Chemistry In Action!

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Designing science laboratories: the old and the new at St. Columba's College, Dublin

Contents #125

Disclaimer

Contributions on any matter of interest to second-level chemistry teachers are welcome. Normally the results of research (chemical or educational) are **not** published, except in a general form or as a review. Articles should be submitted electronically (email or disc) to **peter.childs@ul.ie** together with a printed copy.

For general information, subscription details etc. see back page.

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Editorial #125

New LC science specifications

New specifications in Biology, Chemistry and Physics have been produced for consultation (see p.12) on-line and in person and have now been released for implementation. They are being rushed out, after a gestation of almost 10 years, to meet a deadline of September 2025 for introduction in schools. This means they must be finalised by Sept. 2024 to give a year's notice to schools, teachers and publishers.

The Minister of Education, Norma Foley, has also decreed that the courses should have 40% for a research project, taking 20 hours out of 180 hours for the whole course. (For a detailed criticism of this proposal see p. **).

I was at the consultation in Athlone on Feb. 21st organised by the NCCA. The participants were drawn from a range of backgrounds, mainly teachers, and from around the country, and arranged in subject groups, with a rapporteur from the NCCA. This was a very useful exercise lasting around 3 hours of intensive discussion. There were many comments, criticisms and suggestions and the main impression for Chemistry from my table, (I can't speak for the other subjects or tables) was of a rushed job. Lots of errors, omissions, poor sequencing of topics, inadequate detail of how the Crosscutting Topics and Nature of Science were to be integrated into the course. A major omission was any discussion of the format and style of the written examination and there was a strong recommendation that sample papers must be issued at the same time as the final specifications. This has been a major problem when new courses have been introduced in the past.

There was a deadline of Feb. 23rd for people to fill in the online questionnaire or send in submissions. The most controversial aspect is the arbitrary 40% for a single element of coursework taking 20 hours (11%) versus 60% for the other 160 hours (89%). Coursework as part of external assessment is being abandoned in other countries because of the potential for cheating.

There are many problems with organising, running and marking a research-based project and 40% is far too much and downplays the taught element and written assessment. On p. ** there is a more detailed criticism of this proposal. Curriculum development projects typically fail because they don't involve teachers enough, so that teachers have ownership, and because they don't provide the extra resources needed to underpin a new approach. I fear that this is what we are seeing here: science teachers are not being listened to and their advice and concerns acted upon, and the resources for the increased practical work that the assessment will demand will not be provided to all schools, thus increasing the existing disparity of resources between schools.

If one is going to introduce a major curriculum revision, long overdue for the LC sciences, then it must be done properly, not rushed out, and adequately resourced.

On p. 12 you can see the timeline for the LC sciences curriculum revision process. The final versions were released to schools in Sept. 2024 for implementation in Sept. 2025 and the first examination is due in June 2027. You can access the new Chemistry course on the NCCA website at the link below.
Chemistry | Curriculum Online

Peter E. Childs
Hon. Editor

In this issue #125

In this issue you will find a good mix of articles. The Proceedings of ChemEd-Ireland 2023 can be found on p. 29ff. This would normally be printed in the Spring issue but this year this was a special issue on the ESTA Project. It is always difficult to get speakers to turn their talks into articles, as it's a lot of extra work. I am grateful to Johanne Brolly for her article on microchemistry (p. 30), Humphry Jones for describing how they renovated and rethought their science labs at St. Columba's (p. 33 and cover), Claire Murray for her article on bringing science to the people using crystallography (p. 36) and an article by John O'Donoghue (conference organiser) discussing the value of Chemical Education Research (p. 39).

Many Irish science teachers will remember Sr. Mercedes Desmond with affection and appreciation for her support for the ISTA (see p. 9). This year we also lost John Daly (p.11), another stalwart of the ISTA. Both of them will be greatly missed by their family and colleagues.

The new LC Biology, Chemistry and Physics syllabi (specifications) have now been released to schools and there is a discussion on the proposed 40% for a research project on p. 12 and the problems of assessing coursework. Despite many objections to such a large weighting for coursework, this has been pushed through without change. The new course on Climate Action and Sustainable Development has also been introduced on a trial basis from Sept. 2025 (p. 19), sadly missing the opportunity for a much more science-based course. This will first be trailled in 100 schools.

The annual analysis of the LC Science results can be found on p. 22.

The delayed PISA results came out in Dec. 2023 and Ireland did well in all three categories: Maths, Reading and Science (p. 26).

We started a series on Great Irish Chemists in the Autumn 2023 issue with Professor Dervilla Donnelly. This series continues p. 42, with an article on Kathleen Lonsdale by Adiran Ryder (see also p. 61). Adrian has been reminding us of some great chemists we should know but this series will focus specifically on Irish chemists.

Gypsum is an amazing mineral and an important building material (p. 48). The sulfur story continues on p. 50 with a look at hydrogen sulfide and sulfides.

Peter Davern returns with some more Quirky Elemental Facts on p. 52.

Many research chemists turn their discoveries into patents and set up spin-off companies. On p. 54 you can read how Henry Lyons became a chemical entrepreneur, turning the green gold of the oceans, seaweed, into profitable companies. Henry was Head of Science at Tralee Institute of Technology and was also active in chemical education. He was the person who first got me involved in speaking to chemistry teachers in Ireland, and remains a good friend.

Chemistry is often known as 'Stinks' because of its smells, and Chemlingo on p. 60 looks at the importance of smell in chemistry and perfumery.

PEC

Education News and Views

This section is for news and views about chemical/science education in Ireland and abroad. If you have material of interest to Irish chemistry teachers, please send it in for consideration.

Practical work and green and sustainable chemistry and the circular economy

Dr James Lovett of DCU has asked us to publicise the following project.

Do you teach chemistry at second level in Ireland? If so, we're interested in hearing from you!

Through an online, anonymous survey, we want to hear about what types of practical activities you choose and why you choose them. We'd like to know if any of these relate to green and sustainable chemistry or the circular economy. We want to learn about supports you'd like to be available to further enhance your teaching of practical activities.

If you are interested, please scan the QR code or vist this link (https://bit.ly/gschemsurvey)

This project has received funds from the International Union of Pure and Applied Chemistry (IUPAC). The gathering of Irish data has received ethical approval from DCU (DCUREC/2024/011).

Conferences and workshops

ChemDemo Workshop 6/4/24

Department of Chemical Sciences, University of Limerick

Dr Peter Davern organised a short chemistry demonstration workshop at the University of Limerick on Saturday April 6th. The photo shows the participants in front of the new interactive Periodic Table in the Chemistry Department at UL. This course was a follow-up to the residential ChemDemo workshops run at UL for several years up to the pandemic. If you are interested in attending future courses contact Dr Peter Davern at peter.davern@ul.ie .

In this hands-on, interactive Saturday morning workshop, you will:

- learn how to perform a selection of interesting chemistry demonstrations for your students and how to align these demonstrations with the learning outcomes of the Junior and Senior Cycle courses
- receive a 'goodie bag' of selected props and chemicals, and softcopies of the demonstration procedures, risk assessments, etc. to help you perform the demonstrations back at school
- get a 'guided tour' of the UL Dept. of Chemical Sciences' large-scale, interactive periodic table display.

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13th BASF Summer School for Chemistry Teachers

Wednesday June 19th

Eureka Centre, UCC

The participants are shown above and the programme for the day is given below.
Congratulations to Dr Declan Kennedy and his team and the sponsors for another successful workshop. These Summer Schools have been running since 2012 with sponsorship from BASF Ireland.
The programme for the day is given below.

Oide Tacú leis an bhFoghlaim Ghairmiúil i measc Ceannairí Scoile agus Múinteoirí
Supporting the Professional Learning of School Leaders and Teachers

13th Annual BASF / Oide Chemistry Summer School

Eureka Centre, Kane Building, University College Cork.
Wednesday 19th June 2024.

BASF We create chemistry

This summer school involves a partnership between BASF, Oide, UCC, RSC and the Cork branch of the ISTA. The aim of the summer school is to give teachers of Chemistry the opportunity to enhance their knowledge and understanding of key areas of the current Leaving Certificate Chemistry syllabus, enhance laboratory practical skills and engage with teaching, learning and assessment ideas for Leaving Certificate and Transition Year Chemistry.

Progamme	
09:00 - 09:30	Registration. Tea / Coffee in Room G2 Kane Building, UCC
09:30 - 10:15	Teaching and learning approaches to patterns of students responses to the Leaving Certificate Chemistry assessment in the classroom context.– Pat Walsh, De La Salle College, Macroom, Co. Cork
10:15 - 11:00	The use of Artificial Intelligence in teaching Chemistry – Stephen Murphy, Gaelcholáiste Mhuire, An Mhainistir Thuaidh, Cork.
11:00 - 11:15	Tea / Coffee
11:15 - 12:00	My approach to teaching students how to solve volumetric problems– Dr Ryan Gallagher, School of Education, UCC
12:00 - 13:00	Laboratory practical workshop on Leaving Certificate Chemistry Mandatory Student Experiments and Transition Year Chemistry. Dr Declan Kennedy, Dr Ryan Gallagher.
13:00 - 14:00	Lunch in UCC staff dining room
14:15 - 15:00	*Developing the skills and scientific literacy of students via Laboratory Practical Work: the experience in the UK*. Dr Robert Campbell, St Mary's University, Twickenham, London.
15:00 - 16:00	Teaching and learning through the prism of Johnstone's triangle: equilibria and gas law calculations – Oide Chemistry Team
16:00	Raffle for Molymod kits

To register for a place on this event please click:
https://oide.ie/apply-book-now/teachers/
For further details email sean.arthur@oide.ie

SCAN ME

UCC Coláiste na hOllscoile Corcaigh, Éire University College Cork, Ireland
ista
ROYAL SOCIETY OF CHEMISTRY

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10th SMEC 2024

St Patrick's College, DCU
June 13-14th
"Beyond Boundaries – Future-proofing Science, Maths, Technology and Engineering Education"
The schedule and book of abstracts can be accessed below and a book of Proceedings is in preparation.
Schedule – SMEC (castel.ie)

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9th European Chemistry Congress 2024

7-11 July saw Dublin welcome the largest chemistry conference in Europe, the European Chemistry Congress sponsored by EuChemS and organised successfully by the Institute of Chemistry of Ireland. Previous conferences have been held in Budapest, Turin, Nuremberg, Prague, Istanbul, Seville, Liverpool and Lisbon.

It was held in the Dublin Conference Centre, which proved to be an ideal venue with everything happening in one location. There were 8 programme strands of which one on **Education, History, Cultural Heritage, and Ethics in Chemistry**
Contained papers on the history of Chemistry and on Chemical Education. For the first time one of the plenary lectures was in the area of the history of chemistry.
You can read highlights of the conference at Highlights of ECC9: Europe's Premier Chemistry Congress in Dublin 2024 - ChemistryViews

The 10th EuChemS Chemistry Congress (ECC10) will be hosted by the Royal Flemish Chemical Society (KVCV) and will be held in Antwerp, Belgium, from July 12 to 16, 2026.

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Diary

2024

43rd ChemEd-Ireland 2024
Saturday October 19th
University College Cork
The theme for this year's conference in 'Preparing for the new Leaving Certificate Chemistry Curriculum. Registration will be available via the ISTA website.
d.kennedy@ucc.ie

Future ChemEd-Ireland venues
Since the 26th conference the venue has alternated between the West and East coasts.
2025 44th TU Dublin (Grangegorman)
2026 45th UL
2027 46th DCU
2028 47th TUS-Limerick

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2025

2025 ASE Annual Conference at the University of Nottingham
9 - 11 January
2025 ASE Annual Conference at the University of Nottingham | www.ase.org.uk

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ISTA Conference
4-5 April 2025
Maynooth University

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Chemistry Education Research and Practice
Gordon Research Conference
Exploring Interactions in the Chemistry Curriculum in Physical and Digital Spaces
July 6 - 11, 2025
2025 Chemistry Education Research and Practice Conference GRC

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ChemEd2025
20-24 July 2025
Colorado School of Mines,
Golden, Colorado, USA
Learn.mines.edu/chemd2025

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ESERA 2025
25-29 August
Embracing Transitions in Science Education
Copenhagen, Denmark
Conference 2025 - ESERA

We warmly invite you to the ESERA Conference 2025, which will be held from August 25th to 29th in the vibrant city of Copenhagen, Denmark. Under the theme Transitions in Science Education: Sustainability and Digital Advances, we wish to stimulate fruitful conversations and big ideas within and beyond our community.

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2026

8th ICASE WORLD CONFERENCE ON SCIENCE AND TECHNOLOGY EDUCATION,

22-25 June 2026
Cork, UCC

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28th ICCE/17th ECRICE
13-17 July 2026
Erzurum, Turkiye

28th IUPAC International Conference on Chemistry Education & 17th EuChemS European Conference of Research in Chemical Education (ICCECRICE 2026) – July 13-17, 2026 / Erzurum, Türkiye

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Sr Mercedes Desmond (1922 - 2023)

Sr Mercedes Desmond was an important figure in Irish science education for many decades and especially for the Cork branch. The Irish science teaching community was saddened to hear of her death at 100, and CinA! is pleased to be able to print this appreciation, which first appeared in the ISTA's Science magazine.

Sr Mercedes Desmond 1922-2023

Sr Mercedes Desmond was born in Donoughmore, Co. Cork in 1922 and received her secondary education at the Presentation Convent school in Thurles. She sat her Leaving Certificate in 1941 and entered the Mercy Convent in St. Maries of the Isle, Cork in 1942. Although she had never studied science at secondary school, she enrolled as a student in UCC to study Physics as her main subject. She also studied Mathematics and Chemistry and in 1948 she graduated with a B.Sc. degree and subsequently a H.Dip in Ed.

In 1949 Sr Mercedes was assigned to St. Aloysius School, Sharman Crawford Street, Cork where she taught Physics, Chemistry and Mathematics throughout her teaching career. In 1962, along with a small group of other science teachers, she played a key role in founding the Cork branch of the Irish Science Teachers' Association. St Aloysius School became the home of the Cork Branch of the ISTA and for over 40 years, Sr Mercedes would personally open the school for the monthly meetings of the ISTA and would welcome teachers with tea, coffee and delicious baking.

Sr Mercedes immersed herself in science education both at local and national level. She participated in and organised numerous continuing professional development courses for science teachers ranging from glass blowing to electronics to ecology field trips to astronomy. Since the founding of the ISTA she served at all levels of the ISTA, represented the Cork branch on the Council of the ISTA and represented the ISTA at conferences at home and abroad.

