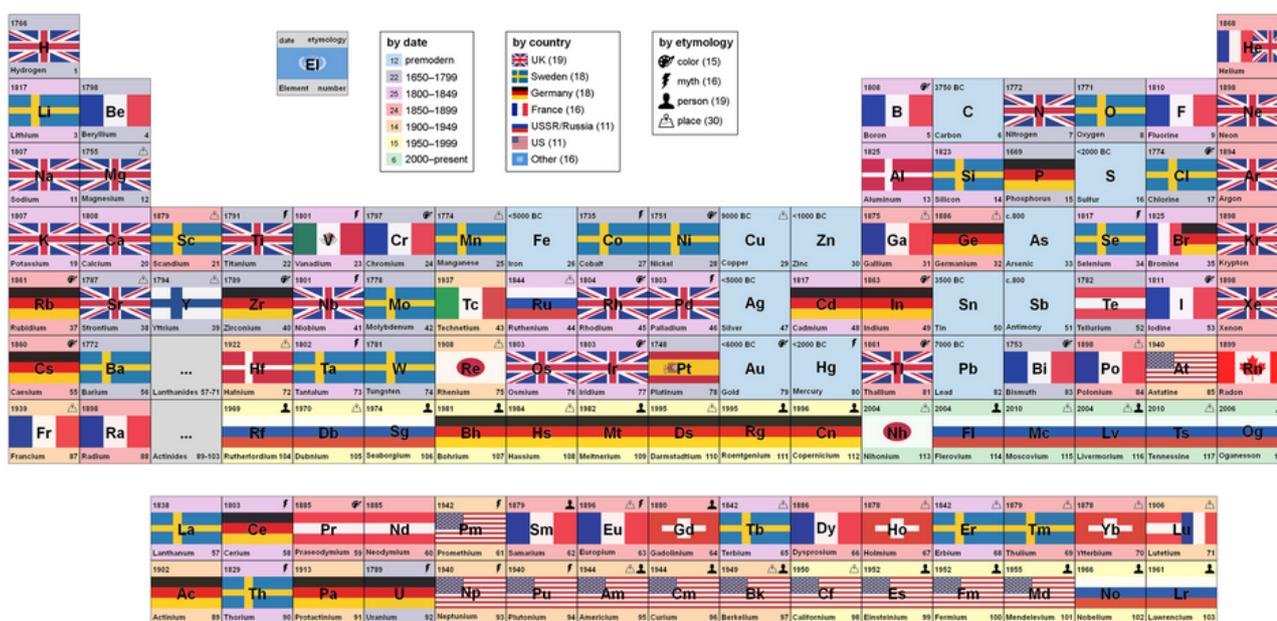
Support notes for teachers are available for download here.

It is available in many European languages but not yet in Irish.

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THE PERIODIC TABLE

with country and date of discovery



*dates, discoverers, etymologies and flags all from Wikipedia; etymology icons by Simpleicon and Freepik from www.flaticon.com, licensed by CC 3.0 BY.

AuUdzu

Periodic Table showing the country of discovery
<https://plus.google.com/u/0/+GoogleScienceFair/posts/LHUK6s7qQX7>

Things to do to mark IYPT in school

1. Have a limerick competition based on either a chemical element or the discoverer of an element or a poem in any form.
2. Create your own illustrated PT by getting students to create an A4-sized poster for each element. (This would take up a large wall as it would be about 4 m across for a short form.)
3. Collect samples of elements or pictures of elements to make an illustrated PT.
4. Get students to write short stories which illustrate the chemistry of an element e.g. A day in the life of a carbon atom.
5. Collect/download as many different versions of the Periodic Table and make a display of them, including 3D versions.

Any other ideas?

Periodic table activities and lesson ideas (from Philip Harris

<https://www.philipharris.co.uk/blog/secondary/international-year-of-the-periodic-table/>)

Teaching the periodic table doesn't have to be daunting, take a look at these ideas for fun and simple classroom-based activities.

- Periodic table bingo – create enough cards for your class, each one showing different combinations of elements. Pick individual elements out of a bag and the first to get a full house wins.
- Classroom display – simply create your own periodic table using folded paper so each one opens like a book and on the inside write the properties of each one. Why not divide the class into small teams so each can focus on a different group or element type? They can then report their findings back to the rest of the class, a great way for students to learn about the individual elements.
- Match everyday items to the element - for example, match salt to sodium or lithium to batteries.
- Element top trumps – cut out each of the elements, giving 10 to each student. They then battle it out using atomic numbers and mass. The person with the most elements at the end wins.
- Something's missing – there are a lot of variations of this activity. You could ask your class to fill in the missing element symbol, a missing atomic mass or even the group name.

Infographic on the history of the Periodic Table from OUP

[\(https://blog.oup.com/2019/02/150-years-of-the-periodic-table/\)](https://blog.oup.com/2019/02/150-years-of-the-periodic-table/)

Teaching resources from the American Chemical Society:

This link is for ages 15-18 but there are also materials for other age groups on the same site.

<https://www.acs.org/content/acs/en/education/whatischemistry/periodictable/educational-resources-for-ages-15-18.html>

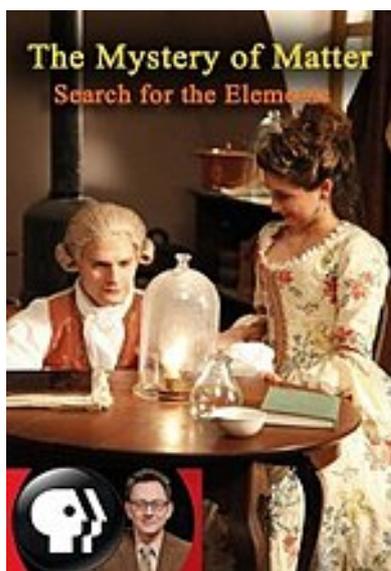
Resources from the Royal Society of Chemistry:

<https://eic.rsc.org/periodic-table>

Video resources for teaching about the Periodic Table

YouTube has become a go-to resource for teaching videos, which are free to use providing you have access in the classroom or lab to a video projector and internet access. There are an enormous number of videos available. They bring the elements to life and allow you to show reactions too dangerous to do in school. Use short clips to illustrate your lessons. Use the flipped classroom approach to get your students to view the longer videos at home and prepare for a quiz and discussion the following day.

The Mystery of Matter (PBS series, 2015)



The Mystery of Matter: Search for the Elements is an exciting series about one of the great adventures in the history of science: the long and continuing quest to understand what the world is made of. Three episodes tell the story of seven of history's most important scientists as they seek to identify, understand and organize the basic building blocks of matter.

The Mystery of Matter: Search for the Elements shows us not only *what* these scientific explorers discovered but also *how*, using actors to reveal the creative process through the scientists' own words and conveying their landmark discoveries through re-enactments shot with replicas of their original lab equipment. Knitting these strands together is host Michael Emerson, a two-time Emmy Award-winning actor.

Meet Joseph Priestley and Antoine Lavoisier, whose discovery of oxygen led to the modern science of chemistry, and Humphrey Davy, who made electricity a powerful new tool in the search for elements. Watch Dmitri Mendeleev invent the Periodic Table, and see Marie Curie's groundbreaking research on radioactivity crack

open a window into the atom. Learn how Harry Moseley's investigation of *atomic number* redefined the Periodic Table, and how Glenn Seaborg's discovery of plutonium opened up a whole new realm of elements still being explored today.

Each programme is just over 56 minutes long.

1. Out of thin air (1754-1806)

<https://www.youtube.com/watch?v=z3Gt5IOjAuc>

Joseph Priestley, Humphrey Davy and Antoine Lavoisier

2. Unruly elements

Dimitri Mendeleev and Marie Curie

<https://www.youtube.com/watch?v=wbuDmY5gpXQ>

3. The mystery of matter

<https://www.youtube.com/watch?v=GWQZE0HPoAY>

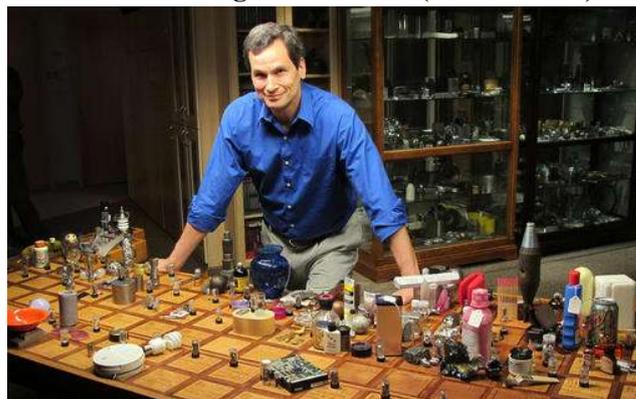
Henry Moseley and Glenn Seaborg

Periodic Table Videos from the RSC and University of Nottingham

<http://www.rsc.org/periodic-table/video>

The clickable PT links to the University of Nottingham short videos on each of the elements.

PBS Nova Hunting the elements (1 hr 53 mins)



<https://www.youtube.com/watch?v=G04h9kK3ZJs&list=PL8520FB7B0206116B&t=0s&index=2>

OU Classic: reactions of the alkali metals (2:21)



<https://www.youtube.com/watch?v=uixxJtJPVXk>

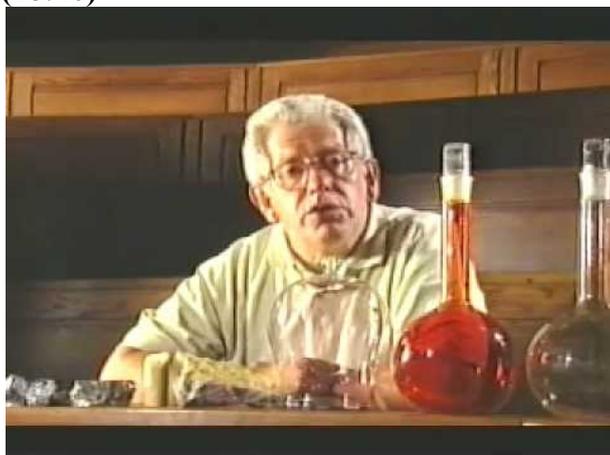
A short clip to insert into your lesson.

OU Classic: the halogens (3:39)

<https://www.youtube.com/watch?v=u2ogMUDBaf4>

Shows some of the reactions of the halogens, which would be unsafe to do in school.

Adam Hart Davis on Mendeleev's Dream (18:46)



<https://www.youtube.com/watch?v=O2dnk4OtbYE>

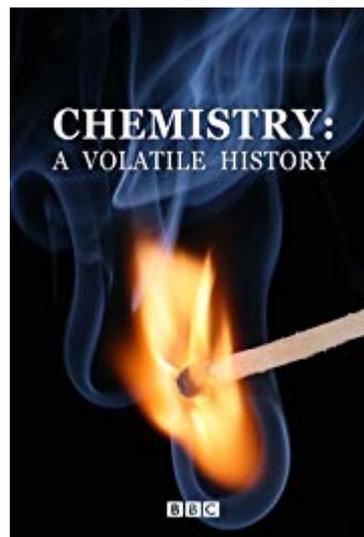
An engaging introduction to the Periodic Table.

Mendeleev and Lothar Meyer – The Periodic Table (14:10)

<https://www.youtube.com/watch?v=-wYDRfKd6Rk>

A short introduction, partly dramatised, going up to the transuranium elements.

Chemistry: a volatile history (3 part, BBC series, 2010)



One of the best chemistry series in recent years, first broadcast on BBC4 in 2010.