Sr Mercedes was appointed principal of St Aloysius school in 1978 and during her term as principal, enrolment in the school rose to 1200 students making it the largest girls' secondary school in Ireland at the time.

In 1995 Sr Mercedes was the recipient of the Science Educator of the Year Award from the ISTA and in 2006 was conferred with an honorary Master's in Science Education degree by UCC. In recognition of her enormous contribution to science education,

she was conferred with an honorary doctorate in 2015 by UCC as part of the 200th anniversary celebrations of the birth of George Boole, the first professor of Mathematics in UCC. In the encomium read out at her conferring, it was pointed out that in conferring this honorary degree on Sr Mercedes, UCC was also honouring all those religious women in Ireland throughout the decades who not only provided excellent educational opportunities for girls, but who, like Sr Mercedes, were outstanding role models and exemplars of female leadership.

Receiving an honorary doctorate from UCC in 2020 with Áine Hyland, Declan Kennedy and Mary Mullaghy

In her acceptance speech Sr Mercedes said that she was deeply honoured and humbled to be conferred with this Honorary Doctorate and although she was 93 years of age she felt very young as she was still less than half the age of George Boole whose birthday was being celebrated on that day! She recalled that George Boole's chosen profession was that of a secondary school teacher in Lincoln, He was a gifted teacher of Mathematics and Science and she accepted this doctorate on behalf of all the members of the Irish Science Teachers' Association and on behalf of the Sisters of Mercy. Interestingly, she pointed out that the Mercy University Hospital was established in 1851 and these Mercy Sisters lived next door to George Boole in Grenville Place where he wrote his famous book *"An Investigation of the Laws of Thought"*, which was published in 1854. Even at the age of 93, Sr Mercedes had her homework done!

Sr Mercedes had a wonderful sense of humour. When asked why she chose Physics as a subject in which to specialise at UCC, she described the day that she went to UCC to register as a student. The Registrar addressed the young students and told them that those who wished to study Botany should join the queue on the right and those who wished to study Physics should join the queue on the right. *"All the ladies in the room joined the Botany line and all the men in the room joined the Physics line - so I followed the men!"* explained Sr Mercedes, with a twinkle in her eye. Indeed, it was always clear at ISTA meetings and conferences that Sr Mercedes loved the company of men!

Sr. Mercedes was a woman of phenomenal wisdom, intelligence, experience, and achievement. The common thread weaving through the tapestry of Sr. Mercedes' life, achievements, and the accolades she received, was her humility. She was one of the humblest people one could ever meet. Sr. Mercedes was also a very gentle, kind, compassionate and thoughtful person. She put others and their needs before herself. She was a people's person. The person, where it was a student, parent, teacher, or interviewee, was always at the centre. Her focus was always on the person, to bring out the best in her or him. She had a deep respect for everyone. She was the type of person that having met her you got the feeling you had been in the presence of someone very special. She radiated not only warmth but also genuineness because she was a most sincere person.

Celebrating her 100th birthday with Declan Kennedy

In the homily preached at her funeral Mass, it was pointed out that religious life is about many things, but at the end of the day it is about witness. Words are important but no human word reaches the depths to which real witness goes. Sr. Mercedes gave great witness by her way of life – the simplicity of her lifestyle, her willingness to give of herself and her time to and for others, and her faithfulness to God and prayer. From the moment she entered the Sisters of Mercy, she sought with singlemindedness, commitment and dedication to live the charism and mission of the congregation and to follow in the footsteps of Catherine McAuley.

Sr Mercedes celebrated her 100th birthday on 14th May 2022 surrounded by her relatives, ISTA friends and fellow Sisters of Mercy. She went to her eternal reward on 12th May 2023 just three days short of her 101st birthday. Sr Mercedes, we remember you with great warmth of affection and love. The ISTA extends its deepest sympathy to her family, relatives and to the Sisters of Mercy community. *Ar dheis Dé go raibh a hanam dílis.*

□

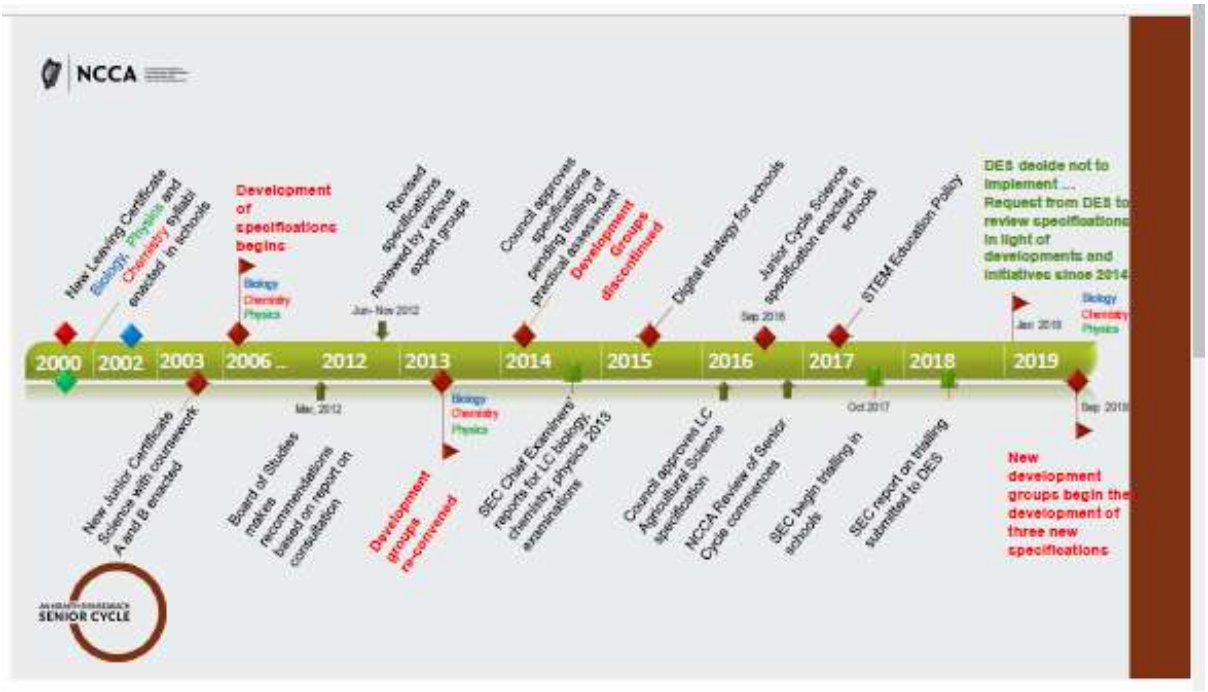
John Daly RIP

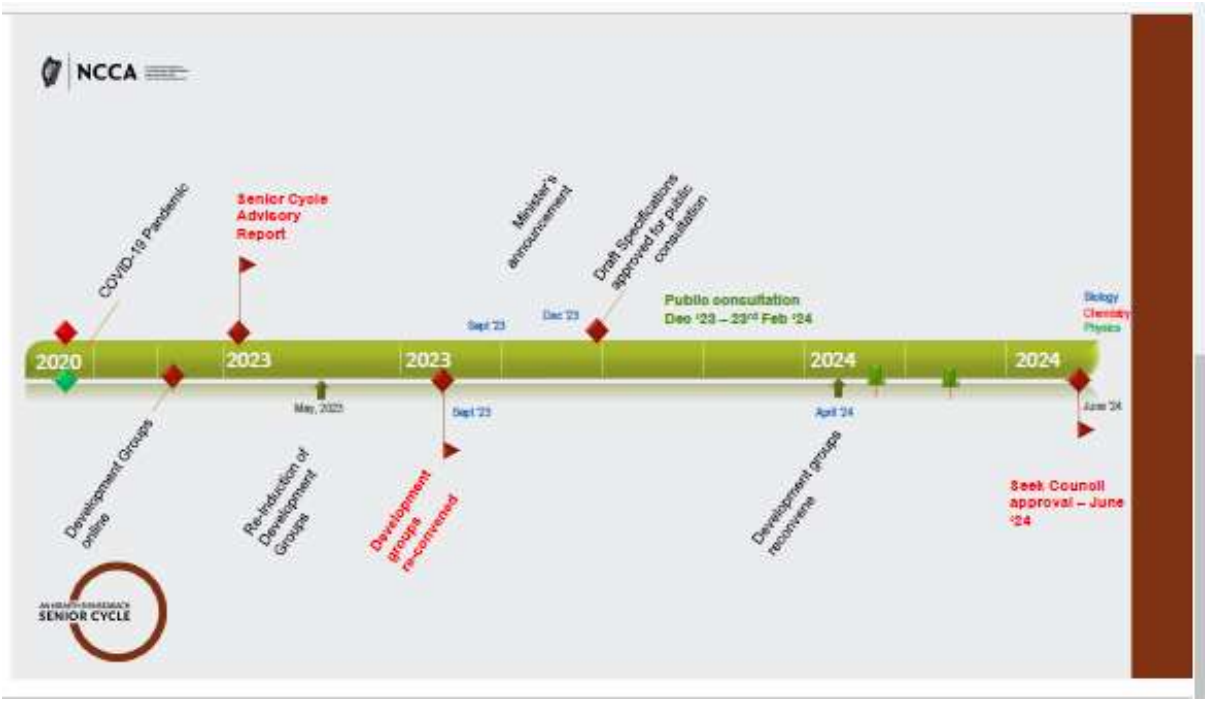
Dear Colleagues,
With great sadness, I report the passing of our dear friend and colleague, John Daly in June 2024.
John was a stalwart member of the ISTA, acting as an officer at a local level in the Dublin Branch and at the National level, being a former Chairperson & Chemistry convenor. John taught Chemistry at Blackrock College where he inspired generations. He received the ISTA Science Educator of the Year Award in 2002 and the prestigious Lodge Award this year at the ISTA conference in Waterford.
He will be greatly missed by the science community in Ireland, and his many friends.
We express our sincere condolences to his wife Deirdre and his family.
Ar dheis Dé go raibh a anam dilís.
Is mise le meas,
Mary Mullaghy

□

The revised LC Chemistry specification

The NCCA have helpfully provided a timeline from 2000 to 2024 for the revision of the LC sciences. These were published in September 2024 for implementation in September 2025, for examination in June 2027.





The timetable for the current consultation is as follows, for all the LC sciences – Biology, Chemistry and Physics. A new LC Agricultural Science has already been revised and implemented.

Problems with allocating 40% to a research project in LC science

Peter E. Childs peter.childs@ul.ie

(This is an expansion of a letter in the *Irish Times* on 24th Feb. 2024 Plans for Leaving science projects – The Irish Times). I would like to support and echo the concerns of Richard Fox (Letters, *Irish Times* 16/12/23) regarding the decision of the NCCA to recommend that 40% of the marks of the revised Leaving Certificate Biology, Chemistry and Physics courses should be awarded for a single research project, to take 20 hours of teaching time. I have several concerns regarding the revised courses. These LC science subjects were last changed in 2000/2002 and the process of revision was started over 20 years ago. The new specifications (the term syllabus was considered outmoded) attracted serious criticism of for their over-reliance on learning outcomes, rather than a detailed specification of syllabus content and depth of treatment. The Irish Science Teachers Association (ISTA) commissioned the Hyland Report (2014) which showed that this approach was not defensible on academic grounds and was out of step with international best practice. The NCCA seemed deaf to the case made by science teachers, the people with the experience and expertise in teaching science, who are the people responsible for implementing new curricula. The new Agricultural Science course went ahead using this new model based on learning outcomes, over the objections of teachers before, during and after its implementation. Failure to specify course content properly means that every teacher must interpret the curriculum themselves, not knowing what the examiners will expect. This means a lack of consistency and objectivity in defining what should be taught and examined on a high-stake examination. The same flawed approach is in danger of being applied to the other LC science subjects, despite the valid objections of science teachers and other vested interests. What was needed was minor revision and updating of the existing courses, rather than a wholesale revision and change of educational philosophy. The proposed specifications are a great improvement in specifying what has to be covered, at ordinary and higher level, alongside learning outcomes. Learning outcomes alone do not define a curriculum adequately and it is important that the detail of what is taught not be left to the individual teacher, or the textbook writers or even to the exam setters. There also needs to be room for innovation within the specification but the core content of what is examinable must be unambiguous to both teachers and students.

The idea of a substantial element of assessed coursework is a laudable idea but again one that has not proved successful or fair or workable in other countries. Other countries have rejected coursework, either all or in part, and returned to a reliance on an external, objective final examination.
It could also be argued that 40% is too much, and especially for a single assessment element, like a research project, taking only 11% of the course time. At the very least the percentage should be less (no more than 20%) and other items of coursework included, to provide a more balance and diverse assessment.

However, there are also problems with assessing research projects. I have taught chemistry at third level for 40 years and supervised and examined undergraduate research projects for over 30 years. Such projects are notoriously difficult to examine objectively and reliably. There are too many variables (student ability, research topic, access to resources, quality of supervision etc.) to assign reliable numerical marks.

This is why most research reports or theses are broadly graded: as pass/fail or distinction/merit/pass/fail.

As well as reliable assessment there are other problems with introducing a research project into all the LC science courses.
Firstly, the large numbers involved across all three sciences (51,878 in 2023), with the heavy demand it would place on teachers, facilities and resources in schools, and on individual students, who might be doing up to three such projects simultaneously in their final year.
Secondly, the Achilles' heel of all coursework is the problem of authenticity: the danger of other people contributing to the student's work, especially parents, or indeed the use of AI in future. The assessment will be based mainly, I imagine, on the final research report and it will be hard to guarantee that it is the student's own work. Marking nearly 52,000 reports will be a logistical challenge, needing large numbers of experienced examiners.
Thirdly, and perhaps more seriously, implementing this proposal presupposes a level playing field in schools – regarding laboratories, equipment and resources for undertaking these research projects. There is not equal or adequate provision now, if we consider private fee-paying schools at one end and DEIS schools at the other end of a provision spectrum. The vast majority of schools have no science technicians, are short of laboratory space and have inadequate resources, and introducing this scheme for all the main LC sciences would seriously overload the system and compromise the integrity of the assessment. The quality and integrity of the STEM subjects at Leaving Certificate level is important for students, parents, teachers, academics, and employers in business and industry. It is important to listen to their concerns and ensure that consultations are real, and responses are listened to by the NCCA and the subject development groups. Arguably the most important voices in this debate are those of the STEM teachers who will implement any new curricula. New curricula often fail because the curriculum developers don't listen to the teachers and fail to provide the resources needed for proper implementation.

If 40% are to be allocated to externally marked coursework, then it should be allocated to more than one item (a research project) and thus be allocated more time in the specification. I would suggest that 20% be allocated to the research project (still out of line with the teaching allocation) and the other 20% used for other coursework activities, perhaps two items worth 10% each and taking up to 10 hours each. These would be mainly literature-based, rather than putting extra demand on laboratories, equipment and practical resources. For example, an item could be a report on a science-based local industry, explain how science is used. Or it could be an assessment of sustainability in an everyday product or activity. All coursework materials would have to be checked externally for plagiarism or use of AI. Explicit guidelines would need to be given to teachers and students regarding the use of sources, referencing, plagiarism etc.

Knowledge versus skills; content versus process – a fallacious dilemma

Back in 2010, Scotland introduced a new curriculum - the Curriculum for Excellence. The Curriculum for Excellence explicitly reduced the content knowledge in the curriculum, and organised the curriculum around a set of content-free skills statements like: "Using what I know about the features of different types of texts, I can find, select and sort information from a variety of sources and use this for different purposes."
Yesterday, the Sunday Times had a long article on the curriculum's performance so far. It does not make for great reading. They quote parents unhappy with low standards and teachers unhappy with vague and unhelpful documentation. Most remarkably,

they quote one of the architects of the curriculum, Keir Bloomer, accepting that the curriculum may have gone too far in reducing its emphasis on knowledge.
"The problem is we did not make sufficiently clear that skills are the accumulation of knowledge. Without knowledge there can be no skills."
The skills-knowledge debate is one of the perennial educational debates in many countries. If, after more than a decade, this flagship skills-based curriculum is not working out, then that is of relevance for educators globally and is worth exploring further.
Daisy Christodoulou
Skills vs knowledge, 13 years on - by Daisy Christodoulou (nomoremarking.com)

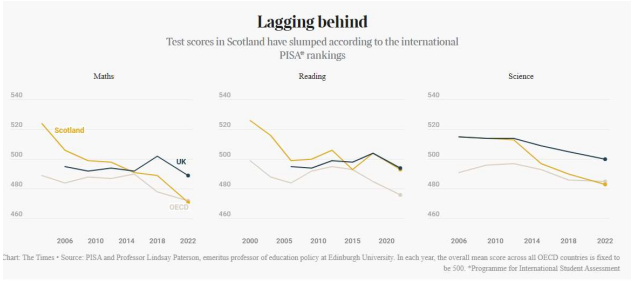
There has long between a debate between educationalists and subject teachers about the value of subject knowledge (content) versus skills (process). No academics think that knowledge in their subject is unimportant or less important than skills. The recent PISA results have shown that countries which adopted vague learning outcomes and promoted skills over knowledge, have performed poorly. In the UK this debate has been focused on Scotland's performance versus England and Wales. The extract above references this debate. We are in danger in Ireland of repeating these progressive mistakes and abandoning a clear specification of the knowledge and depth required by students in favour of vague learning outcomes, and an over emphasis on intellectual skills. I am in favour of learning important skills, like creativity and critical thinking and communication, **alongside** knowledge and **through** the subject content. Without a firm basis of knowledge there is nothing for skills to operate on. The PISA assessments provide an objective test of each country's performance in Reading, Maths and Science, going back several years now.

"The problem is we did not make sufficiently clear that skills are the accumulation of knowledge. Without knowledge there can be no skills." Keir Bloomer
The headline problems have been well-rehearsed. Scottish attainment has fallen strongly in the past decade. In mathematics, the fall was by 27 points, in reading by 13, and in science by 30. Expressed as the loss of years of schooling, the OECD estimates that these are approximately equivalent to respectively 1.4, 0.7 and 1.5.
The Scottish changes were all greater than in England, which had losses of around 0.2 years in mathematics and reading and 0.7 years in science. Moreover, a large part of this loss in England has occurred since 2018, and so is plausibly attributable to the disruption caused by Covid. In Scotland, by contrast, the decline has been persistent over the decade.
The Scottish decline in mathematics and science was much the same for male and female students, but in reading it was twice as great for females (0.9 of a year) than for males. This contrast in reading was similar in Wales and Northern Ireland. But in England, the sex contrast was much less pronounced, mainly because, since 2012 (or even earlier), boys' reading has been improving faster than girls'.
In two other respects, the loss in Scotland from 2012 was greater in lower-attaining than in higher-attaining groups. For example, among pupils at the lowest 10% of attainment in reading, there was a fall over the decade of the equivalent of 1.7 years of schooling, whereas the highest 90% showed a gain of half a year. In mathematics, the contrast was between losses: 1.8 years in the lowest 10%, and 0.8 in the highest. In science, the losses were 2.4 years and 0.7 years.
Lindsay Paterson
Lost opportunities to last a lifetime 1 - Sceptical Scot

Curriculum for excellence – or inequality?

Explanations are inevitably speculative, but a plausible candidate is Curriculum for Excellence. It has been in place across the whole of Scotland since 2010. Its main theme has been skills and well-being, rather than systematic knowledge. Abundant research from many countries (including England) shows that a curriculum of that kind tends to disadvantage students who are weaker academically. It also disadvantages students from low-status social groups because they are less likely to acquire systematic knowledge from home, partly because their parents are less likely to have advanced education themselves, but mainly because they cannot afford the experiences and equipment that only well-funded schools with well-educated teachers can provide.
Lindsay Paterson
https://www.dailymail.co.uk/news/article-12829679/LINDSAY-PATERSON-16-years-botched-SNP-reform-ruined-education-envy-world.html

Scottish attainment fell from early in the century to the middle of the first decade, stabilised for a few years, and then, from 2012, started a steady decline which was unmitigated except for a brief rise in reading in 2018 (which was wiped out by the 2022 fall).
As a result, over the whole decade from 2012 to 2022, the Scottish decline was equivalent to about 16 months of schooling in mathematics, eight months in reading and 18 months in science.
That decline started to become noticeable at the moment when the new Curriculum for Excellence began to impact on children's learning after its implementation from 2010.
One of the main criticisms of the CfE is that it neglects knowledge of the kind that students can obtain only from expert teachers – in effect, it was a kind of dumbing-down.
No long-term change can be achieved without an overhaul of the CfE, but it is only part of the problem – albeit a highly significant one.



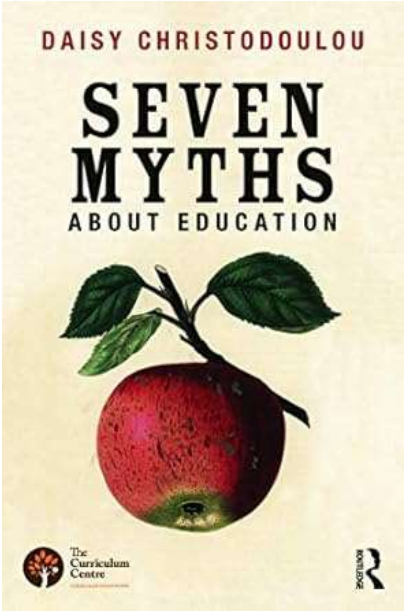
Lindsay Paterson, emeritus professor of education policy at Edinburgh University, and John Jerrim (UCL) both pointed to the introduction of the "curriculum for excellence" in Scotland — which focuses on teaching pupils to think for themselves more than imparting knowledge — as one of the key issues.
Paterson also noted there had been a large focus on wellbeing over learning. He said: "The amount of wellbeing instead of grounding in basic functions you see in Scotland is now showing in these catastrophic Pisa results."
Pisa analysts consider a 20-point decrease to be equivalent to missing one year of teaching. The latest results, from tests sat by 15-year-olds at sample schools in 2022, show a 35-point drop in maths in Scotland since 2006 and a 32-point drop in science. Paterson said this compared to missing 21 months and about 18 months of teaching respectively.
The Times Scotland's failings revealed in first Pisa scores since pandemic (thetimes.co.uk)

Scottish Schools have tumbled from top of the class
Sonia Sodha
The Observer 10/12/23
https://www.theguardian.com/commentisfree/2023/dec/10/scottish-schools-have-tumbled-from-top-of-the-class-this-is-what-went-wrong
Pupils became unwitting guinea pigs of faddish, unproven theories – and paid a high price.
Some experts lay the blame squarely on Scotland's curriculum reform. In 2010, the SNP, with the support of other parties,

introduced the "Curriculum for Excellence". It downgraded the status of knowledge and adopted a competence-based approach, emphasising the development of transferable skills and interdisciplinary learning.
This is in line with a growing movement in western education that discipline-based knowledge is becoming outdated in a world of Google and artificial intelligence, and that we would be better off focusing on skills children can one day apply to jobs that don't even exist yet. It's a theory with considerable traction. But the problem is that it is only that: a theory, based on zero evidence.
And it is one associated with declining educational standards where it has been adopted. "Scotland appears to be entering the same serious crisis of education as Sweden in the mid-1990s," Tim Oates, of Cambridge Assessment, tells me. That's significant, because Sweden, like Scotland, adopted a competency-based curriculum back then, paving the way for long-term decline in its international performance. Other places that have suffered falling standards and rising inequality after adopting a competency-based curriculum include France and the Canadian province of Quebec.
These kinds of curriculums are based on an entirely false but faddish dichotomy between knowledge and skills. As Daisy Christodolou sets out in her seminal book on knowledge in education, fact-based learning cannot be separated from understanding; being able to engage with facts is the key to conceptual understanding in disciplines such as maths, science and reading. Of course, we want the school system to produce independent learners with transferable skills; but that does not mean the best way to do this is to emulate real-world problems in schools.

These comments on the experiences in other countries of reducing the emphasis on content mastery should sound a warning bell for Ireland. It sounds to me as though Ireland, through the NCCA, is going down this same road with the wrong emphases in the proposed new curricula: an emphasis on skills rather than knowledge; an emphasis on well-being over subject mastery; a specification that is competence-based rather than content-based. In a previous article I have discussed how we can integrate 21 century skills into the teaching of science, without compromising the content.
('Teaching 21st century science with 21st century skills', Peter E. Childs, *Chemistry in Action!*, #121, Spring 2023, 11-22)

Facts are not opposed to understanding; they enable understanding. This is because of the way that our minds work. Our long-term memories are capable of storing a great deal of information whereas our working memories are limited. Therefore, it is very important that we do commit facts to long-term memory, as this allows us to 'cheat' the limitations of working memory. The facts we've committed to memory help us to understand the world and to solve problems.
Daisy Christodoulou



In the book *Seven Myths about Education* (published 2014) Daisy examines seven widely-held beliefs in education, which she believes are holding back pupils and teachers:

- *Facts prevent understanding*
- *Teacher-led instruction is passive*
- *The 21st century fundamentally changes everything*
- *You can always just look it up*
- *We should teach transferable skills*
- *Projects and activities are the best way to learn*
- *Teaching knowledge is indoctrination*

"For the past century, our schools of education have obsessed over critical thinking skills, projects, cooperative learning, experiential learning, and so on. But they have paid precious little attention to the disciplinary knowledge that young people need to make sense of the world. This deeply ingrained suspicion - hostility, even - towards subject matter is the single most significant reason for the failure of the standards movement in American education over the past generation.
We should have been educating future teachers to study their subject or subjects in depth. We should have paid attention to what Lee Shulman, educational psychologist and professor emeritus at Stanford, calls "pedagogical content knowledge." We should have been helping teachers determine ways to light up young minds and to generate excitement about historical imagination or scientific discovery."
Ravitch, D., (2015), *21st Century Skills: An Old Familiar Song.* Available at: https://www.commoncore.org/maps/documents/reports/diane.pdf Accessed 21/1/2015
It is not a case of either/or between content and skills in teaching science: this is a false and fallacious conflict. Our emphasis should be on both/and; in integrating the teaching of relevant skills (which in science includes practical, laboratory skills) into the teaching of science content. This will equip our students for the 21st century, where knowledge and skills are both valued and become resources our students can draw on.
"The truth is that skills are based entirely on knowledge; they are the appropriate demonstration of knowledge. There is no false dichotomy here. There is no 'skills or knowledge'. Skills are knowledge in context. Many abilities are called skills, such as analysis, creative thinking and so on, but these faculties are nothing without knowledge."
Tom Bennett (2014) 'Knowledge v skills: The debate at the heart of teaching'. *TES* 10/1/14 26-30

□

New LC courses released to schools

The revised Biology, Chemistry and Physics specifications, and the new Climate Action and Sustainable Development course, have now been released. You can access the chemistry one at Chemistry | Curriculum Online

As well as the other Sciences on the NCCA website. Curriculum | Curriculum Online

This year's ChemEd-Ireland conference in UCC on Saturday October 19th will look at the new specification.

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LC Consultation on the new LC subject: Climate Action and Sustainable Development

One of the new LC subjects which is now open for consultation is on Climate Action and Sustainable Development. Climate Action and Sustainable Development | NCCA
As part of the broader reform of Senior Cycle, it is envisaged that a new specification for Climate Action and Sustainable Development will be introduced into schools on a phased basis from September 2025. The Development Group for Leaving Certificate Climate Action and Sustainable Development will have a key role in this work. The Group will include nominees of the education partners, the Department of Education and other key education agencies.

The consultation period runs from Friday 2nd of February until 5th of April 2024 with a meeting in Limerick on March 13th.
The plan for this new course is that it will be trialled first in a number of pilot schools, which is a welcome development.
The draft syllabus is available at:
lc-climate-action-sustainable-development-draft-specification-2024.pdf (ncca.ie)

Strands of study and learning outcomes

The Leaving Certificate Climate Action & Sustainable Development specification sets out the knowledge, skills, values and dispositions for students in four strands - Earth & Planet; People, Power & Place; Global Connections; and the Applied Learning Tasks strand (see figure).

Overview of the strands

The specification emphasises a non-linear, integrated approach to learning across the strands. The learning outcomes in the strands Earth & Planet; People, Power & Place; and Global Connections identify the core concepts, principles and theories through which students learn about and experience meaningful action. The Applied Learning Tasks strand identifies four tasks through which students engage with contemporary issues as they learn about and through action, integrating and applying their learning across the specification. These tasks act as lenses through which students experience some of the learning in the first three strands.

This Leaving Certificate Climate Action & Sustainable Development specification is designed for a minimum of 180 hours of class contact time.

The introduction to each of the strands is given below.