Part 1: Discovering the elements

<https://vimeo.com/23948902>

<http://www.documentarytube.com/videos/chemistry-a-volatile-history>

Part 2: The order of the elements

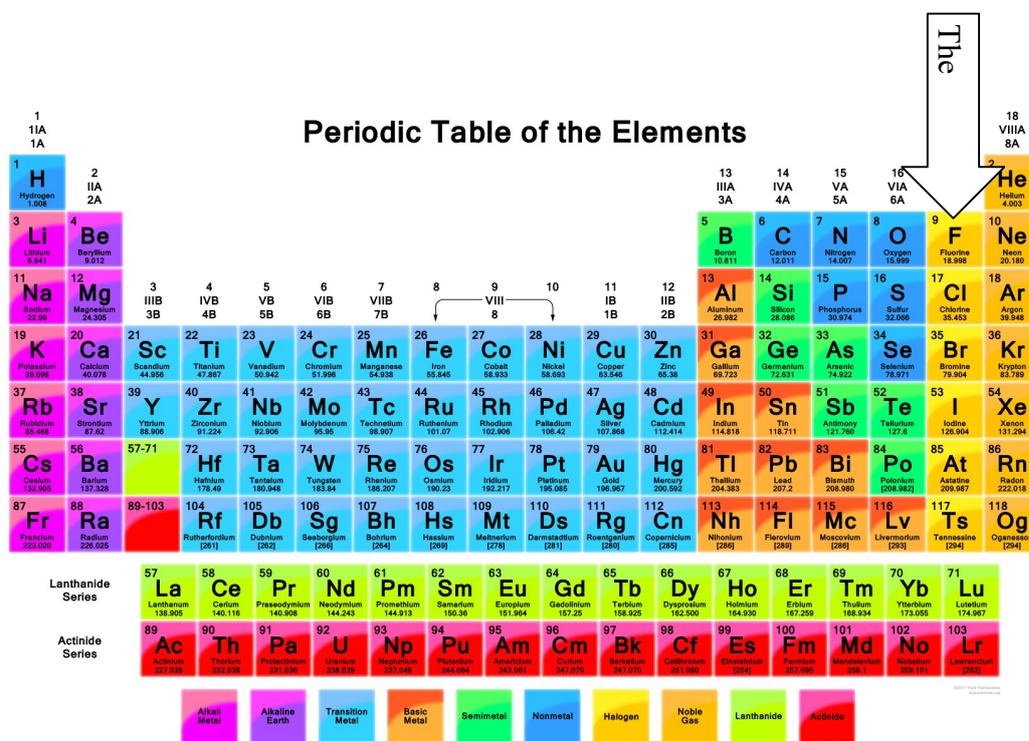
<https://vimeo.com/23979283>

Part 3: The power of the elements

<https://vimeo.com/23988758>

Have you used any good chemistry videos? Share them through Chemistry in Action! with your colleagues.

IYPT: The halogens - the French connection

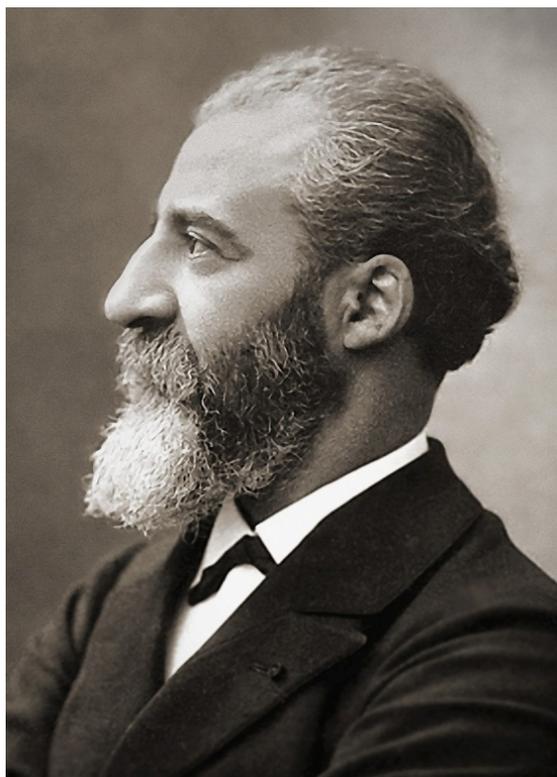


Every chemistry student is familiar with the halogens, group 17 in the Periodic Table, because several of the elements – fluorine, chlorine, bromine and iodine – crop up in everyday life. The two heaviest ones are radioactive and the last member of the group, Tennessine, wasn't named until 2016. One interesting feature of the stable halogens (F to I) is that 3 of them were first identified in France. We could call this the French connection. This is summarised in Table 1. The group was named the halogens by J.J. Berzelius in 1826 meaning salt-formers, as all the elements were known to form simple salts with metals. Three of the halogens (Cl, Br and I) are most commonly found in sea-water because the large, monovalent ions form soluble compounds with most metal ions. They are thus weathered out of rocks and soils and run off into the oceans. Fluorine has a smaller ion and forms strong ionic bonds with divalent metals, like calcium, and is thus found mainly in rocks and its compounds resist weathering. Two of them (I and Br) were discovered in the ashes of sea-weed. All the elements are to one degree or another, toxic to humans.

Table 1: The halogens

Name, symbol	Date of Discovery/ isolation	Person(s)	Country
Fluorine, F	1886	Henri Moissan	France
Chlorine, Cl	1774	C.W. Scheele	Sweden
Bromine, Br	1826	A.J. Balard Jacob Löwig	France, Germany
Iodine, I	1811	B. Courtois	France
Astatine, At	1940	Team	USA
Tennessine, Ts	2010	Team	USA & Russia

Fluorine, F



Henri Moissan (Wikipedia Commons)

Fluorine is the first member of the group but the element was not isolated until after the other stable halogens. The existence of an unknown element was known for a long time and fluorspar, CaF_2 , was described in 1529. Fluorine is difficult to obtain for three reasons: first, its compounds are very stable and hard to break up chemically; second, it is a powerful oxidising agent and needs a more powerful oxidising agent to liberate it – in the end electrolysis had to be used; third, the element is so reactive that it reacts with its containers e.g. glass. The element, difluorine, F_2 , is a gas and is very reactive and poisonous.

It was eventually isolated, after many failed attempts, by the French chemist Henri Moissan (1852-1907), in 1886 by the electrolysis of KHF_2 in anhydrous hydrofluoric acid.

By the time it was discovered the other halogens had been named and the ending *-ine* adopted for the group. Fluorine was named after the mineral fluorspar, where *fluere* means to flow, named because fluorspar was used to produce a flux in metal smelting to remove impurities. (The element is often misspelt as fluorine.)

Chlorine, Cl



Statue of Scheele in Koping, Sweden (Wikipedia Commons)

Chlorine was the first halogen to be isolated by the Swede Carl Wilhelm Scheele (1742-1786) in 1774, when he reacted hydrochloric acid (muriatic acid) with the mineral pyrolusite (MnO_2), producing a choking green gas. He named it dephlogisticated marine acid. In 1807 Humphry Davy correctly identified it as an element and suggested the name chlorine, from *chloros* – yellow-green, for its colour. In 1789 the French chemist Claude Berthollet found that chlorine gas had bleaching properties and in 1799 Charles Tennant developed a solid form of chlorine, Ca(OCl)_2 , bleaching powder, by reacting chlorine gas with lime. The use of chlorine as a bleaching agent transformed the textile industry by reducing the time needed to bleach cloth for weeks to hours. A major use of chlorine is in treating drinking water to kill bacteria and make it safe to drink.

Bromine, Br



Balard in his 70s (Wikipedia Commons)

The third halogen to be isolated was bromine. In 1826 the French chemist Antoine Jerome Balard (1802-1876) treated the ashes of sea-weed with chlorine gas and observed the formation of a red colour, which he first thought was iodine chloride. He originally called it muride but later the name was changed to bromine, from *bromos* = stench, because of its strong smell. He was a young pharmacy student at the time aged 24 and this discovery made his name. Justus Liebig said: "[*Balard*](#) did not discover bromine, rather bromine discovered [*Balard*](#)." A young German chemist Jan Jacob Löwig discovered it independently in 1825 and they are now given joint credit.

The main source is still sea-water or other brines, and it used to be made at plant on Anglesey. (<https://pdfs.semanticscholar.org/b419/bf465e6c425791601ef1f058e3faf8436ec5.pdf>)

Iodine, I

Iodine was discovered by accident by a French chemical manufacturer, Bernard Courtois (1777-1838), who was involved in extracting alkali from seaweed ash as part of the process of making saltpetre for gunpowder. One day he treated the residue in his pans with sulphuric acid and on heating observed a violet-coloured gas, which condensed to form dark, shiny crystals. He sent a sample to the distinguished French chemist Joseph

Gay-Lussac, who showed it to be an element. It was named iodine after its colour, *iodes* = blue-violet. "... *This substance was discovered accidentally, 2 years ago by M. Courtois, a Paris manufacturer. In the course of the procedure by which he obtained soda from seaweed ash, he found that the metal vessels he used were corroded and he looked for the cause, when he discovered the new substance. It appeared when a little sulfuric acid was added to the ash after extracting carbonate of soda. When the acid is concentrated enough to produce a strong heat the new substance appears as a beautiful violet vapour and condenses in crystals which are the colour and lustre of graphite.*" H. Davy 1813
<http://acshist.scs.illinois.edu/awards/OPA%20Paper%202007-Swain.pdf>

Astatine, At

All the elements beyond bismuth are radioactive (i.e. unstable) and when radioactive elements like polonium and radon were identified, it was clear that there should be another halogen below iodine. Traces have been found to exist in nature as a product of radioactive decay of heavier elements. The first sample was made by an American team [Dale R. Corson](#), [K.R. Mackenzie](#), and [Emilio G. Segrè](#), who bombarded [bismuth](#) with [alpha particles](#). It was named astatine after *astatos* = unstable.

Tennesine, Ts

This is one of the newest elements. It was made in 2010 by teams in Russia and the USA and named Tennesine (Ts) by IUPAC in 2016, after the state of Tennessee in the USA where it was made.

Properties of the halogens



Chlorine gas Bromine liquid Iodine solid
<https://en.wikipedia.org/wiki/Halogen>

The three groups of elements with the clearest group trends are group 1 (alkali metals), group 17 (halogens) and group 18 (noble gases). All the elements of group 17 (excluding the bottom two)

are non-metals and exist as X_2 molecules. As the molecules get heavier going down the group, the melting points and boiling points increase in a regular way with increasing molecular mass. They favour the formation of single covalent bonds with other non-metals (including themselves) or ionic compounds with metals, forming the X^- ions. They are all oxidising agents (positive E° s) and become less oxidising and less non-metallic down the group. Fluorine is anomalous (unusual) in many ways (first row anomaly) due to its small size. Table 2 shows some properties of the elements.

Uses of the halogens

All four of the stable halogens are widely distributed in nature and widely used in industry. Some of their major uses are described below.

Fluorine: fluorine-based polymers e.g. Teflon; chlorofluorocarbons as refrigerants (being phased out to protect the ozone layer), drinking water and toothpaste

Chlorine: treatment of drinking water, disinfectant, bleach, organochlorines – solvents and polymers (PVC), food as sodium chloride

Bromine: flame retardants, silver-based photography

Iodine: medicine - treatment for goitre and iodine deficiency; antiseptic; halogen lamps (<https://www.bulbs.com/learning/halogen.aspx>), extraction of metals

The relative importance of the elements can be judged by their annual production:

Fluorine ~17,000 t

Chlorine ~ 40,000,000 t

Bromine ~ 330,000 t

Iodine ~ 31,000 t

Table 2: Some properties of the halogens.

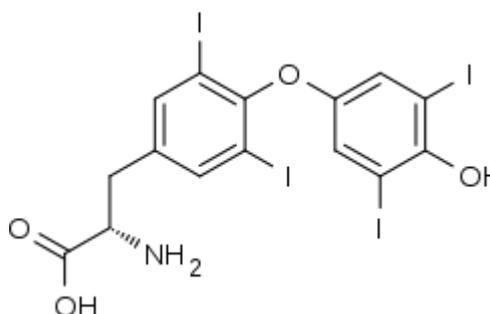
Property	Fluorine, F	Chlorine, Cl	Bromine, Br	Iodine, I
Atomic radius/Å	0.71	0.99	1.14	1.33
Ionic radius/Å	1.33	1.81	1.96	2.20
First IE/kJ mol ⁻¹	1681	1251	1140	1008
Electron affinity/ kJ mol ⁻¹	-328	-349	-325	-295
Electronegativity	4.0	3.0	2.8	2.5
X-X strength/ kJ mol ⁻¹	155	242	193	151
E°/V $\frac{1}{2} X_2(aq) + e^- \rightarrow X^-(aq)$	2.87	1.36	1.07	0.54
Colour/state	Yellow gas	Green gas	Red liquid	Violet solid

1 Å = 0.1 nm or 100 pm

Both chlorine and iodine are essential elements for human life and so we need them in our diet.

Too much salt (our major source of chlorine) is a bad thing but so is too little. Iodine is a trace element but is essential for the proper functioning of the thyroid.

Lack of iodine produces goitre. In general the Irish diet is low in iodine and it is almost impossible to buy iodised salt, the simplest and cheapest way to correct for iodine deficiency.