Strand 1: Earth & Planet

In this strand, students learn that a healthy environment is vital to sustainability, and interrogate the evidence of environmental damage and loss caused by human influence on natural systems. In emphasising the complexity of sustainability challenges, this strand builds students' knowledge of climate science and environmental systems. Through considering up to date scientific evidence and models, students explore the causes and effects of environmental change and develop understanding of ways in which those changes can be measured. This will provide students with a scientific basis to justify and evaluate their actions. As they learn about the Earth system, students recognise that the environment has limits and appreciate the risk of damage once pushed beyond certain thresholds. Through their learning across this and all strands, they develop an understanding that environmental balance is interconnected with everything - from our history to our futures, our locality, and at all levels of decision making.

Strand 2: People, Power, & Place

In this strand, students have an opportunity to explore our place in climate action and sustainable development and the constantly evolving relationship between people and place.

Place, in this instance, refers to students' school, local community and country. It also reflects the identity and values of individuals and groups both locally and nationally, including political values. As students explore concepts such as community, decision making, energy usage and root causes of environmental change, they take time to reflect upon their own identity and values. They consider values demonstrated through the actions of individuals and groups in their school, their locality and across Ireland, and appreciate the power of community in instilling a spirit of sustainability through collective endeavour.

Strand 3: Global Connections

In this strand, students explore global thinking and actions. They situate their experiences of climate action and sustainable development in broader issues of decision making and power as evidenced through governance, economic forces and global inequality. They explore climate justice in the context of transnational efforts to address climate loss, damage, and ecological debt. Through engaging with real world examples, they build knowledge of the role of technology and innovation in imagining alternative futures.

Strand 4: Applied Learning Tasks

As far as is practicable, students need opportunities to apply their learning in Leaving Certificate Climate Action & Sustainable Development through action for a just and sustainable world. The Applied Learning Tasks strand emphasises the importance of students developing the competencies to think and act sustainably. Over the two years of study, students engage in four Applied Learning Tasks carried out in small groups. Students plan, design, and carry out tasks which they deem personally relevant to them or their peers, their local community, or to society more broadly. The four Applied Learning Tasks allow students to collaboratively engage with the core concepts of the subject in authentic situations. They are a lens through which students can experience some of the learning from across the strands. The learning outcomes from the first three strands are interwoven and to complete their Applied Learning Tasks students will

• consider issues from multiple perspectives
• recognise the interconnectedness between local and global
• make informed decisions based on evidence
• consider interdisciplinary approaches to solve problems and generate solutions.

Students document, reflect and share their learning from each Applied Learning Task. The knowledge, skills, values and dispositions students develop through completing the Applied Learning Tasks will help inform their learning throughout the subject. Teachers will assess and provide feedback on student learning as part of ongoing teaching and learning in the classroom. The Applied Learning Tasks will not be assessed by the State Examinations Commission (SEC). The learning achieved through the Applied Learning Tasks and their associated learning outcomes can be assessed by the additional assessment component and by the end-of-course examination.

Assessment

Written examination 60% Higher and Ordinary
Action Project 40% Higher and Ordinary

Additional assessment component: Action Project

The Action Project provides students with an opportunity to develop a deeper understanding of the concepts and principles of Climate Action & Sustainable Development, while also employing the practical strategies and thinking they have developed through the course to take effective action. The senior cycle key competencies, developed through all the learning in this course, will be applied through the student's engagement in the Action Project. The Action Project provides opportunities for students to pursue their interests in Climate Action & Sustainable Development, make their own decisions, acquire conceptual understanding and self-regulate their learning. The Action Project allows students to build on their experiences to date and demonstrate learning related to the learning outcomes of the Applied Learning Tasks strand, as well as learning outcomes from the other strands as appropriate to the brief. Students will engage in an action of their choosing that relates to a topic within the common brief, which will be issued annually by the SEC. Whilst students will utilise and work with others in carrying out their Action Project, their evidence of learning is submitted and assessed individually. They will research and define an issue they wish to address, and identify ways others have engaged with similar issues. They will use this learning to plan, design and carry out an action to address

the issue. Throughout the process they will use and apply the strategies, tactics and thinking they have learned throughout the course to organise and take effective action. They will be expected to evaluate work done on their action project and reflect upon the experience. The time allocation for completion of the Action Project is up to 20 hours of class time, and schools will have a level of autonomy over how these hours are allocated. Upon completion, students produce an individual submission on their Action Project in a format prescribed by the SEC.

Commentary

The first thing to say about this new course is that it is **not** a science course. The topic demands a strong science base, in all the main sciences. This course is a missed opportunity to have an interesting, relevant, and attractive science course as an alternative to the existing courses, especially Physics with Chemistry. Study of the environment, which includes as sub-topics climate change and sustainability, requires an understanding basic science. A course in Environmental Science would build directly on Junior Science and be a broadly based science course, with a focus on the environment. It would be acceptable for third level entry as a science course, unlike this new course. There are several suitable third courses in environmental science for which this would be a good preparation, but not necessarily the new course unless students had also done one or more of the main sciences.

The various issues in the environment, which includes climate change, cannot be understood properly without dealing with the underlying science and can not be tackled effectively without the science. Climate action is not the same as climate science.

If we compare the content of this course to that of the Biology, Chemistry and Physics specifications, then it is very thin by comparison. The Applied Learning Tasks are not being examined externally but 40% of the marks will go for an Action Project.

The danger of a course like this is that it will attract and produce ill-informed activists, who don't understand the science behind the issues they are protesting about. Again we might ask the crucial question:

Where's the science?

This is a wasted opportunity to have a relevant general LC science subject.

This new course has now been published and will be trialled from Sept. 2025 in 100 schools. https://www.curriculumonline.ie/senior-cycle/senior-cycle-subjects/climate-action-and-sustainable-development/

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Some school environmental science courses

Two examples are given below of senior cycle courses in Environmental Science: one from a UK examinations board (AQA) and one from the International Baccalaureate (IB). Note that these are clearly science courses so that students have a good knowledge foundation for thinking about environmental issues.

AQA AS/A-level Environmental Science
AQA | AS and A-level | Environmental Science | Specification at a glance
Subject content

- 1. The living environment
- 2. The physical environment
- 3. Energy resources
- 4. Pollution
- 5. Biological resources
- 6. Sustainability
- 7. Research methods

Examined by two written papers each worth 50%.

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IB Environmental Systems and Societies
ess-ibdp-subject-brief.pdf (ibo.org)
Core content
1. Foundations of environmental systems and societies
2. Ecosystems and ecology
3. Biodiversity and conservation
4. Water and aquatic food production systems and societies
5. Soil systems and terrestrial food production systems and societies
6. Atmospheric systems and societies
7. Climate change and energy production
8. Human systems and resource use

150 hours. 75% external exam, 1 paper; 25% student investigation.

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LC Results 2024

A summary of the LC science results, which came out on August 23rd, is given in Table 1 and the % uptake shown in Figure 1.

Table 1: LC Science uptake for 2022-2024
(Total number of candidates: 2024 56,787, 2023 58,006; 2022, 58,056)

Subject	Year	HL(%)	OL(%)	Total	% LC cohort
Biology	**2024**	**28,461 (85.7)**	**4,750 (14.3)**	**33,211**	**58.4**
	2023	28,723 (83.0)	5,879 (17.0)	34,602	59.65
	2022	28,671 (84.1)	5,409 (15.9)	34,080	58.7
Chemistry	**2024**	**7,939 (84.3)**	**1,478 (15.7)**	**9,417**	**16.6**
	2023	8,068 (82.7)	1,682 (17.3)	9,750	16.8
	2022	8,481 (87.6)	1,198 (12.4)	9,679	16.7
Physics	**2024**	**6,009 (82.2)**	**1,301 (17.8)**	**7,310**	**12.9**
	2023	6,143 (81.6)	1,383 (18.4)	7,526	13.0
	2022	6,487 (83.5)	1,280 (16.5)	7,767	13.4
Ag. Science	**2024**	**5,501 (85.7)**	**917 (14.3)**	**6,418**	**11.3**
	2023	6,132 (82.2)	1,328 (17.8)	7,460	12.85
	2022	6,218 (83.9)	1,195 (16.1)	7,413	12.7
Phys.+Chem.	**2024**	**309 (82.1)**	**67 (17.9)**	**376**	**0.65**
	2023	344 (84.5)	63 (15.5)	407	0.7
	2022	369 (85.8)	61 (14.2)	430	0.75

Comments:

The uptake in 2024 was broadly similar to 2023. Total number of students was down but the % uptake remained almost the same. Biology remains the dominant LC science subject, with just under 60% of the LC cohort taking it. This is followed by Chemistry, Physics and Ag. Science. Physics has clearly regained its place as the 3rd most popular science. All the sciences showed a small decrease in numbers from 2023 to 2024. All the sciences have HL uptake of over 80% This cohort did not take the Junior Cycle exams and so this year was their first experience of external examinations.

The graph below (Figure 1) shows fairly consistent uptake of the LC science subjects since 2010, although Biology continues to be far and away the most popular science subject.

While this is true in many countries, the disparity is greatest for Ireland where many more students take Biology than either Chemistry or Physics. The provision of a new LC Science subject following on from the JC Science course, would probably reduce this disparity.

The numbers of students taking all the sciences declined slightly, in line with the decrease in candidates) and so did the % taking the sciences.

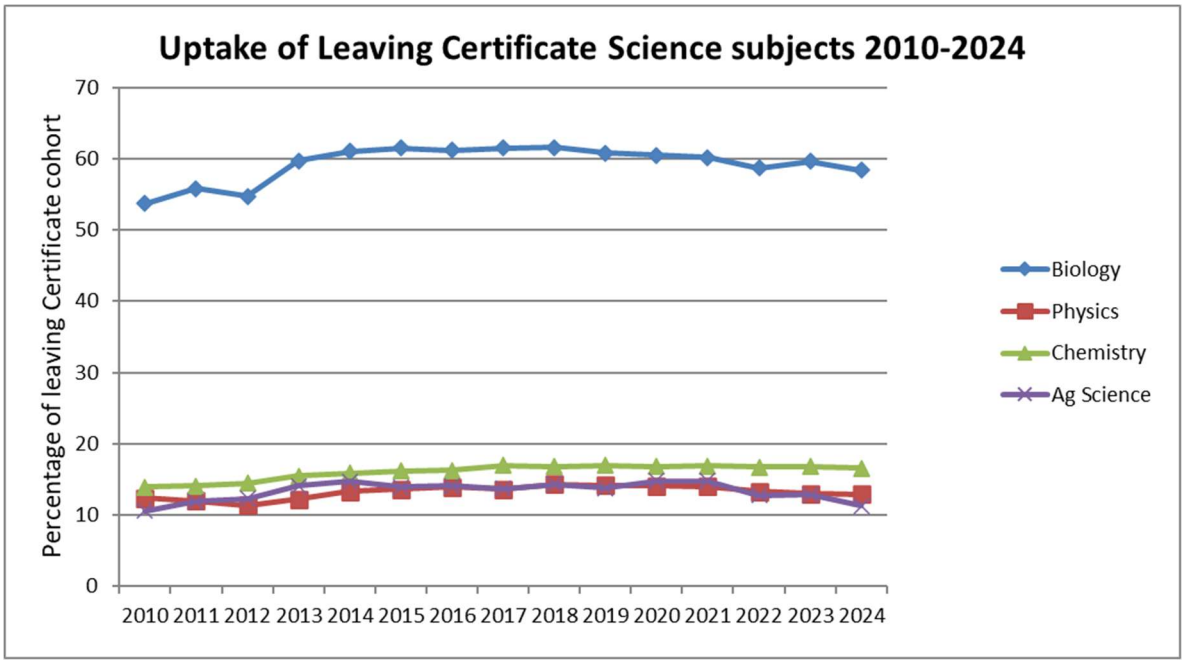

Figure 1: Percentage uptake of LC science subjects from 2010 to 2024

Grade inflation in the LC sciences

Table 2 shows the change in the % of students getting H1s from 2019 (pre-Covid) to 2023, showing the effect of grade inflation due to the disruption of teaching and state exams during the covid pandemic. Unlike the UK, Ireland has not reduced grade inflation, in fact it has deliberately retained it.

Table 2: Percentage of H1s from 2019 to 2024 in HL Maths and LC Sciences

Subject	2019	2020	2021	2022	2023	2024
Maths	6.4	8.6	15.1	18.1	10.9	**12.6**
Biology	8.2	11.6	17.4	17.6	18.8	**19.0**
Chemistry	13.5	18.1	23.4	19.1	22.8	**22.0**
Physics	10.9	16.1	21.1	23.7	20.8	**20.7**
Ag. Science	5.0	9.5	11.3	5.8	12.4	**13.6**

Comments:

The 2024 % of H1s is slightly up for Maths, Biology and Ag. Science, and slightly down for Chemistry and Physics. This is an artificial increase as the SEC increased marks by an average of 7.5% as a 'postmarking adjustment'. The adjustment was greater at the bottom of the scale than at the top, but still means almost double the % of H1s compared to 2019. The main thing to note is the significantly higher %s of H1s , meaning that the grading curve has been shewed artificially to the right, from 2020 to 2024, compared to 2019, the last 'normal' LC year. From 2020 onwards the grades have been inflated, first by using teacher assessments and then by maintaining these inflated grades now, even when we have gone back to assessment by state examination.

This is reflected in the number of students now getting the maximum possible points, 625, including 25 bonus points for HL Maths (Table 3). Table 4 shows the distribution of CAO points from 2019 to 2024, showing the effect of inflation on the points used for third-level entry.

Note also the small increase in LC numbers from 2019 to 2024. Numbers taking the LC will continue to increase as the bulge (due to increased birth rate and immigration) enters senior cycle this year. Around 74,000 students

took the Junior Cycle exams this summer and these results are due out on October 9th.

In Ireland there is a delay of 6 days between the release of the LC results and the first round CAO offers. In the UK the A level results came out on August 15th and students received notification of offers the same day. The LC results go from the SEC to the CAO before release day, so why cannot the offers and results come out together?

Table 3: Number of students with maximum CAO points (600-625)

	2019	2020	2021	2022	2023	2024
Number (%)	781 (1.4%)	1,812 (3.1%)	3,330 (5.7%)	3,205 (5.5%)	2,800 (4.8%)	1,813 (3.2%)

Table 4: Change in numbers in differ CAO bands 2019-2023 (% in brackets)
(Source: Central Applications Office (cao.ie))

Year/ Points	625	600-624	500-599	400-499	300-399	200-299	100-199	<100	Total
2019	207 (0.4)	574 (1.0)	6,684 (11.9)	13,489 (24.1)	14,266 (25.4)	10,732 (19.1)	6,557 (11.7)	3,562 (6.4)	56,011
2020	577 (1.0)	1,235 (2.1)	9,512 (16.5)	15,932 (27.7)	14,229 (24.7)	9,068 (15.8)	4,764 (8.3)	2,252 (3.9)	57,569
2021	1,342 (2.3)	1,988 (3.4)	12,133 (20.9)	16,189 (27.9)	12,865 (22.2)	7,544 (13.0)	3,623 (6.3)	2,268 (3.9)	57,952
2022	1,122 (1.9)	2,083 (3.6)	11,353 (19.6)	15,367 (26.5)	13,667 (23.5)	8,466 (14.6)	4,083 (7.0)	1,915 (3.3)	58,056
2023	952 (1.6)	1,848 (3.2)	11,378 (19.6)	15,852 (27.3)	13,902 (24.0)	8,233 (14.2)	4,022 (6.9)	1,819 (3.1)	58,006
2024	923 (1.6)	1,813 (3.2)	10,998 (19.3)	16,020 (28.2)	13,683 (24.1)	7,844 (13.8)	3,613 (6.4)	1,903 (3.4)	56,787

Comments:

The size of the LC cohort has changed very little over the past 5 years. The number of students with the maximum 625 points (inc. the Maths bonus) has jumped from 207 (0.4%) in 2019 to 923 (1.6%) in 2024, peaking at 1,342 (2.3%) in 2021. In addition, the % of students with more than 300 points (halfway up the CAO scale) has gone from 62.8% in 2019 to 76.5% in 2024. For reference in 2010 it was 56.1%. This represents a massive inflation of grades without any real change in the student population. In fact, as more students stay on at school and take the LC exams you would expect the grades to shift downwards not up. The same argument applies to third-level students, where a larger and academically more diverse population should result **in a lower %** getting 1st and 2.1 degrees, not more, as is the case. Grade inflation at third-level has been highlighted in both Ireland and the UK. The grade inflation of LC grades and the inflation of degrees devalues the qualifications and reduces their credibility and comparability with other countries. One immediate effect of having many more top grades, is that more students are qualified for the high-demand courses than there are places, and so places are allocated by lottery. Thus a student might get a perfect score (625 points) and still not get their first choice.

This reminds one of the Dodo in Alice in Wonderland who said after the race, "*Everybody has won and all must have prizes.*" In fact, if everybody wins and gets a prize, then nobody wins, as winning is meaningless. We must remember, of course, that the Dodo is now extinct. If we reject the idea of meritocracy, rewards based on merit,

what we will end up is mediocrity, a lowering of achievement.

The Minister of Education announced in April that from 2025 the LC grades will be gradually reduced back to pre-pandemic levels i.e. normality.

In April this year, the Minister announced that the phased return to normal results would start in 2025, with a modest and gradual reduction in the level of post marking adjustment applied to minimise the impact on students in so far as possible.

The return to normal will be done in stages over the coming years, in a phased and student-centred way. The adjustment next year will seek to bring the overall set of results on the aggregate to a point no lower than broadly midway between 2020 and 2021 levels.

The same adjustments to assessment components themselves, including Leaving Certificate examination papers – for example, greater choice - will also apply for next year's students.

The argument that grades must be elevated this year to avoid disadvantaging the class of 2024, also applies to subsequent years. In the UK the A-level grades have been returned to pre-pandemic level already (Figure 2), a much more sensible and realistic policy. The UK approach is shown in Figure 2 below showing the change in % getting A and A* from 2019 to 2024. The UK schools went through many of the same restrictions faced by Irish schools and have slowly reduced the grade inflation since 2022.

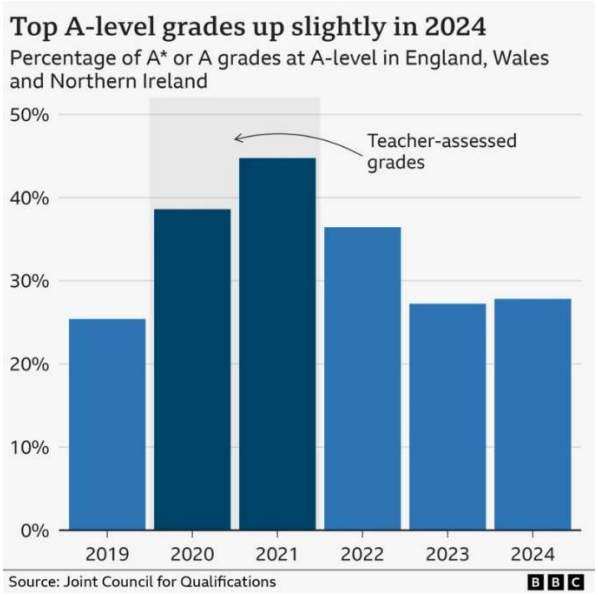

Figure 2: Top A level grades in the UK 2019-2024

Exam results: More students achieve top A-level grades - BBC News

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PISA 2022 Results

The survey for the PISA study run by the OECD were delayed by Covid to 2022 and the results were released in Dec. 2023. The Country Notes for Ireland can be accessed using the link below.
PISA 2022 Results (Volume I and II) - Country Notes: Ireland | OECD

See also the Department of Education press release:
gov - Major international study shows Irish students are the best performers in reading literacy in the OECD and the EU (www.gov.ie)

The Programme for International Student Assessment (PISA) assesses the knowledge and skills of 15-year-old students in mathematics, reading and science. The tests explore how well students can solve complex problems, think critically and communicate effectively. This gives insights into how well education systems are preparing students for real life challenges and future success. Ireland participated for the first time in PISA in 2000. By comparing results internationally, policy makers and educators in Ireland can learn from other countries' policies and practices.

This assessment came at the end of the Covid pandemic when all countries had their education disrupted. Not surprisingly the average test scores fell in each area (Figure 1). In total 5,569 students in 170 schools in Ireland participated in PISA 2022. The tests were held in October and November in 2022. In total, 600,000 15-year-olds took the PISA tests in 81 countries/economies, including 37 OECD countries (26 EU countries).

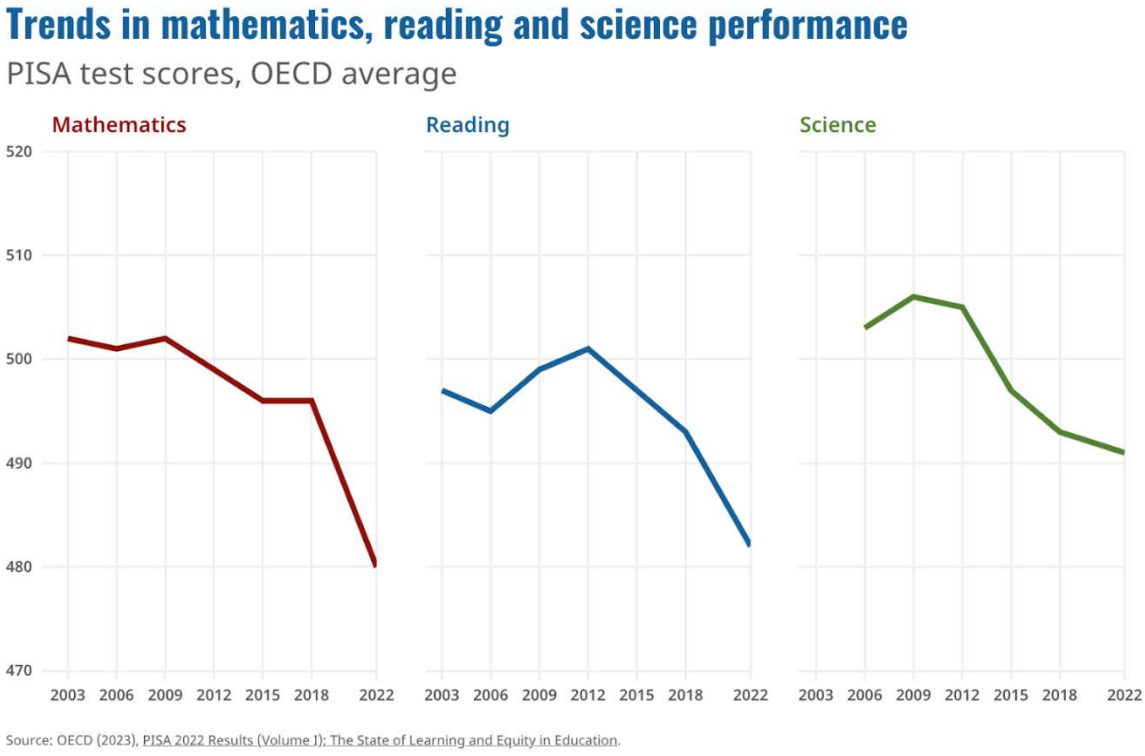


Figure 1: Trends in PISA scores for Mathematics, Reading and Science.
Scores Plummet Around the World: Scanning the Headlines on the Release of the 2022 PISA Results | International Education News (internationalednews.com)

In Figure 2 you can see the scores for Ireland from 2000 to 2022.

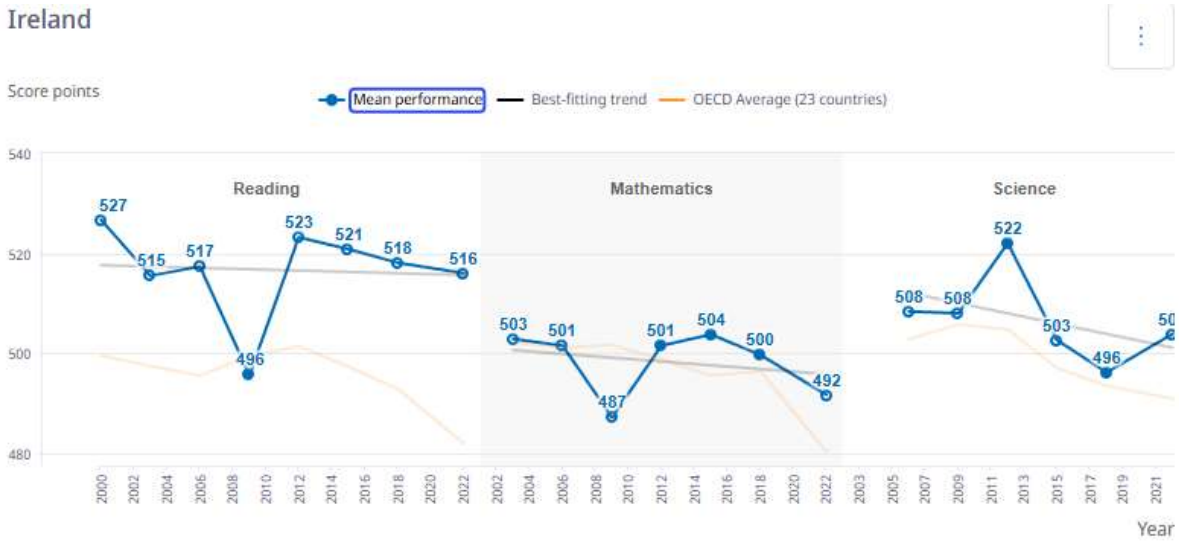


Figure 2: PISA results for Ireland from 2000 to 2022

- Average 2022 results were down compared to 2018 in mathematics; about the same as in 2018 in reading; and up compared to 2018 in science.
- In science, performance returned close to the performance observed in 2015, but remained below the high mark set by PISA 2012. In reading, the overall trend since 2012 can be described as flat – neither improving, nor declining. In contrast, in mathematics, mean performance was below that of any other assessment since 2012.
- Over the most recent period (2018 to 2022), the gap between the highest-scoring students (10% with the highest scores) and the weakest students (10% with the lowest scores) did not change significantly in mathematics, reading and science. In mathematics, performance dropped to a similar extent for both high- and low-achievers.
- Compared to 2012 the proportion of students scoring below a baseline level of proficiency (Level 2) did not change significantly in mathematics; did not change significantly in reading; and increased by four percentage points in science.

Ireland ranks 9th overall (Figure 2)out of 81 countries and each area Ireland is above the EU average. In Reading Ireland went from 8th to 2nd overall, in Science from 22nd to 12th, and in Mathematics (the main focus of the 2022 Assessment) from 21st to 11th.

Mathematics[30]		Science[30]		Reading[30]	
1	Singapore 575	1	Singapore 561	1	Singapore 543
2	Macau 552	2	Japan 547	2	Ireland 516
3	Chinese Taipei 547	3	Macau 543	3	Japan 516
4	Hong Kong 540	4	Chinese Taipei 537	4	South Korea 515
5	Japan 536	5	South Korea 528	5	Chinese Taipei 515
6	South Korea 527	6	Estonia 526	6	Estonia 511
7	Estonia 510	7	Hong Kong 520	7	Macau 510
8	Switzerland 508	8	Canada 515	8	Canada 507
9	Canada 497	9	Finland 511	9	United States 504
10	Netherlands 493	10	Australia 507	10	New Zealand 501
11	Ireland 492	11	Ireland 504	11	Hong Kong 500
12	Belgium 489	12	New Zealand 504	12	Australia 498
13	Denmark 489	13	Switzerland 503	13	United Kingdom 494
14	United Kingdom 489	14	Slovenia 500	14	Finland 490
15	Poland 489	15	United Kingdom 500	15	Denmark 489
16	Australia 487	16	United States 499	16	Poland 489
17	Austria 487	17	Poland 499	17	Czech Republic 489
18	Czech Republic 487	18	Czech Republic 498	18	Sweden 487
19	Slovenia 485	19	Denmark 494	19	Switzerland 483
20	Finland 484	20	Latvia 494	20	Italy 482

Figure 3: The PISA 2022 results for the top 20 countries in each category

Figure 4 below shows the overall worldwide rankings.

Figure 4: PISA 2022 overall scores

PISA 2022 Worldwide Ranking - Average Score of Mathematics, Science and Reading - FactsMaps

Proceedings: 42nd ChemEd-Ireland 2023

21st October
Department of Chemistry
Trinity College Dublin

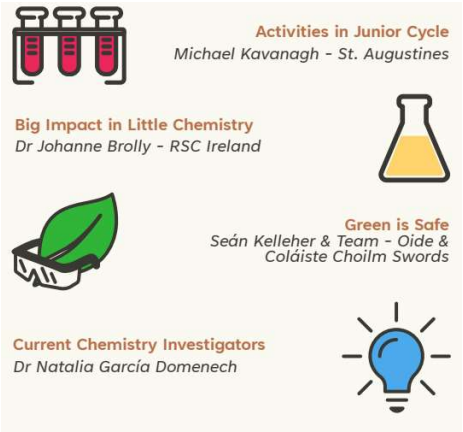
The Proceedings of the ChemEd-Ireland conference from the previous year are usually published in the Spring issue of Chemistry in Action! This year the Spring issue, #124, was a special issue devoted to the ESTA project and so the Proceedings are now in the Autumn issue, #125. A brief report on the conference was given in issue #123, Autumn 2023. Publishing the Proceedings is only possible if the speakers send in written versions of their talks or details of their workshops. Some years there is almost 100% response and one year it was zero.