(S)-thyroxine (Wikipedia)

□

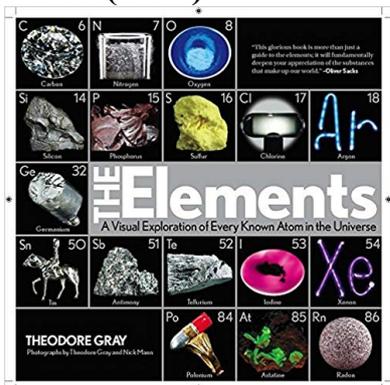
Top ten books on the Periodic Table

Chosen by Graham Woods (#1-) and Peter Childs (#9-10)

All of these books should still be available. The most convenient way to get them is using Book Depository, free shipping anywhere in the world and discounted price. The BD price will indicated in brackets in euro (BD: €). The BD price will indicated in brackets in euro (BD: €), but prices will vary with the exchange rate. (www.bookdepository.com) It is also worth checking Abe Books (www.abebooks.co.uk) as they have secondhand copies, often at very reasonable prices. Also note that several books have been through many editions and the cover art changes and may be difefernt from the ones shown below.

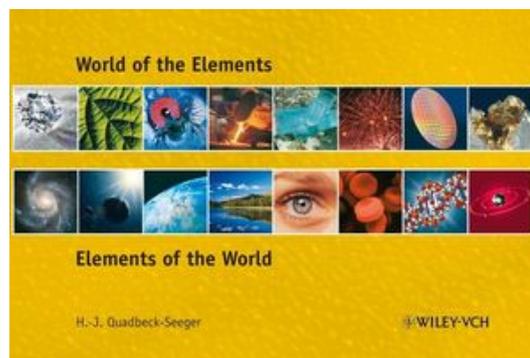
Two coffee table books

#1 *Visual Elements, A Visual Explanation of every known atom in the Universe.* (2009)



Theodore Gray with photographer Nick Mann. Black Dog & Levanthal publishers, New York. (2009) Hardback. £25, 240pp. The author is a chemist who collects element samples. (BD: €21.05 hb, 2012 €15.34 pb)

#2 *World of the Elements: Elements of the World.* (2007)



H-J Quadbeck Seeger. Weinheim:Wiley-VCH. (2007) Hardback £18.90. 118pp (aptly the number of elements!). An American translation of text of a German Professor. (BD €19.88 hb)

These admirable volumes will be compared & contrasted using VE and WE as identifiers. On picking them up VE is double the size & much heavier. They both have colour images/photos but VE has white text on a black background which can be harder to read whereas WE has more familiar white paper which I found easier. They were first published only two years apart and represent a leap forward in presentation. Both have some chemical formulae, particularly for natural sources, but no chemical equations since they must attract but not daunt coffee table readers.

They both have a hierarchical size order available for individual elements. Both use the same size for most of elements 1-92, with double spaces for about ten, a very similar selection, and elements 93-118 with less space. VE sizing is based on double spreads of opposite large pages whereas WE features two elements per smaller page. Hence there is a vast difference in visual appearance.

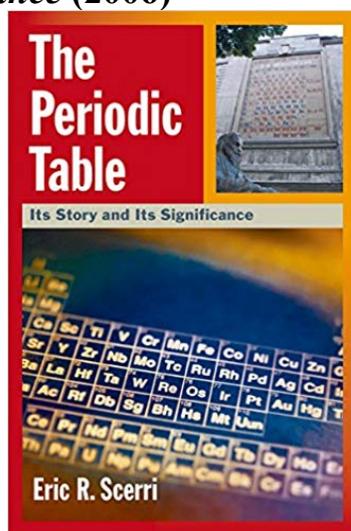
Both books include melting & boiling points, symbols, atomic weight & numbers for each element. WE has a wide variety of tables & charts at the end: discovery dates and places, physical data plotted graphically, world production by value & abundance and four periodic tables very different from the usuals rectangular layout. Each VE element is given a full left hand page of a natural source facing a

page with photos illustrating of up to a dozen uses because of the much greater space available.

Three Eric Scerri books

Eric Scerri's first degree was in London and now he is a Professor of the Philosophy of Science specialising in the History of Chemistry at UCLA. He is the only author to have written three of the books I have chosen and the only one I have personally met, indeed we once both spoke at a conference in London.

#3 *The Periodic Table. Its story and its significance* (2006)



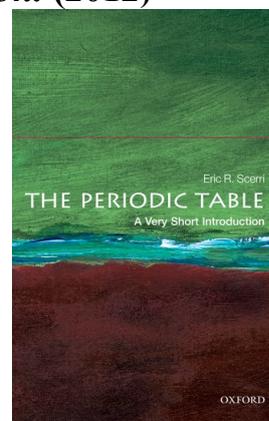
Eric Scerri. Oxford University Press (New York). Hardback 360pp. (BD: €32.44 hb, 2006) (may be cheaper on Abe Books).

290 pages of text are followed by some 70 pages of notes, references, detailed comments and index. Of course these are not completely error free but it is where I usually turn for accurate detail when I am writing myself. This paragraph's numerical data indicates the quality and breadth of the book.

The book starts with Lavoisier and many others who led up to Mendeleev's seminal identification of his periodic system, then its recognition, initially reluctantly, and its explanation and application in the 20th century. To summarise it describes the gestation, birth and growth and development of the chemists' icon. It is an authoritative volume for

professional chemists, particularly those with a historical leaning.

#4 *The Periodic Table: A very Short Introduction*. (2012)



Eric Scerri. Oxford University Press (New York). Softback £7.99. 11x 17cm, 60g. Black & grey text. Many less diagrams & charts which are almost all smaller versions from the above book. Two portrait photographs. 170pp. 140 pages of text precede pages of notes, references, detailed comments and index. The reading list includes mostly books from my selection. (BD: €7.36 pb, 2012)

The publishers of the series of Very Short Introduction books state that they are written by experts who provide a stimulating introduction to a new subject. It is common for authors to create them as briefer versions of more substantial volumes. Many teachers may prefer to first read this book to help identify sections from the above volume which will both help their teaching and enhance their interest. Almost all the books I have chosen are also in its reading list.

#5 *A Tale of 7 Elements*. (2013)



Eric Scerri (2013) Oxford University Press (New York). Hardback £17.49 270pp. (BD: €19.42, hb, 2013)

This third Scerri book is very different in style to The Periodic Table books above not merely because it deals with only 7 of its members. This volume deals with discovery of the last seven elements up to number 92 Uranium thought by Moseley and others to be the final Periodic Table element. Listed in discovery order, these are Protactinium Pa, Hafnium Hf, Rhenium Rh, Technicium Tc, Francium Fr, Astatine At & Promethium. Hf & Rh are stable & occur naturally. Pa, Fr & At are unstable/radioactive & occur naturally. Tc & Pm are radioactive & do not occur naturally. In his introduction Scerri wondered whether to consider them, alphabetical, atomic number but decided that discovery date was the most logical.

This book theme is concerned with the frustrations, false trails and other problems in finding and then proving that a new element has been found. The focus is on human difficulties as much as on the chemical elements. All three books are sequential in time but this book focuses on chemists more than chemistry. Like the above books it is very carefully researched, as noted by some of authors of similar style volumes.

Two older unavailable books

#6 *Principles of Chemistry*. (1891)



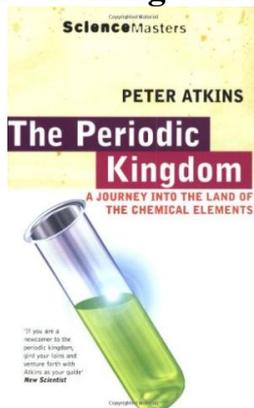
D Mendeleeff . (1891). 2 volumes. Longmans Green ,New York & London. Unavailable. 460pp

This is the first English translation of this historic multi-edition work. The translator was George Kamensky, ARSM (i.e. a musician) of Russian Imperial mint at St Petersburg where Mendeleeff worked and editor A J Greenaway FIC (Fellow of the Institute of Chemistry.)

By 1891 Mendeleeff's periodic law was generally accepted by the discovery of elements with properties similar to his predictions. The 2 volumes are a detailed description of current inorganic chemistry . Volume 1 is a general introduction followed by some chapter of commoner non-metals. Volume II starts with a long chapter 'The Grouping of the elements and the periodic law' then deals with metals arranged in chapters headed by their Group Number.

A striking feature of the text is that the notes, in a smaller font, below the text are often longer, even forming 90% of a page! (P25) "*When in 1871 I wrote a paper on an application of the periodic law to the determination of the properties of as yet unknown elements I did not think that I would live to see the verification of the law after 20 years I had the pleasure of seeing them discoveredand named after the countries of where they were found ...Gallia,, Scandinavia and Germany.*" Some such personal features are the particular attraction of the book to me. How could I ignore the writings of the originator of the periodic table?

#7 The Periodic Kingdom. (1997)



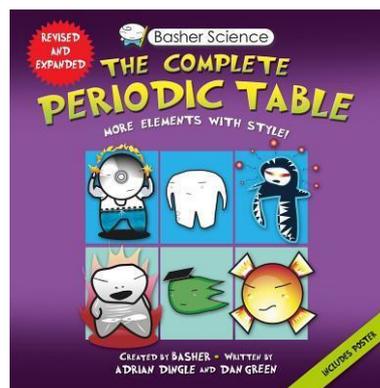
Peter Atkins. 1997. Ingram. Softback. (Out of print and unavailable on Book Depository, but available cheaply on Abe Books.)

Peter Atkins is an Oxford chemistry don, a prolific author of textbooks and popular science books, of which *Molecules* is probably his most known book. *The Periodic Kingdom* is an unusual book which describes the systematic nature of the periodic table through considering its properties and organisation as if it was a map of the periodic kingdom, hence the title and subtitle, a journey into the land of the chemical elements.

The book is divided into three sections, each subdivided into three or four chapters, one or two of which will be glanced at. The Geography section has The Terrain in which s, p, d, f are named Northern Shore, Eastern Rectangle, Western Desert and Southern Shore. History deals with the discovery and naming of the regions (elements). Government and Institutions looks at the laws of the interior and exterior of the regions (properties within and outside the nucleus).

Pages need to be read thoughtfully to see the parallels and whether this throws a new light on your comprehension of periodic patterns. Teachers should think how analogies drawn from their pupils' locality or everyday interests can help them understand their chemistry. It is not a textbook but a range of ideas from which to increase one's understanding of the Periodic Table.

#8 *The Periodic Table, Elements with Style!* (2007)



Simon Basher with consultant Mark Winter (webelements) 2007 Kingfisher, the children's section of Macmillan Press. Small softback. £6.99 (BD: pb €11.21)

This is the chemistry member of three science booklets which aim to interest children aged 8-18. The elements are listed in an order linked to their groups. Most elements have a double page with the right hand page a colour cartoon linked to a property. The facing page has about 120 words in which each element, writing in the first person, informally describes its properties and uses and perhaps also compound(s) of which it is a part. At the top and bottom of each left hand element page are ten numerical values (boiling and melting points, discovery year, appearance and metal/non-metal character etc).

A few lines about lead will best illustrate the style. *"Don't let my heavy weight status fool you-at heart I am a malleable softie. My chemical symbol is Pb (and the word plumbing) come from my Latin name plumbum. Over the years I have gained a bad rep. They say that I build up in bones as a slow poison"*

There is a periodic table inside the end flap based upon the page cartoons.

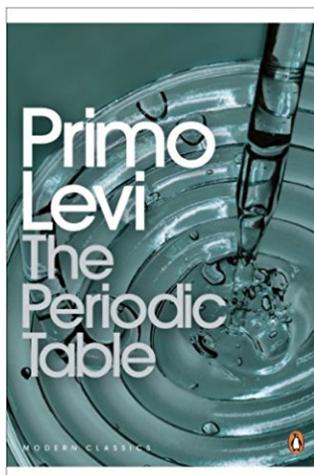
Overall there is much information informally given. A suitable prize or gift ... my daughter gave it to me!

Two semi-autobiographical books

These two choices are quite different in that the chemistry, and the Periodic Table, are incidental to the autobiography. They are both excellent examples of good science writing. Nicholas Shrimpton reviewing *The Periodic Table* for the Sunday Times said: *"Parents who wish to inspire children with an enthusiasm for science could not do better than give them this*

humorous, moving and peculiar book. Adult victims of the two cultures who, like me, suffer from a shameful scientific illiteracy should give it to themselves and wonder. Scientists can read it and rejoice.”

#9 *The Periodic Table*. (1975/1984)



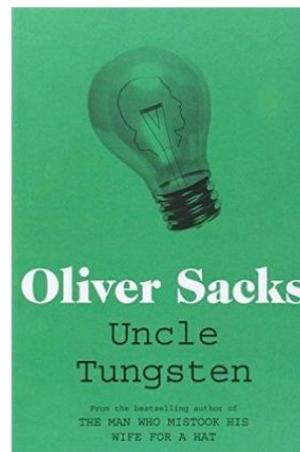
Primo Levi. (1975), first English translation 1984 Trans. R. Rosenthal Penguin Classics (BD: €17.88 hb, 2011; €8.12 pb, 2015)

This book consists of 21 short chapters following the career of Primo Levi, a Jewish industrial chemist. He was sent to Auschwitz and his chemistry saved his life as he was sent to work in a laboratory using his skills. The experience affected his subsequent life and he wrote a number of biographical memoirs about his experiences. In this book he uses the chemical elements as a framework and each episode in his life is related to a particular element, from argon to carbon. This book is a fusion of science and literature and has remained a classic since its publication. Sadly Primo Levi died in 1987 after a fall. This quotation illustrates the style of Levi's writing. *“Distilling is beautiful. First of all, because it is a slow, philosophic, and silent occupation, which keeps you busy but gives you time to think of other things, somewhat like riding a bike. Then, because it involves a metamorphosis from liquid to vapour (invisible), and from this once again to liquid; but in this double journey, up and down, purity is attained, an ambiguous and fascinating condition, which starts with chemistry and goes very far.”*

This year marks the centenary of Primo Levi's birth. There is a nice appreciation of him at <http://www.bbc.com/culture/story/20190305->

primo-levi-a-clear-eyed-view-of-evil-pain-and-humanity by Thomas Graham. See also: https://en.wikipedia.org/wiki/Primo_Levi

#10 *Uncle Tungsten: Memories of a Chemical Boyhood* (2001)



Oliver Sacks. (2001) 317 pp Vintage Books (BD: €11.58 pb, 2016)

Oliver Sacks is better known as a neurologist, made famous by the book and film *Awakenings*. He was born in England and grew up in a Jewish family in London. His uncle ran a light bulb factory using tungsten filaments and his visits there stimulated a passion for chemistry and the chemical elements in Oliver. Most of his books are about his patients and his work as a neurologist, but he never grew out of his love for chemistry and the elements, and this is interwoven with his early history growing up in London in the blitz. He died in 2015 at the age of 82. You can watch an interview with Oliver Sacks talking about the book at <https://www.c-span.org/video/?167699-1/uncle-tungsten>

Here is a quote from *Uncle Tungsten*:

“The periodic table was incredibly beautiful, the most beautiful thing I had ever seen. I could never adequately analyze what I meant here by beauty – simplicity? coherence? rhythm? inevitability? Or perhaps it was the symmetry, the comprehensiveness of every element firmly locked into its place, with no gaps, no exceptions, everything implying everything else.” (https://en.wikipedia.org/wiki/Oliver_Sacks)

□

Chemlingo: elemental misnames

Peter E. Childs

Fluorine was the last of the stable halogens to be discovered. Chlorine, iodine and bromine had been identified, isolated and named first with the suffix (ending) –ine and the prefix describing a property of the element. In the case of chlorine (yellow-green, Gk. *chloros*) and iodine (violet, Gk. *iodos*) it came from their colour. Surprisingly bromine was not named for its distinctive red colour but for its smell (Gk *bromos* = a stink), as it does have a distinctive smell (like chlorine). This was a missed opportunity to be systematic based on colour but originally it had been called muride, to indicate its discovery in sea-water. Fluorine should thus have been named for a property of the element but instead it was named fluorine by Humphry Davy in 1813, on the suggestion of Ampere, after its source in fluorspar. This was, of course, long before the isolation of the element by Henri Moissan. Ampere later had second thoughts and suggested phthorine instead from the Gk. *phthora* = destroyer. Davy rejected the idea and fluorine stuck as the name. Students and non-chemists already have problems with the name, often rendered as fluorine. Think of the problems in pronouncing and spelling phthorine, if this had been accepted! The ending –ine is now accepted for all group 17 elements and the 5th member, astatine (Gk. *astatos* = unstable) is also named for a property, as it is radioactive and thus unstable. The final member (so far) of the group was only named in 2016, and tennessine is named for its place of discovery (Tennessee), thus breaking the unwritten rule again.

The first member of group 18 was helium, first discovered in the solar spectrum before it was found on earth. It was named after the Greek for sun, *helios*. At the time it was not known that it was the first member of a new group, the noble gases. The next 4 group 18 elements -neon, argon, krypton and xenon - were discovered by William Ramsay in air, where they had all been secretly lurking, and all given names ending in –on. They are all monatomic gases and chemically unreactive (although not inert) and were named after their properties. Radon was discovered as a radioactive gas emitted by radium. The last member of the group, oganesson, was named after its Russian discoverer (Yuri Oganessian), but given the right ending.

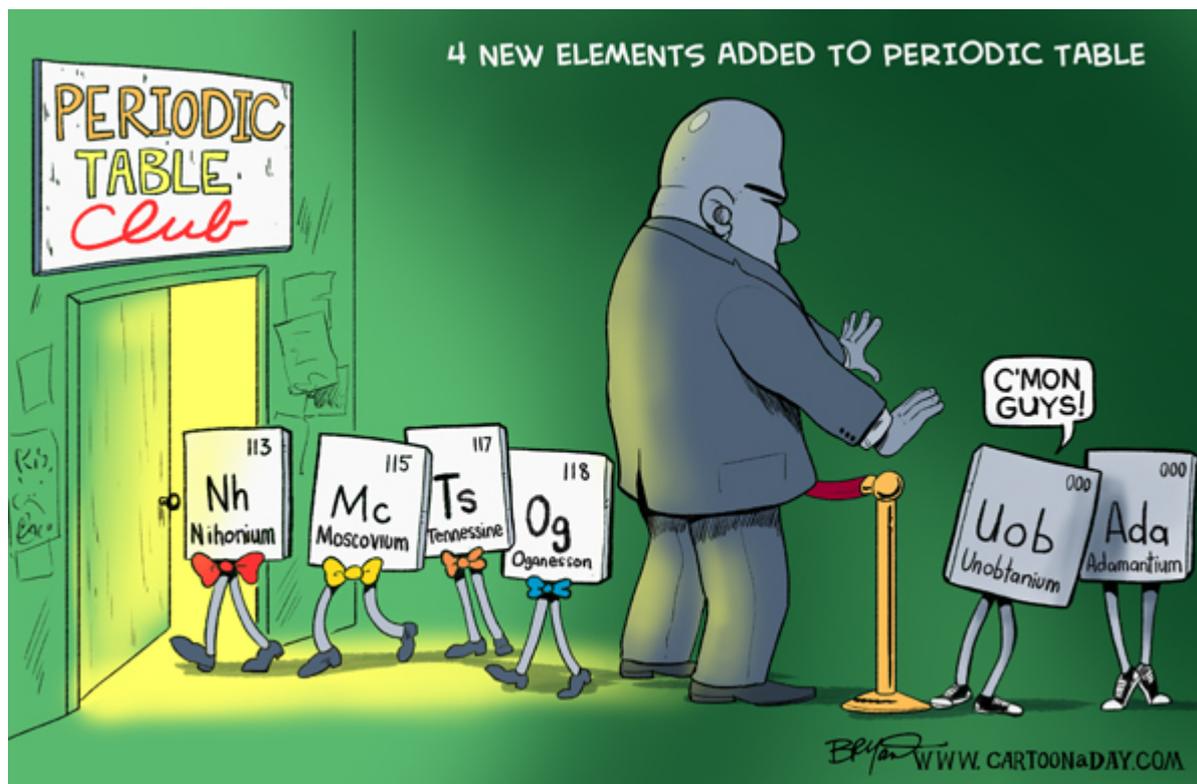


Clearly helium is the odd element out in the group as it ought to be called helion for consistency and to show its family resemblance to the others.

The suffix –ium is used to denote a metal and is the ending for the majority of the chemical elements. Which is the odd one out? For some reason, lanthanum is a metal but ends in –um not –ium, unlike the other rare earth elements. The other exception to the rule, but only in America, is aluminum for aluminium. Aluminum was actually the first way the element was spelt but later it was changed to aluminium and this is the official IUPAC name. We should always remember, of course, that although the symbols for the elements are universal, each language has its own names for the elements. Thus in Swedish, the names of the halogens are fluor, klor, brom, jod and astat (notice no suffix.)

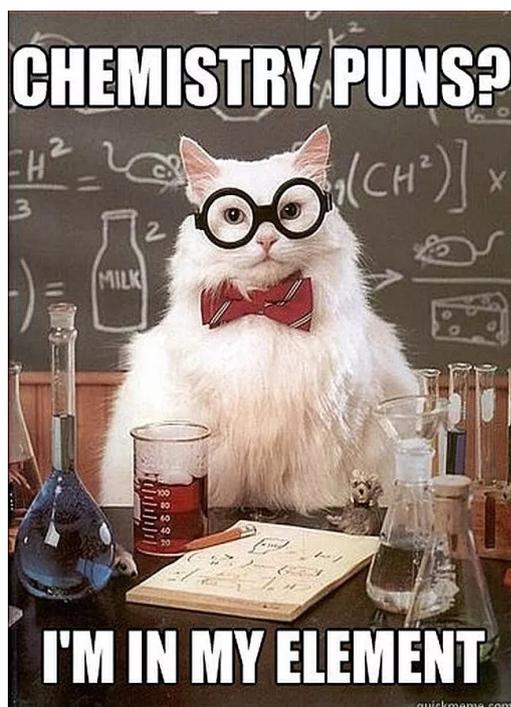
□

Humour and the Periodic Table



(Cartoon used by permission www.cartoonaday.com)

The Chemistry Cat cartoons are great: (see <https://www.thoughtco.com/chemistry-cat-meme-4054181> for more examples)



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AT  M**



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EVERYTHING**

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**What do you do
with a dead chemist?**

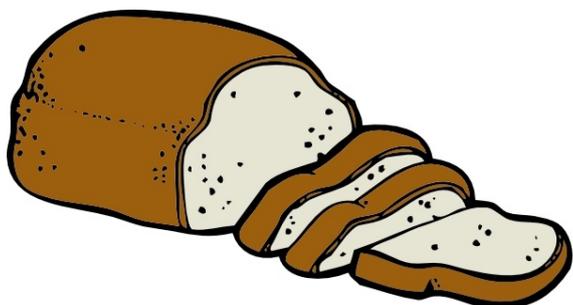


The story of a staple: bread for the workers and money for its makers

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Bread is a ubiquitous commodity, eaten in diverse forms in many parts of the world since the earliest farming communities settled. Since the introduction of industrial-scale bread production, bakers are no longer a common sight on the high street, though a resurgence in popularity seems set to reverse this trend and, once again, small-scale bakeries are thriving. The re-constructed Victorian baker's workshop and shop at the Black Country Living Museum (<http://www.bclm.co.uk/locations/veals-bakers-shop/39.htm#.WPUD-IjyvIU>) shows the small-scale production, which is once again flourishing.



The reconstructed bakery at the Black Country Living Museum (BCLM)

The move of the population into urban settings after the agricultural revolution during the eighteenth century largely separated people from the source of their food and deprived them of community facilities, including the village bread oven. The

local baker in the town was relied upon by many families, who lacked cooking facilities of the kind needed for baking bread. These bakeries were small and close to the consumers of their products, as shown by the picture of the re-constructed bakery at the BCLM. A typical worker's family would expend around two thirds of its income on bread, so steady profit from the sale of bread could be relied upon. Nevertheless, some bakers added adulterants to extend their profits still further. Indeed, John Snow (of Soho cholera epidemiology fame) described it as 'the universal practice' of bakers.

Commonly used adulterants included:

- 'Potash alum', potassium aluminium sulphate, a naturally occurring mineral which is weakly acidic
- Bone, a mixture of calcium carbonate, calcium phosphate and collagen protein (see *Walsall bags the world* for more on the chemistry of collagen)
- Chalk, composed predominantly of calcium carbonate
- Sawdust, comprising insoluble polysaccharide cellulose and a polyphenol, lignin. It is not digested by the human gut, so provides 'dietary fibre' which promotes the movement of food through the gut.

The effect of these additives was to decrease the nutritional value of the bread, whilst maintaining or, in the case of the potash alum increasing, the price so raising the profit margin.

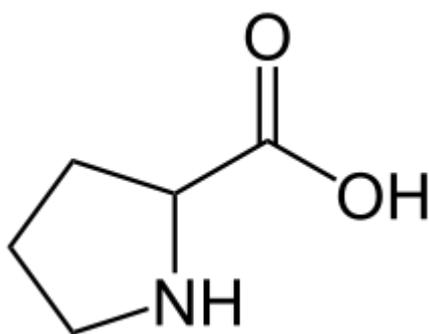
The health inspectors were appalled at the level of food adulteration they discovered on their tours of inspection (See <https://eic.rsc.org/feature/the-fight-against-food-adulteration/2020253.article>) Whilst the substances added to bread might have affected the quality of the bread, none were toxic, whereas some of the substances added to other food stuffs, such as strychnine in beer, were positively dangerous. There was some anxiety that adulterated bread was contributing to rickets although this was

later disproved, and is now attributed to a number of factors associated with poor housing, poor diet (See

http://www.ph.ucla.edu/epi/snow/injepidemiology32_336_337_2003.pdf)

As the analyst's art became ever more precise during the nineteenth century, it was possible to ascertain the nature and amount of adulteration in sampled foodstuffs. Thus, for the first time, it became possible to specify acceptable levels of contamination and to enforce the law through chemical analysis.