In these Proceedings we have been able to obtain four articles and I would like to thank the authors. The programme for the day is given below and you can see it was a very full and interesting programme. The 2024 ChemEd-Ireland will be hosted by UCC and is organised by Dr Declan Kennedy on Saturday October 19th. Book this date now.

TIMETABLE

9:30 - 10:00	**Regristation, Coffee and Posters**
10:00 - 10:10	**Welcome and Conference Opening** *Prof. Graeme Watson - Head of Chemistry, TCD*
10:10 - 10:40	Hydrogen, Solar Cells and our Future *Dr Michelle Browne - Helmholtz-Zentrum, Berlin*
10:40 - 10:55	Current Chemistry Investigators *Dr Natalia García Domenech - Trinity College Dublin*
10:55 - 11:00	Oide: the new CPD service for teachers *Seán Kelleher - Oide & Coláiste Choilm Swords*
11:00 - 11:25	**Coffee and Posters**
11:25 - 11:35	Chemistry Olympiad Ireland *Dr Carl Poree and Dr Brian Murphy*
11:35 - 12:05	Demonstrations and how to survive them *Chris Lloyd - Scottish Schools Education Research Centre (SSERC)*
12:05 - 12:40	Clean Energy Storage *Prof Serena Cussen - University of Sheffield*
12:40 - 13:10	WORKSHOP
13:10 - 14:05	**Lunch**
14:05 - 14:35	WORKSHOP
14:35 - 15:05	Crystallography for the people *Dr Claire Murray*
15:05 - 15:25	A new approach to school lab design *Humphrey Jones - ISTA Vice-Chairperson and St. Columba's College*
15:25 - 15:45	Overview and pitfalls from the 2023 Leaving Cert Chemistry exams *Gerry Hyde - State Examinations Commision (SEC)*
15:45	**Close of Conference**

Workshops (Cocker Laboratory)



Micro Chemistry, Major Impact!

Johanne Brolly
The Royal Society of Chemistry
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Just when I thought I couldn't love my subject anymore, I discovered it could be done in the millimolar scale. I have always adored miniature lab glassware and so in my opinion, it doesn't get much cuter than this!

What is microscale chemistry?

In her *Education in Chemistry* article, Maria Burke describes microscale chemistry as *"practical activities that use much smaller amounts of reagents, and often with simpler equipment…..using less than 100 cm^3 of gas, 1 g of solid or 0.5–1 cm^3 of liquid"* (Burke, 2022). In other words, it is the scaling down of the quantity of chemicals and the size of the equipment used to facilitate practical chemistry, without detriment to the learning outcomes and skills development, usually achieved from "standard" chemistry practical facilitation.

Why consider microscale chemistry?

There are several reasons to replace traditional chemistry practicals with microscale versions. If you are teaching a young and inexperienced group of learners, microscale practicals can build up confidence and competence, provide learning opportunities with reduced risk and lower cognitive load, that so many learners in first year of secondary schools can sometimes struggle with, when introduced to practical science.

In senior school, microscale practicals are perfect for introducing new techniques, or to help learners make the link between macroscopic, symbolic, and sub-microscopic levels (Hofgartner, 2019) in more complex topics.

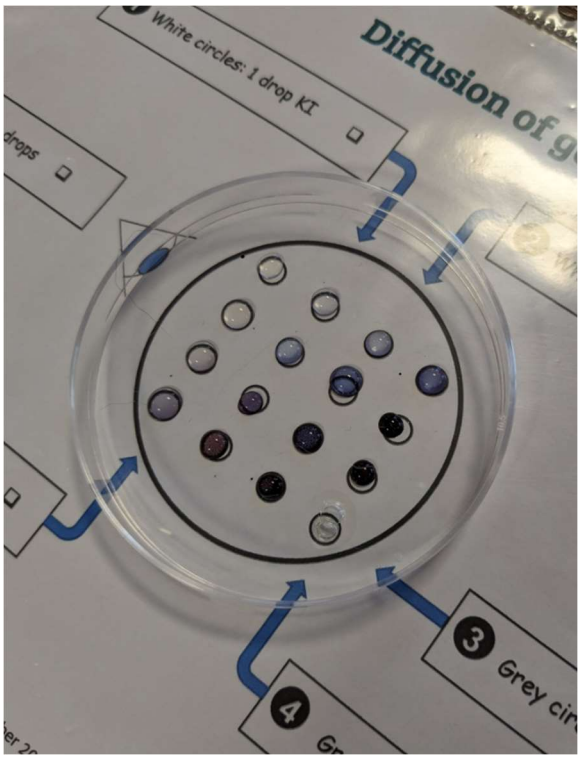

Figure 1: microscale diffusion of gases

Regardless of the age group being taught, most educators however, are embracing microscale because they use less chemicals, meaning a quicker reaction, a safer experience for the learners, less waste to dispose of and less cost to the school. These are exactly some of the reasons why Bob Worley, "The Godfather" of microscale chemistry, began designing microscale versions for CLEAPPS (Worley, Little wonder: microscale chemistry in the classroom, 2021). You can find out more about Bob's CLEAPPS microscale chemistry project and the impact these techniques have had on chemistry education in his "Introduction to microscale chemistry techniques for teaching" video (Worley, You Tube, 2020). For more microscale techniques, accompanying pedagogy and ways to use microscale to help students learn and understand chemistry, take a look at Bob Worley and David Paterson's *Understanding chemistry through microscale practical work* book (Paterson B. W., 2021).

It is important to note that if you decide to use the dropper bottles, so often used in microscale

practicals, some time is needed to initially make up the solutions, fill and label the bottles. However, I consider it time well spent as they probably won't need to re-filled until several classes have had their turn. Plus, there is always the miniature filter funnel that accompanies the kits to coo over while you do it.

The most appealing aspect of microscale chemistry to me, however, is that it is very visual. It is easier to see a solid dissolving, a gas spreading or a precipitate forming inside a little puddle of solvent on a page inside a plastic document (or laminated page), than in a test tube, and therefore much easier to initiate discussion and challenge misconceptions amongst your learners.

Figure 2: "What makes a Good Indicator" (Allan, 2021)

The Impact

Teachers who attended the workshop in October, had the opportunity to try six miniature marvels and saw for themselves, why they will capture the attention of learners, spark discussion and engage them like never before. You also may have noticed that our worksheets used integrated instructions, shown to alleviate cognitive load of students who seem to struggle to understand what they have to do during a practical, explain what they did, or why they were doing it in the first place, according to David Paterson, who goes on to give tips on overcoming them in his article "Improving practical work with integrated instructions" (Paterson D. , 2018). We highly recommend integrated instructions.

We understand the work required in preparing a class (or an entire year group) for a practical lesson, and to demonstrate how microscale practicals can reduce the workload of teachers prepping and cleaning up after a practical, we have been showcasing our microscale kit at teacher workshops and conferences.

Here is what some of those teachers thought:

"Microscale Chemistry will save the department money but it will still get the teaching point across using practical."

"Absolutely loved this, found it so useful and encouraging as this allows for more practicals to be done in the classroom."

"I thought it was excellent, it's great to attend training when it is really beneficial coming back into the classroom."

"Microchemistry was excellent."

What next?

We, at the Royal Society of Chemistry, are committed to a sustainable approach to practicals, and through microscale practicals, educators and awarding bodies can also do their bit and adapt their practices and recommendations according to the Twelve Principles of Green Chemistry (Eghbali, 2010). If you want to get in on the action too, take a look at our microscale microsite for tips, ideas and practical experiments to help you make the most of microscale chemistry in your classroom. (https://edu.rsc.org/resources/collections/microscale-chemistry).

For more information, please get in touch with me.

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Biography

Johanne is an RSC Education Coordinator in Ireland who has over 16 years' experience delivering and teaching practical chemistry and lab skills. She now supports primary and post-primary teachers across the island of Ireland, to deliver high quality science lessons, with confidence. Johanne has designed and delivered workshops on microscale chemistry, chemistry demonstrations with impact, drug development (from concept to consumer), cognitive theory within chemistry lessons and STEM club provision.

□

ICCE 2024: Microscale symposium

IUPAC 24 is hosting the meeting on chemical education (27th IUPAC International Conference on Chemistry Education - ICCE 2024 (icce2024thailand.com)) on the 15-16 July. Within that event is an unprecedented 2-day symposium on microscale and small scale chemistry. SYM A.pdf (icce2024thailand.com). The microscale approach now fits ideally with the theme of the event which is **"Power of Chemistry Education for Advancing Sustainability Development Goals". (See** THE 17 GOALS | Sustainable Development (un.org))

□

Developing a Pod-Based School Science Laboratory

Humphrey Jones
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Back in 2016, my colleagues and I were presented with an extraordinary opportunity; we were challenged to design our own school science laboratories.

Let me back up a little.

The Science Building at St. Columba's College in Dublin was built in 1971 and was designed by Miesian Irish architect Robin Walker. Its facade was dominated by a double-skin glass exterior, while inside there were four science laboratories – one for junior science, biology, physics and chemistry. (Figure 1)

Figure 1: The outside of the original building

Despite the modern exterior, the classrooms themselves were very traditional and consisted of two or three long front-facing wooden desks with an elevated desk for the teacher, primarily designed for demonstrations rather than collaborative practical investigations. (Figure 2) The building's design was celebrated by Irish architects and the sight of architecture students wandering the campus to view this "marvel" was a regular one. The truth is, by 2016, the building was anything but a marvel.

Figure 2: The old laboratory

At that point, the building was starting to age badly. The heating system was struggling to keep the four labs at a comfortable working temperature; heat seeped through the thin glass during the winter yet seemingly couldn't find a route out in the summer months. Interior lows of 4°C in the winter were followed by highs of 38°C in the early summer. While the building and its laboratories had their charm, the interior at least had aged poorly, and the layout didn't suit how we wanted to teach. Thus, when the decision was made to refurbish, update, and future-proof the building, the Science Department was presented with a unique opportunity to design their own learning environments.

We gratefully seized the chance to collaborate with the architects (who themselves were challenged with maintaining the building's protected design while improving its functionality) and actively participated in the design and layout of the laboratories and prep room areas. What teacher wouldn't? However, this opportunity unexpectedly sparked a deeper discussion. The department began to question what we valued in science education, questioned our department philosophy, evaluated our current strengths and weaknesses, and explored how we could maintain and improve own high standards.

Our vision was to create classrooms that would inspire creativity, allow for greater movement and collaboration, and generally served as

habitats for excellence. We wanted to design spaces that would evoke joy, wonder, and awe. Additionally, we sought to create a new shared space for teachers which could help is foster greater collaboration, while also provide us with the necessary storage for equipment and chemicals. Importantly, we wanted to preserve the integrity of Walker's design and maintain the building's character while incorporating modern technology.

To gather insights and experiences, we consulted other local schools that had recently renovated their own laboratories. While we found inspiration in some of these visits, we realised that we needed to devise a design that suited our unique building. The original footprint of the rooms meant that many of the designs we encountered wouldn't work in our restricted space. We swiftly reached a consensus that a pod-based system would best suit the layout of our new laboratories, aligning closely with our teaching philosophy and the principles of the Irish junior and senior science curricula.

We had originally encountered a pod-based system at Belfast's science museum, W5, which, although not perfect, closely matched our objectives. We decided on six bean-shaped pods per classroom, each accommodating four pupils with two workstations, enabling seating on the curved side and positioning the electricity, gas, and water supply opposite to minimise distraction when not engaged in practical activities. This shape would also optimise the available space between the pods since they could be turned and positioned accordingly. (Figure 3)

Figure 3 The pods in the new biology lab

We constructed several full-sized pod models, experimenting with curvature, length, and width to ensure they would fit within the space and accommodate the necessary equipment. The pod design underwent a slight alteration to incorporate a straight edge for the water, gas, and electricity connections. Professional laboratory fitters, LabFit, then built the final design.

The complete restoration of the building and the renovation of the laboratories were accomplished in just three months, during the summer of 2016. Additionally, a slightly smaller fifth laboratory, located beneath the Physics lab, was introduced. Each lab was assigned its own colour: with yellow for Chemistry (Figure 4), green for Biology (Figure 3), teal for General Science, and purple for Physics. Furthermore, each room was equipped with a 72-inch Android interactive monitor and high-speed wireless internet.

Figure 4: The new chemistry lab

The fixed fume cupboards in the previous labs were replaced with two mobile units.(Figure 4) Some original features, including the notable "Belfast sinks" were preserved, while even great care was taken to acquire the best chairs for the space.

One of the standout features of the new building was the creation of a shared preparation area and teacher space between the Biology and Chemistry labs (Figure 6). The department agreed to dedicate one wall in this preparation area to a tray-based storage solution, which proved highly effective. This space transformation had a significant impact, as it allowed for joint planning, collaboration, and discussions on methodology, enabling the sharing of best practices and exploration of new ideas.

Figure 6: The new shared prep room

Interestingly, there has been a notable increase in the enrolment of Science subjects at the Senior level, reaching levels not seen in recent memory. While it is impossible to prove causation, the department achieved its best results a few years later. The Science Department considers themselves fortunate to have been given the opportunity to design what they believe to be the ideal science classrooms. While there were limitations, we now perceive their laboratories (Figure 6) as vibrant hubs for learning, exploration, collaboration, and wonder. Our pupils agree with us too.

Figure 6: The outside of the refurbished building

Crucially, allowing us, the teachers, to be a key voice in the design process ensured that the new laboratories were purpose-built and reflected best practices. More significantly, this process facilitated a discussion on the values held by the Science Department at St. Columba's and set the direction for the department's teaching and learning approaches for the decade ahead.

We now have bright, welcoming learning environments equipped with modern technologies, up-to-date science equipment, and functional furniture. However, the most significant outcome is the team of science teachers who have actively reflected on their core values in science education and are fully committed to those shared values.

Biography

Figure7: Humphrey Jones in action in the new lab

The new labs were designed and built by Labfit Furniture, Westport, Co. Mayo.

Biography

Humphrey Jones is Head of Science & Biology at St. Columba's College in Dublin and currently Chair, ISTA. Twitter: @humphreyjones

The other science staff involved were: Peter Jackson (who has since retired), Mary Singleton and Emma McNelis (since moved to a different school).

□

Chemistry and Crystallography for the People

Claire Murray
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Introduction

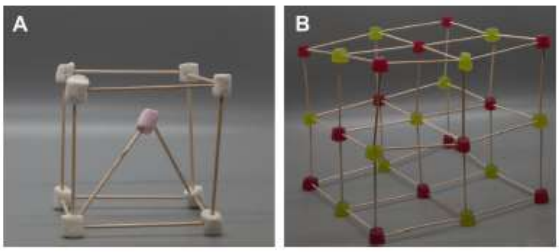
This article builds on my talk at ChemEd-Ireland 2023. I really enjoyed attending and learning about your great work and also about the challenges you are facing. As I mentioned in my talk, I think it is just as important to share solutions rather than just present problems. This article is intended to be a resource that you can consult or build on in your own classroom as solutions, with links to open access articles or free resources.

Diversity in Chemistry and Science

I was lucky enough to have incredibly supportive family and friends and a fabulous chemistry teacher called Miss O'Toole in St Paul's Secondary School in Greenhills, Dublin 12. This created the perfect mix for me to explore and pursue my chemistry undergraduate and postgraduate degrees. In reflecting on how I was able to pursue a degree and career in chemistry, I often think about how much support and opportunity I had that many other people may not have. There are many cultural issues which can drive women out of chemistry and science and can affect their retention and progression (Royal Society of Chemistry, 2019). One such issue is representation, where it is difficult for women to achieve when you cannot see good role models. Textbooks are a mandatory part of secondary school chemistry and science education used by every student, but they are not always representative (Murray *et al*., 2022a). This is where you as teachers have an opportunity to influence and support women to enter science. Making women scientists and chemists visible in the classroom provides clear visual cues for all students that women have a place in science and chemistry, and there are resources available for this (Posters, 2024; Murray *et al.,* 2022b).

Exploring Scientific Careers

Scientific careers can be difficult for students to conceptualise when they don't know people with STEM career paths. The reality of life as a scientist can feel so distant when you have never met a scientist. There is great work ongoing in classrooms all over the country to address this gap, but it is not always possible for every student to meet a scientist. To try to support teachers and careers guidance advisors, we created a board game about scientific careers and the life of a scientist, which I shared at ChemEd-Ireland 2023. We initially developed the game for classrooms but converted it to a print and play game during the COVID-19 pandemic. More copies of the game can be freely downloaded online (Diamond the Game, 2020). We shared the process and evaluation outcomes online, where we found that students enjoyed the game and learned about many different scientific careers and the scientific process (Murray *et al.,* 2022c).



Marshmallow crystal models

Crystallography in the Classroom

I did my PhD in Chemistry, but specifically in the field of crystallography, which revolves around how atoms and molecules are organised in crystals. I would argue that it is one of the most beautiful sciences in the world because it lets us understand the full 3D structure of crystalline molecules and their atoms. However, from talking with (thousands of) people, it can feel like an

intimidating or scary science. To try to bridge this perceived scariness, some friends and I developed an activity called 'The Structure of Stuff is Sweet'. This activity is something that you can deliver yourselves in your classroom using cocktail sticks and marshmallows to convey the concept of crystalline order and packing. For some reason, it seems to be very popular with students…! We have used it in classrooms, festivals and local fairs around the world, and it is a simple but powerful way to start conversations about crystals and how important they are in our world. We have shared this activity in an article, with a file in the supplementary information that has a full class plan for secondary school teachers (Murray *et al.,* 2024a). This includes learning objectives, equipment needed and a detailed step by step so you can explore the structure of crystals in your own classroom.

Students from Cheltenham College completing their experiments for Project M, a large-scale school citizen-science project. Image: Cheltenham College Chemistry Department/Twitter

Citizen Science

I work broadly in science communication and citizen science, with a particular focus on how we can create opportunities for enjoying science. I've previously developed a citizen science chemistry project with colleagues, and we have just published results from this that demonstrate that students and teachers can contribute to real scientific research (Murray, C., *et al.,* 2023; Murray *et al.,* 2024b). There is an important push to expand STEM engagement for future careers in Ireland, but for this to succeed we also need more people to be open to science and have confidence in science. Citizen science is definitely something I've seen discussed on the Sharing Science Forum, and I believe it is an amazing opportunity for developing critical thinking skills and for applying curriculum learnings to real world settings. It provides an interesting chance to learn about the nature of science. Engaging with citizen science doesn't have to be difficult – the website Zooniverse has many projects available for your students to test out their analytical and critical thinking skills. From my own experience working on Zooniverse (2024) this year, there is a fascinating point when students realise that science is not just a right or wrong answer. Many students query whether their answer is correct and are shocked to learn that neither their teacher nor the scientists who run the project know (yet!).

Conclusion

The links and resources shared in this article are intended to support you to share the joys and wonders of chemistry and science with your students. We need more scientists, particularly chemists, in healthcare, technology, climate science and so many more areas. Opening up science to more people starts in your classrooms and we will all benefit from a society where everyone feels welcome.

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Biography

Dr Claire Murray is a chemist, crystallographer and citizen science expert. She is interested in creating inclusive opportunities for everyone to enjoy chemistry and science.

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NOTE: In this issue you can read about the life and work of Kathleen Lonsdale, an Irish-born crystallographer who was a pioneer in this area of science.

Chemistry Education Research (CER)

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According to Prof. Michael Seery, Chemistry Education Research (CER) is one of a subset of discipline-based education research fields (DBER), which are areas of education research focussing on particular (usually scientific) sub-disciplines. Personally, I have always treated it as a distinct discipline of Chemistry, just like Analytical, Organic, Inorganic, Physical and Materials etc. But of course, because of its multidisciplinary nature it can be linked with any area of chemistry. I was recently invited to deliver a research seminar for the School of Chemistry in Trinity College Dublin (TCD) about my CER work to date, which prompted me to look at my CER journey for the first time.

The two most prominent peer-reviewed publications in this area of research are the *Journal of Chemical Education* (JChemEd) by the American Chemical Society (ACS) and *Chemistry Education Research and Practice* (CERP) by the Royal Society of Chemistry (RSC). In North American CER is relatively well established with prominent research groups at many universities with CER PhD's and Postdoctoral researchers. The UK is not far behind with numerous active researchers in this area, in addition to those based in Germany, Sweden, Slovenia and others. In Ireland we have punched well above our weight, with dozens of articles published in these journals and others. In particular, CER researchers from Dublin City University (DCU), the University of Limerick (UL) and The Technological University of Dublin (formally DIT) have led the way, with respectable numbers also from the University of Galway and Maynooth University as well.

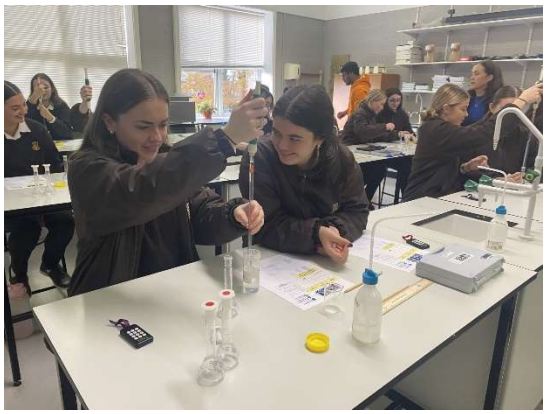

Figure 1: Students at Loreto Secondary School, Letterkenny doing a CCI workshop

My own journey into the world of CER started in the early 2000's during my time at University College Cork (UCC). During my undergraduate degree I trained as a secondary school chemistry teacher with Dr Declan Kennedy, but instead of becoming a practising teacher I decided to undertake a Chemistry PhD instead, to explore the world of research. My PhD was in the area of inorganic chemistry, specifically platinum-based anti-cancer drug design. But my supervisor was keen for me to gain experience in lots of different areas, so I undertook significant amounts of teaching and student supervision as well. I also worked with the Centre of Talented Youth Ireland (CTYI), teaching primary and secondary students advanced science topics on Saturdays. So I have the unique distinction of having experience teaching in primary, secondary and higher education.

After my PhD I was appointed as the Peer Assisted Learning (PAL) coordinator in UCC, where I trained final year chemistry students to run tutorials for struggling first year science students. I also served as the Head Demonstrator for the First-Year lab practicals. This was my first taste of a CER type project, but I had no idea how to evaluate it. I collected verbal feedback and implemented improvements in an *ad hoc* fashion in conjunction with colleagues. We didn't have any experience in this area of research with the

most recent JChemEd or RSC CERP publication from UCC being in 1991, with only two others before that in 1955 and 1974. I am pleased to see a revival in recent years with three JChemEd publications from UCC in 2019, 2020 and 2020 by McGlacken *et al*. However, it should be noted here that there have been numerous other publications in science education from those based in UCC.

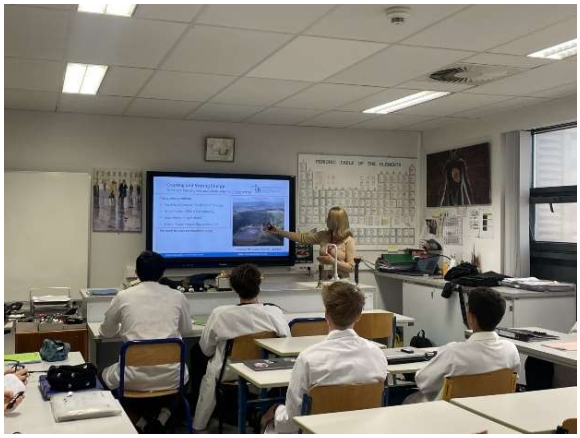

Figure 2: Students at St. John's International School, Brussels doing a CCI workshop

I then moved to Queens University Belfast (QUB) to carry out chemical engineering research into steam heat exchangers, which I thoroughly enjoyed, but I missed teaching and learning. So, it wasn't until I started at TCD almost a decade ago working as Education Officer for the RSC that I finally got the chance to explore CER properly. The TCD School of Pharmacy had published some CER work in 2007 and 2010 as well as the TCD School of Chemistry in 2013, so at least I had some recent starting points. However, my position in TCD did not have any time allocated to carrying out research activities. Every minute of every day was busy, so I had to choose research areas that would overlap with the work I was already doing. It still took me nearly 5 years to find the time to set up a project, run it and write up the results to produce my first publication in 2019. Since then, things have grown immensely, with CER publications nearly every year.

In late 2021 we were awarded funding from Science Foundation Ireland (SFI) to carry out an intervention in Irish secondary schools in the area of electrochemistry, an area of chemistry often cited as troublesome. This gave me the chance to design an entire CER project from scratch, from the development of the workshop, through to the ethics approval, to the data collection, finishing with the analysis and evaluation. We published the first results from this project in the summer of 2023, representing a phenomenally quick turnaround for a CER project. It's safe to say that we finally have the hang of it and TCD recognised this hard work with a Research Excellence Award in 2023. The project is called Current Chemistry Investigators (CCI) and it has just been renewed for another two years until 2026 (website below). One of the key findings to date is that Leaving Cert (LC) students lost many opportunities to meet role models during the COVID pandemic, whereas current transition year (TY) students have already regained these opportunities (Figure 3). This outlines the importance of projects like ours which provides students with tangible role models.

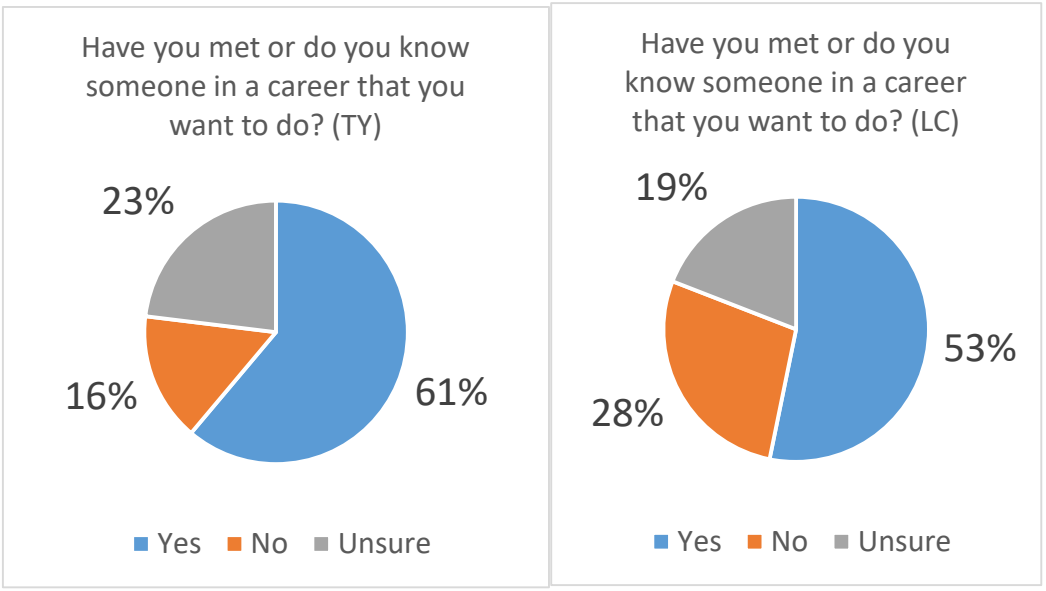

Figure 3: A Comparison of TY and LC (5th and 6th) students from the 2022-2023 academic year. The LC students here had a significantly curtailed TY experience due to the COVID19 pandemic.

Without a doubt, the biggest influence in those early days of trying to get my own CER off the ground in TCD was the Methods in Chemistry Education Research (MICER) conference hosted by the RSC in London and later in Edinburgh. MICER is the brainchild of Prof. Michael Seery and the RSC's Chemistry Education Research Group (CERG). It is unlike any other conference I have ever attended. Instead of speakers talking about their own research and presenting their data, the whole day is focused around how to do CER. It is designed to help people start their own journey into CER through the provision of workshops and practical advice.

So, I was delighted when Dr Kevin Morgan asked if I would like to join his organising committee to bring MICER to Queen's University Belfast in 2024. Our bid was accepted and on the 15th of May this year, the conference will be held on the island of Ireland for the first time. The team already have some great workshops planned in a variety of areas such as Universal Design for Learning, Teaching Chemistry in the Digital Age, Lab Education, and the role of outreach in education and professional development. We are especially interested in teachers attending the conference, because we feel that schools possess huge potential for carrying out CER work either on their own or in partnership with higher education. We look forward to seeing you there, tickets will be available soon (website below for more information).