Bread is made from wheat flour. These days 'bread flour' is differentiated by possessing a high level of the storage proteins known collectively as protein gluten (Latin for 'glue'). These proteins incorporate a high proportion of proline, a unique amino acid because its amine group is secondary, being part of a cyclic side chain. The low water solubility of proline, along with its inability for side chains to rotate freely around a central carbon atom, gives it distinctively useful properties. The side chain bonds well to other lipophilic ('fat loving') side chains, such as in other proline molecules, creating a three-dimensional network of bonded proteins as the dough is kneaded (pressed, stretched and pushed together). The other amino acid thought to contribute to the development of cross linkages between the individual proteins is cysteine, which has a sulphhydryl side chain and disulphide bridges can then form between adjacent protein molecules. The gluten network is strong and much less flexible than a comparable structure with less proline. It therefore forms a good 'scaffold' on to which the starch-water mixture can adhere, giving bread its texture and the dough its elasticity. One of the functions of the fat which is added to bread is to limit the formation of the bonds between hydrophobic proline side chains, a bread without oil has large pockets of carbon dioxide but is quite 'chewy' and dry. Oil-free bread doesn't crumble in the way we are accustomed to bread doing either.



The structure of proline

The flour contains starch molecules which mix with water to form swollen starch granules, in which the water occupies the space between adjacent starch molecules; these granules then touch neighbouring granules at the edges, like balloons packed into a box. The starch also provides food for the yeast, which breaks down the starch into sugars, which the yeast then uses to provide the yeast cells with energy. The by-product of this is the carbon dioxide gas which will make the loaf rise. Acidic metabolites produced in anaerobic conditions would have caused the release of further carbon dioxide when calcium carbonate (chalk) was added to the mix. The final ingredient, salt, is added solely for flavour, but in small quantities as it actually impedes the activity of yeast if present in high concentration.

The sugars produced by the breakdown of starch by the yeast also contributes to the Maillard reaction, which gives the crust its characteristic browning. This occurs as the result of a condensation reaction between reducing sugars, such as glucose, and amino acids, as are found in gluten. The products then undergo a spontaneous rearrangement to give rise to a number of molecules which confer both the brown colouring and the smell of the bread. The initial condensation reaction is slowed by acidic conditions, and the products of the subsequent rearrangement differ according to the level of acidity. It is the acidifying action of the alum which makes the bread less brown. Conversely the additional protein provided by the collagen in the bone meal leads to a greater incidence of browning.

In 1961 the Chorley Wood process was devised, which used vitamin C, an oxidising agent, which oxidises the sulphhydryl side chains and thus speeds up the formation of disulphide bridges and the protein network required for texture. (For home bakers it is added to so-called 'activated' dry yeast.) Vitamin C is a much less toxic oxidising agent than those which had been used previously, which had included chlorine dioxide and potassium bromate, but which still enabled dough processing to be speeded up. The increased speed of processing does, however, reduce the production of substances, such as ethanol, by the yeast, which contributes to bread's flavour and smell. Nevertheless, it did enlarge the scale on which bread could be produced in a given time period, and was another part of the industrialisation of food supply, which had been happening over the twentieth century in Europe. It was also another part of the uncoupling of food production from consumers. This is now seeing a reversal through the production of 'artisan' food

products. The Chorley Wood process placed responsibility for bread quality in the hands of a few manufacturers and so may have regularised quality, though this is at the expense of individual choice.

For a long time, I had wondered whether the buyer couldn't simply spot that the bread was 'cut' with impurities. This question led me to conduct investigations, in which I made five loaves using identical quantities of brown flour, or adulterated flour, water at 40 °C, vegetable oil, dried yeast and salt on the wholemeal loaf setting of my bread maker. I then removed 50 grammes of raw dough at the end of the dough making part of the machine's cycle and froze the dough samples until needed.

The different doughs and loaves contained variously:

- A. 4 % potassium aluminium sulphate
- B. No adulterants
- C. 8 % of the flour substituted with calcium carbonate
- D. 10% of the flour substituted with sawdust
- E. 8% of the flour substituted with bone meal

Comparison of the adulterated bread, and the dough from which they were made, with the loaf containing uncontaminated flour, showed that the distinction is nothing like as clear-cut as might have been imagined. The sawdust gave a more solid and grainier loaf, whilst the calcium carbonate gave a loaf that was hardly distinguishable from the normal loaf, apart from slightly larger bubbles in the bread. The potassium aluminium sulphate gave a paler loaf, with larger bubbles than the uncontaminated loaf; the resultant bread was very slightly bitter, but far from inedible. The bone meal made the bread rise slightly less well and gave a deeper brown colour to the crust.

Interestingly, visitors to the museum were not able to identify the adulterated loaves after examining the breads carefully and handling a sample of the dough from which they had been made. The lack of detection is especially likely if purchases were made repeatedly from the same baker and so no comparison was possible. It has even been suggested that people grew to prefer the taste of the familiar, adulterated food.

My findings lend credence to the idea that the customer might not have been able to identify adulteration up to a threshold level. It also corroborates contemporary reports of the frequent contamination of flour. It is certainly conceivable that the bulk of the loaf made with sawdust was both filling and economical, important characteristics for the poorest families. The social status associated with lighter bread may have tempted shoppers to buy them.

Biography:

Jane is an active member of the Royal Society of Chemistry and currently chairs their Chemical Education Research Group. Her major professional interests are teacher education and educational research, focusing specifically on teacher preparation for inclusion and inclusive science education. She has run inclusive science outreach events since 2004 and was recently awarded the Herald Global Game Changers Award for Innovation in STEM Education and Training.

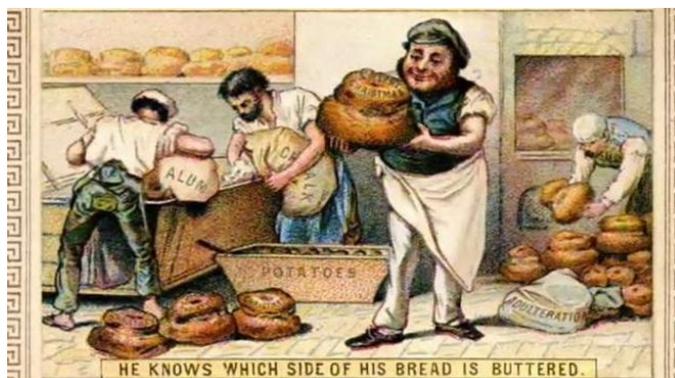
Further reading:

'Food and Drink Adulteration in the 1700 and 1800s'. Geri Walton

<https://www.geriwalt.com/food-and-drink-adulteration-in-1700-and/>

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https://en.wikipedia.org/wiki/John_Snow



<https://www.bbc.com/news/uk-25259505>

Chemists you should know: #5

Thomas Graham 20/12/1805 – 16/9/1869

Adrian Ryder

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Introduction

Thomas Graham is best remembered today for his Law of Effusion (or diffusion).

“**Effusion** refers to the movement of gas particles through a small hole. Graham's Law, formulated in 1848, states that the **effusion** rate of a gas is inversely proportional to the square root of the mass of each of its particles. The law also holds for gases intermixing (diffusion).”



Thomas Graham in 1856

Thomas Graham was born in Glasgow on December 20th 1805 the second child of James Graham (1776 – 1842) and Margaret Paterson (1775 – 1830). James was a prosperous merchant and light linen manufacturer exporting to the West Indies, and lived at 86 Hutcheson Street, Glasgow. Thomas's grandfather was also called Thomas and his great-grand father was called James so the customary practice of naming the eldest boy after the grandfather was strictly followed in the Graham families.

Thomas's siblings were Margaret (1803 – 1866), James (1807 – seemingly died as an infant), Henry (1808 – 1848), Mary (1810 – 1878), John (1812 – 1869) and William (1815 – 1848). Of the seven children in the family, only Mary and John were

to marry: Mary having six children with her husband James Reid, a banker, and John having three children with his wife Mary Hannah Cooper. Margaret looked after her father's household following the death of her mother and later joined Thomas in London to care for him. After Thomas was made Master of the Royal Mint in London, John joined his staff there at a salary of £20 a month.

Education

At the age of five Thomas began his schooling in a preparatory school under Dr. William Angus moving, aged eight, to the High School where he received a classical education under Dr. John Dymock and Rector Dr. William Chrystal. Aged thirteen he entered the University of Glasgow where, instead of studying for the ministry as hoped for by his father, he took chemistry under Prof. Thomas Thomson (1773-1852). At the age of eighteen he received his Master's Degree (MA) and moved to University of Edinburgh to further his chemical studies with Prof. Thomas Hope (1766-1844) for two years. Inspired by his mentor's medical experience, Thomas also took lectures in medicine. Although he never practiced medicine, Thomas had strong views on contemporary medical practice, being quoted by Wooster Beach, in “A Treatise on Anatomy, Physiology and Health” (1848), as condemning the use of mercurial medicines as “*A barbarous practice, the inconsistency, folly and injury of which no words can sufficiently describe.*” He continued: “*(Mercurial medicines) affect the human constitution in a peculiar manner, taking so to speak, an iron grasp of all its systems, and penetrating even to the bones, by which they not only change the healthy action of its vessels, and general structure, but greatly impair and destroy its energies; so that their abuse is rarely overcome. When the tone of the stomach, intestines, or nervous system generally, has been once injured by this mineral it could seldom be restored.*”

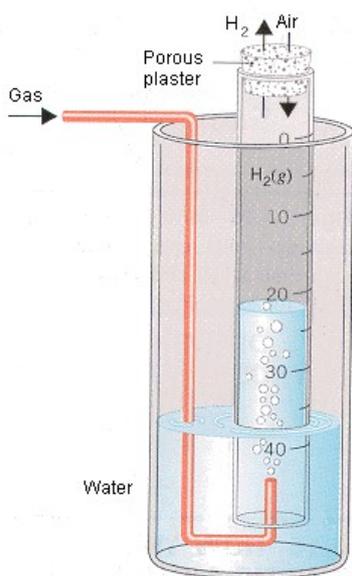
Scientific work

It was during his time in Edinburgh that Thomas prepared and published his first three papers, on

Absorption of Gases by Liquids, the Heat of Friction and the Production of Alcohol in the course of the Fermentation of Bread in Baking. The first of these appeared in both the *Scots Mechanic's Magazine* and the *Annals of Philosophy* in July 1826; the other two were published in Vol. XI of the *Annals of Philosophy* of the following year just prior to its ceasing publication.

In 1827 Thomas returned to Glasgow where he taught mathematics privately before opening a private laboratory in North Portland Street for chemistry analyses and instruction. The following year he was elected an honorary Fellow of the Royal Society of Edinburgh which, no doubt, helped him become a Lecturer on Chemistry to the Glasgow Mechanics' Institution in 1829. It was here that he ran the experiments that are to this day associated with his name.

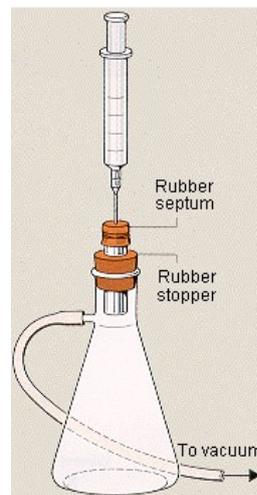
The apparatus used by Thomas in 1829 in his rates of diffusion experiments would have been similar to the diagram below.



The central tube is sealed with a plaster plug, which has holes large enough for gas to pass through. The tube, initially filled with water and standing with its open end in the water of the trough, is partially filled with the desired gas, in the diagram here this is hydrogen. If the hydrogen can pass through the plaster plug at a greater rate than the air above can enter, the level of the water in the central tube will rise; if at a lesser rate, the water level will fall. By means of repeated experiments with different gases Thomas was able to come to a formulation

of his law, for which he is famous and best-known.

To show the law for effusion of gases the apparatus shown below can be used. A syringe is filled with the gas to be tested.



The needle of the syringe is passed through the cork of the conical flask, which is attached by a side-arm to a vacuum pump. A vacuum is formed in the flask and the test gas effuses into it. Time is measured from the base of the plunger of the syringe passing two fixed points marked on the syringe. Further experiments with different gases revealed the truth of the law.

In 1830 Thomas became a professor in Anderson's College, Glasgow, where, although noted as a poor speaker, his care for students and practical ability made him a popular figure. He gave occasional lectures on chemistry to ladies, a daring innovation for the times. He continued his experiments on effusion and diffusion and submitted his completed paper on the 17th December 1831. (*Trans. RSE* vol XII, p 222). This paper saw him receive the Keith Medal of the Royal Society of Edinburgh in 1833. He joined the Royal Philosophical Society of Glasgow, serving as Vice-President from 1834 to 1837. In 1836 Thomas was elected a Fellow of the Royal Society and also had his paper "On the Constitution of Salts, Oxalates, Nitrates, Phosphates, Sulphates and Chlorides" printed in the Royal Society *Phil. Transactions*.

Thomas left Glasgow in 1837 becoming Professor of Chemistry in University College, London. His 1836 paper saw him presented with a Royal Medal

in 1838. He was to receive a second Royal Medal in 1850 for his 1849 paper "On the motion of gases". (*Phil. Trans.* 1849)

1841 Thomas was involved in the setting up of The Chemical Society of London, the first national chemistry society, where he served as its first President from 1841 to 1843 and again from 1845 to 1847.

To make up for his poor lecturing delivery, he published his "*Elements of Chemistry*" in 1842 to provide for his students. (This work is available as a download, see

<https://www.biodiversitylibrary.org/item/65227#page/31/mode/1up>) He was later to collaborate with Friedrich Julius Otto (1809-1870) in producing the text "*Ausführliches lehrbuch der chemie*" in 1854. A further collaboration with Henry Watts and Robert Bridges saw "*Elements of Inorganic Chemistry*" issued in 1866. All three volumes saw a wide readership both in England and abroad in Europe.

By 1844 Thomas was acknowledged as the leading chemist in England.

Later life

James Graham, Thomas's father, bought the lands of Ballewan in Strathblane, about 75km north of Glasgow, in 1825 and made this his residence. The lands are noted for containing the only mineral spring in the area. Following James's death without a will in 1842, Thomas, as the eldest son, inherited many properties. Totally committed to his life in London, Thomas divested all but Ballewan to relatives and used Ballewan as his chief residence for use when the university terms were over.

The Free Church of Strathblanefield, a Presbyterian Denomination, discussed building a Church in 1864 and Thomas, a devout Presbyterian, donated them a site. The Church opened on the 4th of August 1867.

Oxford awarded Thomas an Honorary Doctorate (DCL) in 1853.

In 1855 Thomas left his professorship in UCL to become Master of the Mint, following the retirement of Sir John Herschel (1792-1871). He was to hold this position to his death in 1869. He was not replaced and the position ceased as an independent one in 1870. His annual salary was a very substantial £1,500.

Thomas immersed himself in the work of the Mint, foregoing his scientific experimentation for the next few years but came back to it in 1860. He started working with semi-permeable membranes,

coining the terms "Dialysis" and "Colloids", and using technology which was a rudimentary forerunner of modern day kidney dialysis machinery. His 1861 paper "Liquid Diffusion applied to Analysis" (*Phil. Trans.* 1861), led to his award of the Copley Medal from the Royal Society in 1862 and the Prix Jecker of the Paris Academy of Sciences.

Thomas's first years with the Mint saw him produce four special Reports far removed from his usual to then. These were:

"On the Cause of the Fire in the Steamer 'Amazon'" to the Privy Council (*Jour. of Chem. Soc.*, vol. v, 1853, page 34)

"On the Water Supply of London" with Dr W A Miller and Dr Hofmann (*Jour. Chem. Soc.*, vol. iv, 1852)

"On Original Gravities" to the Board of Inland Revenue, regarding worts of beer on exportation (*Jour. Chem. Soc.*, vol. v, 1853) and

"On the Adulteration of Coffee" for the Board of Revenue (*Jour. Chem. Soc.*, vol. ix, 1856)

In 1866 he was elected as a foreign member of the Royal Swedish Academy of Sciences and he concluded his scientific career with papers on the absorption of hydrogen by metals. Graham showed that hydrogen in solution behaved as a metal, forming alloys with other metals, especially palladium, and he suggested it really ought to be called hydrogenium. However, this was not accepted and the poor gas retained its ordinary name.



Statue of Graham in Glasgow (Photo: Photograph by Jacqueline Banerjee, 2009)

<http://www.victorianweb.org/sculpture/brodie/4.html>

Thomas died in his house in Gordon Square in London at 9 o'clock in the evening of Thursday, the 16th September, 1869. His body was returned to his native Glasgow for burial in the family plot in Glasgow Cathedral. Thomas had never married and received a number of posthumous awards. The building housing the Chemistry Department of the University of Strathclyde, where he had worked at one of its precursor institutions, was named after him. The headquarters of the Royal Society of Chemistry in Cambridge is named the Thomas Graham House. The Graham Prize can be awarded by the Colloid Society for outstanding service to the field of colloid science in a national or international context. A statue of Thomas Graham, done by William Brodie (1815-1881), was erected by Glasgow City Council in George Square in 1872. (See the photograph above.)

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□

The SI units to be redefined!

Goodbye kilogram, hello the exact Planck's constant

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Measurement is a key skill for scientists and engineers and we regularly use units to quantify these measurements. It was a fitting end to Science Week 2018 that a significant event took place affecting measurement for all of science and engineering (even if most people did not notice). This event was a vote of the General Conference on Weights and Measures on the 16th November 2018.

These days everyone is familiar with the metre, the second, and the kilogram. We need other units¹ to quantify other aspects of nature that may be measured. Many are familiar with the unit of temperature called kelvin (note the small “k” in the name, while its symbol is the uppercase K) and the unit of current: ampere. Fewer may be familiar with the mole and fewer still the candela. Yet all these base units of the Système International (SI) are necessary to completely quantify our measurements. Other units you may have encountered before are: units of pressure such as pascal or bar, units of force such as newton, or units of energy such as calorie, or even the foot and pound are derived from, or defined in terms of, these base SI units. Of course, there are some units that are not derived from the SI system, interesting examples are the [smoot](#)¹, the [jiffy](#)², and the [thaum](#) (Terry Pratchett’s definition for the amount of magic necessary to conjure a small white pigeon or three normal-sized billiard balls). My personal favourite of such frivolous examples is the [paddy](#), named after a former classmate of mine, where the paddy is defined as exactly half of the correct answer to a question making the correct answer to all questions ‘2 paddy’. I was never brave enough to attempt using it in an exam, and am sure I would not have gained any marks for it anyway. But I digress...

The gathering at the General Conference on Weights and Measures included a unanimous vote that will fundamentally [change the definitions of](#)

¹ Here I intentionally omit talking about the candela as it depends on human biology, specifically the human eye and how it perceives light. As such it is not a fundamental constant of nature but it is very important for certain measurements.

[four of the SI units](#)³ taking effect on the 20th May 2019. I will start by talking about the change to the kilogram, which is getting most of the press. But I wanted to write this article to give due notice about the changes to three other base units too.

The kilogram is possibly the most dramatic of these changes. The reason for this is that the kilogram is, as I write this, a physical thing affectionately called “Le Grand K” but more properly as the International Prototype of the Kilogram (IPK) that became the kilogram in 1875. This metal object is a piece of platinum-iridium alloy that is EXACTLY 1 kg. That is until the 20th May 2019. At this point it will no longer be exactly 1 kg but it will still be VERY close. So how will the kilogram be defined then? That is a little detailed but I will try to give an overview of this.

First some background. The unit of time called the [second is defined](#)⁴ as “the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.” All this at a temperature of absolute zero. This means that there is a very specific light given off by this atom and if we measure its frequency in the correct way it is EXACTLY 9,192,631,770 oscillations in one second. This is how time is defined, and we just need a particular type of caesium atoms to hand.

The metre has a story similar to Le Grand K, as there used to be a physical metre but this unit was [redefined in terms of the speed of light](#)⁵ by saying that the “metre is the length of the path travelled by light in vacuum during a time interval that is 1/299,792,458 of a second.” So the metre was defined by saying that light travelled in a vacuum at EXACTLY 299,792,458 metres every second. Knowing the size of a second, we defined the metre by fixing the value of a fundamental constant of nature, the speed of light in vacuum, c . A similar trick is being proposed for the redefinitions today. The units being changed are going to be redefined

by fixing the values of other fundamental constants.

In the case of the kilogram this will require fixing the value of Planck's constant h to be EXACTLY $6.62607015 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}$. I should explain that the $\times 10^{-34}$ bit means that you divide (the minus) the 6.62607015 bit by 1-with-34-zeros-after, i.e.

10,000,000,000,000,000,000,000,000,000,000.
It's a very small number.

This was not achieved by simply deciding on a number but is the culmination of a process, and a couple of very precise experiments, that took years to perfect. It was necessary to do these experiments precisely enough so that the other units affected are consistent. One of these experiments was made possible by the development of the watt balance or kibble balance. Derek Muller of the YouTube channel Veritasium has a [nice video](#)⁶ describing the method. While the creation of a silicon sphere, the roundest object on Earth, was another, Veritasium also has another [nice video](#)⁷ on that. Notice that this value for h depends on the metre (m) and the second (s) so the kilogram depends on those too. But the definition of the kilogram also affects some of the definitions of other SI units.

The SI's [current definition of the mole](#)⁸ is "the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12". Notice the dependence on the kilogram. The mole leads to a fundamental constant which is: how many atoms are in a 12 gramme sample of carbon-12 (a particular type of carbon atoms)? The answer is Avogadro's constant N_A , which will define the mole by fixing exactly that $N_A = 6.02214076 \times 10^{23}$ atoms in a mole. So think of it like this: a baker's dozen is 13 while Avogadro's constant is $6.02214076 \times 10^{23}$, i.e. 6.02214076 multiplied by 1-with-23-zeros (100,000,000,000,000,000,000,000). There would be no shortages of bread during a storm if shops stocked their shelves in units of N_A ! It is a point of debate that the mole may no longer be a fundamental constant anymore as it is simply a number of things, but it is a unit in much use by scientists (especially chemists) so there is justification to keep it as it remains useful, but perhaps not strictly necessary.

The next affected unit is the ampere: the unit for electrical current or (as you can also look at it) the charge of all the electrons that pass a point in the wire in one second of an electrical current of one ampere flowing. Currently, the measurement of the ampere is very tricky as it requires two infinite lengths of wire that are negligibly thin and all in a vacuum. Yes, tricky is an understatement. It is a weird and wonderful thing in physics that these two wires exert a force on each other while carrying an electrical current due to Einstein's relativity, and that like charges repel each other while differing charges attract. This is usually interpreted as a magnetic force. It is measuring this force that defines the ampere, and so because there is a force there is a dependency on mass. If the kilogram is fixed, however, the ampere can be defined by fixing the charge of each electron that makes up the electrical current to be

$e = 1.602176634 \times 10^{-19} \text{ A s}$ (ampere second).

The elementary charge e , as it is called, is also used in the experimental setup that defines the kilogram so it is important that the numbers that Planck's constant and the elementary charge are fixed at are consistent with each other. However, with this new definition the ampere itself will only be dependent on the elementary charge and the definition of the second and not dependent on the kilogram anymore.

Finally, the definition of the kelvin will be changed. You may be familiar with the kelvin without really knowing it because the Celsius temperature scale is essentially the kelvin temperature scale just taking away 273.15 from its number, i.e. 0°C is the same as 273.15 kelvin. The kelvin is defined in a very interesting way. (I would think that, because I teach thermal physics!)

A boiling kettle is a case where both liquid water and water vapour exist together at the same temperature and pressure. A melting ice cube has liquid water existing at the same temperature and pressure as solid water (ice). But there is a particular temperature and pressure where water as solid, liquid, and vapour exists at the same temperature and pressure indefinitely: but only at a single precise value of both temperature and pressure. This is called the triple point of water (because of the three phases of water that coexist). The reason it does this is rooted in a generalisation of something you probably learned when solving

equations in secondary school: you need two equations to solve for two unknowns.

The [kelvin is currently defined](#)⁹ in terms of the temperature at this triple point which is **273.16** kelvin. It is this definition that is to be changed so that another fundamental constant of nature is fixed at a particular value. This one is pretty close to my heart.

One of my scientific heroes is [Ludwig Boltzmann](#)¹⁰. He is the father of statistical physics, an area central to my PhD thesis and much of my subsequent research. Boltzmann had a number of distinguished students such as Walter Nernst, Svante Arrhenius, and Paul Ehrenfest, and Boltzmann made many contributions to physics, but his most famous contribution is the following relationship (I intentionally only include one equation in this post).

$$S = k \log W$$

The quantity **k** is called Boltzmann's constant. This equation was deemed so significant that it was inscribed on his memorial at the [Zentralfriedhof](#)¹¹ in Vienna, one of the largest cemeteries in the world. It was so significant to me that on my honeymoon I went there with my wife to get a photo beside the monument (Figure 1).



Figure 1: At the monument to Ludwig Boltzmann at the Zentralfriedhof in Vienna.

So to define the kelvin the value of **k** will be fixed at **$1.380649 \times 10^{-23} \text{ kg m}^2 \text{ K}^{-1} \text{ s}^{-2}$** . Note that it will depend on the kilogram, the metre, and the second. The reason Boltzmann's constant defines the temperature is because **k** times the temperature gives the thermal energy, which can be written in terms of kilograms, metres, and seconds, and have all been defined above.

The implementation date of these new definitions is the 20th May 2019. On that date, it will be a new world where our measurements in all of science and engineering will be based on the fixed and unchanging fundamental constants of nature and not on any earthly objects like a block of metal, a thimble of carbon, or an obscure property of water. Although we still need caesium!

I emphasise that these changes are being made with the intention that the vast majority of people, including scientists and engineers, will not even notice its effects. If you would like to know more the Bureau International des Poids et Mesures YouTube channel ([youtube.com/thebipm](https://www.youtube.com/thebipm)) has a number of interesting talks that took place on the day of the vote.

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Biography

Dr Ian Clancy is a lecturer in the Department of Physics at the University of Limerick where he teaches students including those studying to be teachers. His research interests are in the area of computational modelling of complex systems, involving dynamic phase transitions. He has published on topics including earthquakes, electromigration, nanocomposites, inkjet printing of conductive lines for flexible circuitry, and anodic pore formation in InP.

□

Chemical Myths Exploded!



1. Slippery layers:

The lubricating properties of graphite, a 2-D layered structure, are due to the weak Van der Waal's forces between the layers, allowing them to slide over each other. Wrong! In a vacuum graphite loses its lubricating properties, which are due to air and water molecules between the layers allowing them to slide over each other. Without this adsorbed water graphite becomes gritty rather than soft. Graphite brushes on electric motors at high altitudes wear out more quickly because they are less lubricating.

2. Nascent gases:

There was a prevalent idea that freshly prepared hydrogen, e.g. from acid and zinc, was more reactive than hydrogen prepared separately. The same was thought to be true of chlorine. Many books suggested it was due to the presence of atomic hydrogen or chlorine being produced, which would of course be very reactive. It is now known that the reactions occur at the surface of the solid zinc in the case of hydrogen.

Amazingly you can find people selling nascent iodine preparations on the internet.

‘Whatever happened to the nascent state?’

William Jensen *Bull. Hist. Chem.*, 1990, 6, 26-36

<http://www.che.uc.edu/jensen/w.%20b.%20jensen/reprints/051.%20Nascent%20State%20.pdf>

3. The inert gases:

For a long time the group 18 elements were known as the inert gases because they did not seem to react with anything. This was explained by the fact that they have a full outer electron shell, which is hard to break into. Chemists had tried to make them react without success until in 1962 Neil Bartlett managed to make the first compound of an ‘inert’ gas, xenon hexafluoroplatinate, XePtF₆. This opened the floodgates and there was a gold rush of noble gas chemistry and several compounds were made of

xenon and krypton, mainly with fluorine and oxygen. Linus Pauling had predicted that xenon should form compounds in 1933 but didn't manage to make them. The group 18 elements are still unreactive, especially the lighter ones, but they are now called the noble gases not the inert gases. I'm afraid that chemists have not yet managed to make kryptonite, a fictional compound!

“It was the discovery of the remarkable oxidizing properties of platinum hexafluoride in making the salt O₂⁺PtF₆⁻ that led (via the recognition that O₂ and Xe have nearly the same first ionization potentials) to the oxidation of xenon by PtF₆.

Later in 1962, Howard H. Claassen, Henry Selig, and John G. Malm, at Argonne National Laboratory prepared XeF₄. Syntheses of XeF₂, XeF₆, XeOF₄, XeO₂F₂, XeO₃, and perxenates (XeO₆⁴⁺ salts) were quickly reported from there and elsewhere. Even the highly unstable tetrahedral tetroxide XeO₄ was made (J. L. Houston, 1964). A fluoride of krypton, prepared and correctly identified as KrF₂ (George C. Pimentel and J. J. Turner, 1963), was first reported as KrF₄ (Aristid V. Grosse and coworkers, 1963), but no compound above Kr(II) has ever been established.” Neil Bartlett (2003)

<http://pubs.acs.org/cen/80th/print/noble gases.html>
Bartlett, N. (1962). "Xenon hexafluoroplatinate Xe⁺[PtF₆]⁻". *Proceedings of the Chemical Society* (6): 218

4. Natural chemicals are different from synthetic ones:

This is a myth with a long history. It goes back to the idea of vitalism common in the 18th and 19th century, in that chemicals derived from living things were thought to be totally different from those made synthetically. In fact it was thought that you couldn't make ‘natural’ chemicals except in living systems. Wohler's synthesis of urea from inorganic chemicals put a nail in that idea but it lingers on. A pure chemical derived from natural sources is identical in all its properties to the same substance made synthetically. I stress the word pure, because often the difference, when present,

is due to impurities in the natural product. Thus brown sugar is different from white, refined sugar in that it has additional chemicals present. The idea of vitalism has been resurrected by the organic food movement so that natural is good and synthetic is bad.

5. Something can be chemical-free:

This is one of the most prevalent chemical myths of the 20th and 21st century. Nothing can be chemical-free except a perfect vacuum. Everything is made of matter and this is another name for chemicals. What is meant by chemical-free is that it is free of synthetic chemicals and additives (see myth 4). Every natural substance is a mixture of chemicals, responsible for colour, smell, taste etc. Some synthetic chemicals are toxic or carcinogenic, but then so are some natural chemicals. The most toxic substances known as natural materials.

6. There are only three states of matter:

Students are taught that there are three (and by implication only three) states of matter: gas, liquid and solid. Scientists now recognise plasma as a fourth state of matter and often colloids are also referred to as a state of matter, different from gas, solid or liquid.

Plasma (from Ancient Greek *πλάσμα*, meaning 'moldable substance') is one of [the four fundamental states of matter](#), and was first described by chemist Irving Langmuir in the 1920s.

([https://en.wikipedia.org/wiki/Plasma_\(physics\)](https://en.wikipedia.org/wiki/Plasma_(physics)))

7. Covalent bonds are weak:

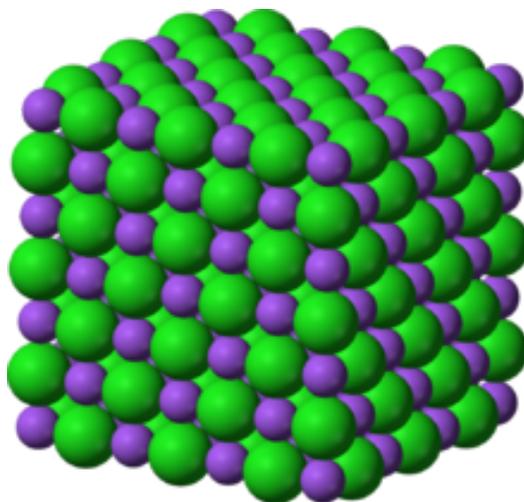
Students often think that covalent bonds are weak because organic compounds, which are covalently bonded, have low melting points and boiling points and smell. The confusion here is between the bonds that hold atoms together in a molecule (covalent bonds, intramolecular bonds, which are strong) and the bonds which hold molecules together in a solid or liquid (van der Waal's or intermolecular bonds, which are weak). Mpt and bpt tell us something about the strength of bonds holding the particles together that make up the solid or liquid. Most covalent compounds are molecule (the particles are molecules) and the bonds between them are weak. Diamond and silica (SiO₂) are solids with only covalent bonds holding the atoms together – they have high mpts and bpts.

8. Dilute acids are weak acids and conc. acids and strong acids:

This is a confusion between concentration (dilute or concentrated, measured in mol/L) and acid (or base strength) which is a measure of the degree of dissociation in solution. 1 M solutions of hydrochloric acid and ethanoic acid have the same concentration in mol/L but HCl(aq) has a lower pH (more acidic) because it ~100% dissociated in solution compared to CH₃COOH(aq), which is less dissociated and less acidic as measured by pH. However, if titrated against 1 M NaOH(aq) they will both give the same equivalence point.

9. Sodium chloride exists as NaCl molecules with strong ionic bonds:

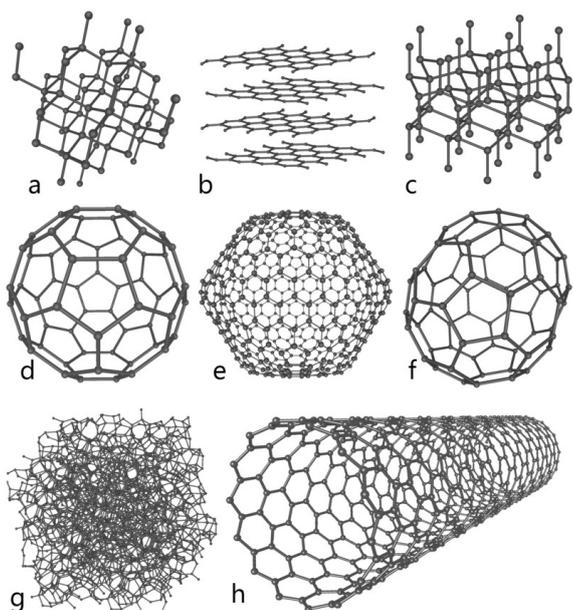
Sodium chloride solid does not contain NaCl molecules (contrary to many elementary textbooks) but rather a 3D array (lattice) of alternating sodium and chloride ions, held together by strong ionic bonds. Each sodium ion is bonded to six chloride ions and each chloride ion to six sodium ions. The smallest visible fragment of salt contains billions upon billions of ions bonded together. However, if sodium chloride is vaporised at high temperatures, the gas does contain NaCl molecules bonded covalently.



A tiny part of the 3D ionic structure of NaCl(s)

10. Carbon has two allotropes: diamond and graphite:

Where have you been since 1985 when buckminsterfullerene, molecular carbon, was discovered by accident? This means that there are at least 3 allotropes of carbon. Scientists now recognise 8 allotopes (different structural forms) of carbon.



Eight allotropes of carbon: a) diamond, b) graphite, c) lonsdaleite, d) C_{60} buckminsterfullerene, e) C_{540} , Fullerite f) C_{70} , g) amorphous carbon, and h) single-walled carbon nanotube.

Source:

https://en.wikipedia.org/wiki/Allotropes_of_carbon

Often chemical myths are the basis of chemical misconceptions – wrong ideas which are persistent and hard to eradicate.

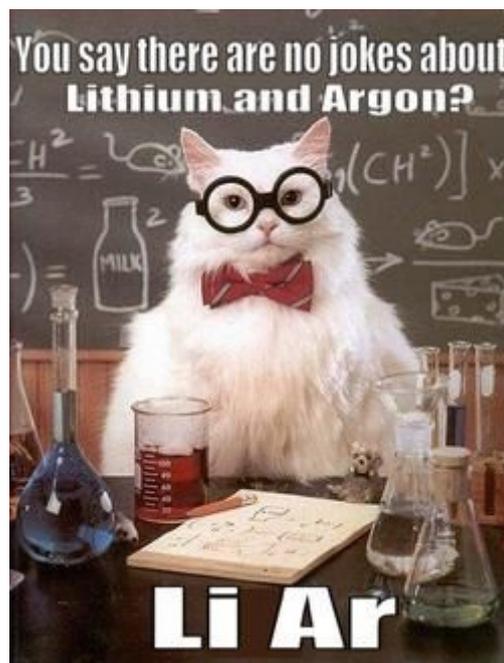
Have you any other examples of chemical myths or misconceptions that you would like to share?

For an interesting article by Mark Lorch on Five myths about the chemicals you breathe, eat and drink see:

<https://theconversation.com/five-myths-about-the-chemicals-you-breathe-eat-and-drink-26849>

Are you teaching any chemical myths?

□



Microscale chemistry #1:

“Go and try this before you go home”

Bob Worley bobworley4@gmail.com

An occasional series of microscale activities, which might stop and make you think.

Place a piece of white paper inside a transparent plastic folder and put this on a flat surface. Grab 2 plastic 1 or 3 ml pipettes and a bottle of 0.1M barium chloride or 0.1M sodium sulfate solution from the stores. Add say 2 drops of 0.1M barium chloride solution on the plastic surface followed by 2 drops of 0.1M sodium sulfate solution. Take a picture with your mobile phone. Wipe the result with a paper towel, put the solutions away, lock up and go home. Think about it.

“Have you tried it yet?”

An occasional series of microscale activities, and I have thought about it.



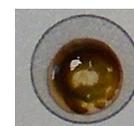
I hope you obtained something like this. The white precipitate of barium sulfate suddenly appears. The technique makes use of the hydrophobic properties of the plastic. (I prefer polypropylene.) My thoughts went to carrying out many more precipitation reactions similar in the same manner and establishing solubility rules. See the sheet I drew up. I put in some mixtures not giving a precipitate as well.

This is Rubbish

1. That method is not in the text book and the examiners would not recognise it
2. “Not using a test tube in chemistry! I have enough of them in stock anyway. Why change?”
3. Too small. Students cannot see anything and they cannot use the pipettes.
4. Phones are not allowed in school so we cannot take photographs.
5. We will get contaminated bottles if they use plastic pipettes.
6. Some were sitting down to do this. It is against laboratory rules.

Just a minute!

1. I did that procedure in a very short time. Perhaps I will not be rushed in these lessons.
2. If I plan this properly, instead of walking about, students might sit down at their own bench or table. With dropping bottles, this cannot do much harm. I could even do this in a normal room!
3. There is very little waste. Also there is no washing up of possibly over 100 test-tubes from the lesson and some of those solids are difficult to remove from glass.
4. All the observations are on one sheet of plastic and be photographed for a permanent record. This could go into the students’ laboratory book. I could even photograph it for them
5. The worksheet contains the instructions as well so there will be less of “What do I do next?”
6. The sheet could be laminated and I can use it again next year.
7. I can use expensive silver nitrate solution.
8. There is so little waste, I could see what bromides, iodides and phosphates do. I could even more hazardous materials such as lead nitrate, cobalt chloride and potassium chromates. Some students might like to take this further with more solutions in science club.
9. I can put in “non-results” and they might not be so disappointed.
10. I also saw chemistry I did not expect (See photos on the right). The green iron(II) hydroxide became brown quickly via air oxidation. The white silver chloride precipitate discoloured due to the light. The blue copper hydroxide precipitate became turned black over in 5 minutes; it must be copper(II) oxide.



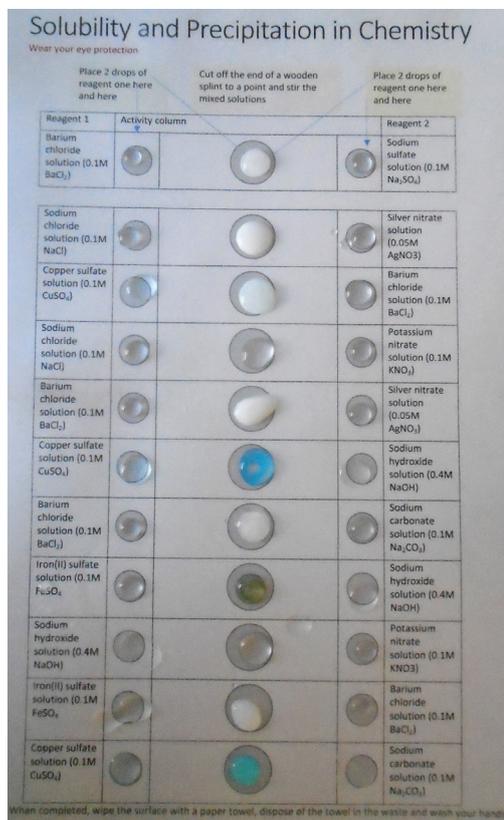
Teaching uses

Work through the first mixture with the students. There are 2 transparent solutions so those chemicals must be soluble in water. Mixing these solutions forms a white precipitate, what can it be? Is it barium sulfate or sodium chloride? However, from experience students know sodium chloride dissolves in water. So, the white solid or precipitate must be barium sulfate and this chemical is not soluble in water.

They can make a list of what is soluble and what appears insoluble in water. They can thus produce solubility rules. If you do not like my choice of solutions, well alter them! Activities are not written in stone. Be creative.

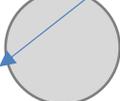
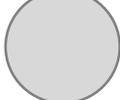
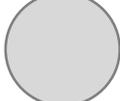
Chemicals soluble in water and used	Chemicals insoluble in water and precipitated	Dispensing	Solubility rules
Barium chloride solution (0.1M BaCl_2) Copper sulfate solution (0.1M CuSO_4) Iron(II) sulfate solution (0.1M FeSO_4) Potassium nitrate solution (0.1M KNO_3) Silver nitrate solution (0.05M AgNO_3) Sodium carbonate solution (0.1M Na_2CO_3) Sodium chloride solution (0.1M NaCl) Sodium hydroxide solution (0.4M NaOH)	Barium carbonate Barium sulfate Copper(II) carbonate Copper(II) hydroxide Iron(II) hydroxide (which air oxidises to brown Iron(III) hydroxide) Silver chloride (which discolours on exposure to light)	Dropping bottles are suitable (iron(II) sulfate does not keep though). A small test tube can be taped to the side of a bottle and the plastic transfer pipette inserted in the test tube. 	All common sodium, potassium and ammonium salts are soluble All nitrate salts are soluble Common chloride salts are soluble except those of silver and lead. Common sulfates are soluble except those of lead, barium and calcium Common oxides, hydroxides and carbonates are usually insoluble except those of the Group 1 Alkali Metals sodium, potassium etc. and ammonium.

This what the worksheet should like when finished.



Solubility and Precipitation in Chemistry

Wear your eye protection!

Reagent 1	Activity column		Reagent 2
Barium chloride solution (0.1M BaCl ₂)			Sodium sulfate solution (0.1M Na ₂ SO ₄)
Sodium chloride solution (0.1M NaCl)			Silver nitrate solution (0.05M AgNO ₃)
Copper sulfate solution (0.1M CuSO ₄)			Barium chloride solution (0.1M BaCl ₂)
Sodium chloride solution (0.1M NaCl)			Potassium nitrate solution (0.1M KNO ₃)
Barium chloride solution (0.1M BaCl ₂)			Silver nitrate solution (0.05M AgNO ₃)
Copper sulfate solution (0.1M CuSO ₄)			Sodium hydroxide solution (0.4M NaOH)
Barium chloride solution (0.1M BaCl ₂)			Sodium carbonate solution (0.1M Na ₂ CO ₃)
Iron(II) sulfate solution (0.1M FeSO ₄)			Sodium hydroxide solution (0.4M NaOH)
Sodium hydroxide solution (0.4M NaOH)			Potassium nitrate solution (0.1M KNO ₃)
Iron(II) sulfate solution (0.1M FeSO ₄)			Barium chloride solution (0.1M BaCl ₂)
Copper sulfate solution (0.1M CuSO ₄)			Sodium carbonate solution (0.1M Na ₂ CO ₃)

When completed, wipe the surface with a paper towel, dispose of the towel in the waste and wash your hands.

The WiSTEM²D programme

Cliona O'Geran

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The photos in this article were taken at the International Women's Day 2019 Team Awards Presentations for WiSTEM²D.

Johnson and Johnson, the global healthcare company, has partnered with the University of Limerick (UL) to deliver the WiSTEM²D programme at the University for the past three years. As part of the programme, research has been conducted among undergraduate students in Science, Technology, Engineering and Maths (STEM) at UL, which has revealed that almost one third are not aware of the types of jobs they could apply for once they graduate.

The findings highlight some of the central challenges in attracting more females into STEM-related careers.

Female students are much more likely to indicate a lack of knowledge over STEM career options. 58% of respondents were female, 41% male and 1% identified as non-gender binary. However, of the 29% of undergraduates that do not know what jobs to apply, 67% were female.



The gender divide became even clearer when students were asked about their exposure to the workplace, with 56% of students surveyed saying they had never visited an industry facility. Of those who had never visited an industry facility, 66% were female. In total, 33% of those surveyed said they would not be comfortable contacting a person working in industry about potential job opportunities.

In an effort to address these issues, Johnson & Johnson (J&J) has expanded the WiSTEM²D programme to include University College Cork (UCC).



The WiSTEM²D programme is part of J&J's commitment to building a diverse scientific community and accelerating the development of women leaders by supporting them at all stages of their lives. The programme in Ireland is underpinned by 13 global partnerships with

academic institutions in the US, Japan and South America.

In Ireland, a lack of female role models has been identified as a barrier to women pursuing STEM careers. The WiSTEM²D programme is unique in terms of offering young women studying STEM²D courses the opportunity to engage with women working in these careers. First-hand experience of site tours, mentoring, project and career workshops enable students to visualise exactly what it is like to have a career in STEM.

Speaking on behalf of J&J, Liz Dooley, Interim General Manager, Janssen Sciences Ireland said, *"We know that increasing female participation in STEM careers remains a global challenge. At J&J, we are committed to helping bridge the gender gap by continuing our partnership with the team here at UL and by extending the WiSTEM²D programme in Ireland with an exciting new partnership with UCC"*.

"Globally, the J&J WiSTEM²D programme focuses on increasing representation of girls and women in STEM²D fields across all life stages. This is achieved through our youth programme at primary and secondary level, and at the professional stage where identification and implementation of best practices for attracting and retaining female talent remain a top priority."

The programme co-ordinator in UCC is Kate O'Brien, College Manager College of Science, Engineering and Food Science and in UL it's Tracey O'Connell WiSTEM²D Programme Co-Ordinator, EPI•STEM, National Centre for STEM Education.

For more information on the programme contact:
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Software Development Manager, EMEA
Development Centre
Tel: +353 (0)61 232910
Email: mfinnan1@its.jnj.com

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At Johnson & Johnson, we blend heart, science and ingenuity to profoundly change the trajectory of health for humanity. We are committed to conquering today's challenges and inventing tomorrow's solutions. When women are given a

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Quotable Quotes

"Don't be afraid of hard work. Nothing worthwhile comes easily. Don't let others discourage you or tell you that you can't do it. In my day I was told women didn't go into chemistry. I saw no reason why we couldn't."

Gertrude B. Elion

(Gertrude B. Elion won the 1988 Nobel Prize in Physiology or Medicine with George H. Hitchings and Sir James Black.)

"Life is not easy for any of us. But what of that? We must have perseverance and above all confidence in ourselves. We must believe that we are gifted for something and that this thing must be attained."

Marie Curie

(Not only did she discover radioactivity, polonium and radium, but she was also the first woman to ever win a Nobel Prize and the first woman to win the award in two different fields. She won Nobel Prizes in physics and chemistry.)

Information Page

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You can contact the editor by email at: peter.childs@ul.ie or one of our assistant editors.

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www.cheminaction.com

Editorial correspondence

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Communications in writing/e-mail are preferred not phone calls!

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We have discontinued selling these modules as postage got too expensive. Some of them are available online, free of charge, at our website:

www.cheminaction.com

In the next issue:

**More on the PT to
celebrate IYPT
Microchemistry 2**

Diary

2019

ISTA Conference

12-14 April
DCU, Dublin
www.ista.ie

ESAI Conference

11-13 April
St. Angelas College, Sligo
<http://esai.ie/conference-2019/>

Irish Variety in Chemistry education

26 April
TUI, Kevin Street
Claire.mcdonnell@dit.ie

Using Education to Foster Meaningful Chemistry

Learning Gordon Research Conference
16-21 June
Lewiston, ME, USA
<https://www.grc.org/chemistry-education-research-and-practice-conference/2019/>

8th Boyle Summer School 'Superhuman'

22-23 June
Lismore, Co. Waterford
www.robertboyle.ie

Chemistry Demonstration Workshop

25-27 June
University of Limerick
Aimee.stapleton@ul.ie

Eurovariety 2019

17-19 July
Prato, Tuscany, Italy
<https://shop.monash.edu/eurovariety-in-chemistry-education-2019.html>

ChemEd 2019

21-25 July
North Central College, Naperville, USA
<https://www.chemed2019.com/>

VicePhec 2019

22-23 August
University of Bristol
Vicephec19@bristol.ac.uk

ChemEd-Ireland

19 October
DIT, Kevin Street
Claire.O'Donnell@dit.ie

2019

ASE Annual Conference

8-11 Jan.
University of Reading
<https://www.ase.org.uk/events/ase-annual-conference-2020>

If you know of any relevant conferences or events of interest to chemistry teachers, please send in details to: peter.childs@ul.ie

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National Centre for STEM Education