Date for your Diary: MICER Conference, Queens University Belfast, 15th May 2024

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Current Chemistry Investigators (CCI) project website: www.currentchemistryinvestigators.com

Methods in Chemistry Education Research Website: https://micerportal.wordpress.com/

Great Irish Chemists: #2

Dame Kathleen Lonsdale (28/01/1903 – 1/04/1971)

Adrian J. Ryder
tutorajr@gmail.com

Stamp issued by An Post for St. Patrick's Day 2020

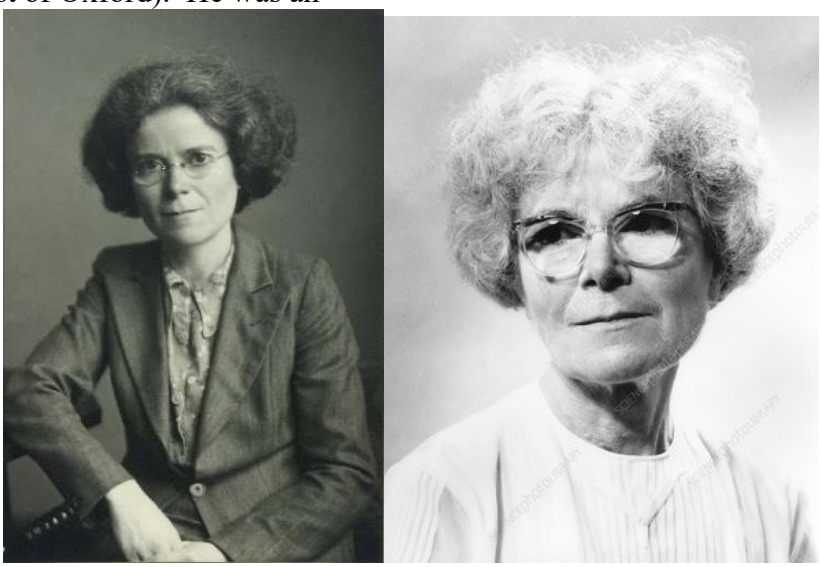
The subject of this profile was born Kathleen Yardley in Newbridge, Co. Kildare on the 28th of January 1903. She was the tenth, and youngest, child of English-born Harry (Henry) Frederick Yardley and Scottish Jessie Cameron. Harry's father was Daniel Yardley, a tailor, deceased by 1889, and Jessie's father was Archibald John Hanbury Cameron, her mother being Anne Greene.

Harry and Jessie had married in the Baptist Church, Dalston Junction, London, in 1889 when Jessie was aged 23 and Harry 31. Of the ten children, six boys and four girls, four of the boys died at early ages. The names of three of the survivors are Henry (Harry) Frederick Junior (b. 1890), Jessie (Spencer) and Kathleen.

On the corner of Charlotte Street and Henry Street in Newbridge stands Charlotte House. It was a former post office building. Photos early 20th Century and modern times. This was the birth-place of Kathleen.

Harry had left his family at the age of ten, and found work first as a telegraph boy and then a postman. Following the call for volunteers to fight the Boers, Harry joined the British army in 1900, serving in South Africa after leaving England in January and returning with the rank of Regimental Sergeant Major in October, after which the unit was disbanded on December 1st. Following his return he was appointed the Postmaster in Newbridge, not earlier than March 1901, replacing a William Croker and taking over the premises at 13 Charlotte Street together with a staff of six to manage. William Croker moved to Lisburn, Co. Antrim as postmaster there.

Years of alcohol abuse and aggravation saw Kathleen's parents separate in 1908, and Jessie and the surviving siblings moved to Seven Kings, Essex, now part of London. Harry followed them back to England where he worked for a while in charge of the post office at Chipping Norton, Oxfordshire (18 miles North-West of Oxford). He was an occasional visitor to the family, but his visits tended to be short, acrimonious and unwelcome. He died from Bright's disease in 1923, a kidney disease caused by excessive consumption of alcohol.



Early and later photographs of Kathleen Yardley Lonsdale

The Yardleys were constantly short of money and Kathleen developed rickets from a poor diet. This left her small in stature, but meant she could later cox for her college rowing eight. She also was secretary of the college music society.

Kathleen attended Downshall Elementary School from 1908 to 1914, and then won a County Minor scholarship which took her to the Ilford County High School for Girls, Royal Holloway, at Ilford from 1914 to 1919. Here she excelled in her studies, and she also took classes in Physics and Chemistry in the local boys' Grammar School, as the High School did not provide these subjects.

Kathleen's eldest brother Fred also won a scholarship but due to the poor finances of the family could not take it up. Fred however was to have a very successful career as one of the first wireless operators in 1910. It was he who received the last signals from the ill-fated Titanic in 1912. He went on to establish one of the first schools of wireless telegraphy in the north of England.

By 1919 Kathleen was recognised as a brilliant and determined student and had been awarded a County Major scholarship as well as the Royal Geographical Medal. This enabled Jessie's financial difficulties to ease sufficiently to enable Kathleen to attend Bedford College, (now part of Royal Holloway), a constituent College of the University of London, where she gained a scholarship at the end of her first year and graduated with a BSc with the highest grades of the past ten years in 1922. The MSc followed in 1924.

The Nobel Physicist Sir William Bragg was one of her examiners during her time in the University and was so impressed with her that he invited her to join his research team, first at University College London and then (from 1923) at the Royal Institution, London. Kathleen was on the road to fame. Her yearly salary of £180 also helped with the family finances.

In Bragg's research group she was the only woman in a group of international researchers. She collaborated with international scientists to produce the International Tables or 'crystallographer's bible', comprehensive tables for determining crystal structure.

In 1927 Kathleen married engineer Thomas Jackson Lonsdale (MSc, PhD, FInstP), whom she had met as a fellow research student, and moved to Leeds where Thomas had got a job at the Silk Research Association, which was based in the Textile Department of the University of Leeds. Thomas encouraged her to continue her scientific work there in the University of Leeds where she was an Amy Lady Tate Scholar and part-time demonstrator. Here she continued her work on X-ray diffraction and having received some crystals of hexamethylbenzene from C. K. Ingold from the Chemistry Department, was able to show conclusively in 1929 that the benzene ring was flat, something that chemists had been arguing about for 60 years. She had applied Fourier methods for the first time to analyse X-ray patterns in solving the structure of hexachlorobenzene. In 1929 their first child Jane (Goodwin) was born and soon after, they returned to London where a further two children, Nancy (Dawson) and Stephen, were born. She was to end up with ten grandchildren altogether.

All the time she was in Leeds, Bragg wanted her to return to the Royal Institution as his research assistant but it was not until he was able to get an allowance of £200 for home help that she felt able to oblige him. Thomas was also able to switch jobs, taking up a position at the Road Research Laboratory in London. She was to spend the next fifteen years at the Royal Institution though her mentor Bragg was to die in 1942. Here she became the Leverhulme Research Fellow (1935-37) and then the Dewar Fellow (1944-46). She also found time to obtain her D.Sc. from the University of London in 1936, a recognition of her academic achievements. In 1943 Kathleen, following her release from Holloway prison (see below), made the first of her many International Conference visits, when she was invited to attend and speak at the Institute of Advanced Studies Summer School in Dublin, where the main topic was the thermal vibrations of atoms and molecules. The School was held under the chairmanship of Erwin Schrődinger and was attended throughout by the Taoiseach, Eamonn de Valera. It was Kathleen's first visit to the land of her birth since she had left in 1908. After the meeting Kathleen paid a brief visit to her birthplace in Newbridge before returning to London.

1943 Institute of Advanced Studies Summer School in Dublin. Front row : Kathleen Lonsdale (3rd from right) and Sheila Power Tinney from Galway is 3rd from the left in Row 2. She was a mathematical physicist of note.

In May 1945 Kathleen Lonsdale was one of the first two women elected as Fellows of the Royal Society and so ending the male dominance of this bastion of science since its founding in 1660, and breaking through another glass ceiling.

She left the Royal Institution in 1946 to become Reader in Crystallography, University College, London, a position she held until 1949. During this time she founded a dedicated Crystallography Group, which led to her being elected as the first female President of the International Union of Crystallography in 1966, having been Vice-President for the previous six years. 1947 Saw her appointed a Special Fellow of

the United States Federal Health Service and in 1949 she was made the first female Professor in University College, London, taking the Chair of Chemistry and Head of the Department of Crystallography, a position she held to 1968, when she retired. She then became Professor Emeritus, University College, London, holding the position until her death in 1971. In 1956 her work was recognised by the Queen, who created her a Dame of the British Empire. She was to serve as President of the British Association for the Advancement of Science in 1968, the first female to hold that office.

Over the years Kathleen was to develop her crystallography skills in different ways. She listed these under nine headings as follows:

1. Mathematical crystallography and space group theory in relation to the structure analysis of crystals.
2. The structure of hexamethyl benzene and other simple aromatic compounds proving the planarity of the benzene nucleus.
3. Magnetic anisotropy of crystals and molecules, particularly of aromatic compounds.
4. Anomalous reflexions, thermal diffuse scattering and atomic and molecular vibrations in crystals.
5. Divergent beam X-Ray photography.
6. The study of synthetic diamonds, of the diamond-graphite transformation and boron nitrides.
7. Reactions in the solid state.
8. Methonium compounds.
9. Studies on endemic bladder stones and other calculi.

In 1966, Lonsdaleite, a rare form of diamond found in meteors, was named after her. Tongue in cheek she wrote to Clifford Frondel at Harvard University, who had suggested the name, "*Certainly the name seems appropriate since the mineral only occurs in very small quantities (perhaps rare would be too flattering) and is generally rather mixed up!"*

While in Leeds, Kathleen and Thomas became involved with the Quakers, becoming members in 1936. As a result, she became a committed pacifist. On the outbreak of war in 1939, the Lonsdales opened their home to refugees from Nazi Germany, sent to her by Quaker relief organizations. She refused to register for civil defence duties and on refusing to pay the subsequent fine of £2, was sent to prison in February 1943 for a month. Her time in prison was tough with bad conditions. After her release she made detailed suggestions to the authorities on improvements that could be made to the prison system, many of which were later implemented. In 1949 she was appointed a prison visitor at Aylesbury Prison for women and later in 1961 she was the Deputy Chair of the Board of Visitors at Bullwood Hall Borstal Institution for girls. Her book "*Prisons for Women*", published in 1952, was part of her continued interest in the treatment of females in prison.

Outside of her academic career, after WWII, Kathleen became an anti-nuclear campaigner. She joined the British Association of Atomic Scientists, and was involved in the Pugwash Conferences on Science and World Affairs. This had been founded with the desire to see all nuclear arms destroyed. She served as President of the British section of the Women's International League for Peace and Freedom. As a member of the East-West Committee of the Society of Friends, she took part in a controversial Quaker delegation to the Soviet Union in 1951. In 1953, she delivered the keynote Swarthmore Lecture, *Removing the Causes of War*.

Her book "*Is Peace Possible?,"* published in 1956, explored the relationship between world peace and world population needs. She felt that the causes of war should be removed by promoting just relationships among nations, even if it meant taking such radical steps as addressing uneven wealth and resource distribution between the wealthier and poorer regions of the world.

Kathleen became ill in 1970 and died the following year in University College Hospital, London on April 1st 1971 of leukaemia, which may have been brought on by the years of exposure to X-Rays during her researches.

Memorials

Kathleen has been honoured in various ways apart from those mentioned above and has been remembered in Ireland in recent years in several ways.

She has been awarded honorary degrees of D.Sc. by the Universities of Wales, Leicester, Manchester, Lancaster, Oxford and Bath, and of LL.D. by the Universities of Leeds and Dundee.

NUI Maynooth has instituted a Lonsdale scholarship to mark her connection with Kildare, and a commemorative plaque was erected at the former Yardley family home in Newbridge in 2003. Maynooth has also launched the Kathleen Lonsdale Institute for Human Health Research on October 25th 2019, with Kathleen's son Stephen as guest of honour.

Prof Ray O'Neill, Vice-President (Research & Innovation); Prof Paul Moynagh, Director of the Kathleen Lonsdale Institute for Human Health Research; Dr Fiona Walsh, Assistant Professor of Biology; Stephen Lonsdale, son of Kathleen Lonsdale and Prof Philip Nolan, President of Maynooth University.

There are buildings named after her at University College, London (above), the University of Limerick and Dublin City University. The RIA awards an annual Kathleen Lonsdale prize for the best chemistry PhD thesis.

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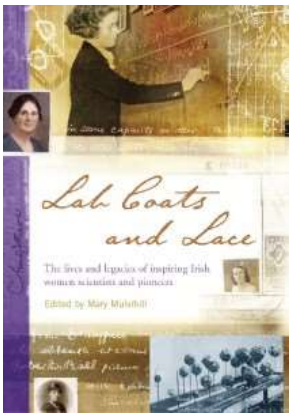

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An interview with Kathleen Lonsdale in 1967.
[BBC Archive Interview with Professor Dame Kathleen Lonsdale, 1967 - BBC]

The Lonsdale Project
In 2020, theatre company Super Paua harnessed an interdisciplinary team of artists, educators and scientists, to create an engaging piece of theatre called The Lonsdale Project about X-ray diffraction, Benzene, pacifism, crystals, and sticking to your guns. On 5th March 2022, The Lonsdale Project, a film by Super Paua, had its premiere screening at Riverbank Arts Centre, Main Street, Newbridge
Co. Kildare, W12D962

In 2012 DoubleBand Films in Belfast made a series of four Irish language TV programmes for RTE on Irish women scientists, including Kathleen Lonsdale, which were shown in 2014.

Deirfiúracha na hEolaíochta — DoubleBand Films

Comment:

Was Kathleen Lonsdale a Irish chemist? She ended her career as Professor of Chemistry at University College London, where the main chemistry building is named after her. Her academic work was in crystallography, a subject which started in Physics Departments but most of its applications were to chemical compounds. Crystallography lies at the interface of Physics and Chemistry and is also vital in Biology and Materials research. Much of the theory of crystallography was done by physicists and most of the applications by chemists. The encouragement of women like Kathleen Lonsdale early in the development of the subject, by the Braggs and others like Nenagh-born J.D. Bernal, has meant that women are well represented in this area of science. Kathleen Lonsdale was a major player in establishing crystallography as an important area of science and I think we can claim her both as Irish and a chemist. She is a worthy role model for the next generation of chemists and crystallographers.
PEC

Amazing Minerals: #3 Gypsum, $CaSO_4.2H_2O$

Our houses are full of it, but we may not know it. Gypsum, hydrated calcium sulfate, is the basis of plasterboard or dry walling. It is produced in Ireland in Kingscourt by Gyproc - Saint Gobain, an enterprise going back to 1936 (Figure 1).

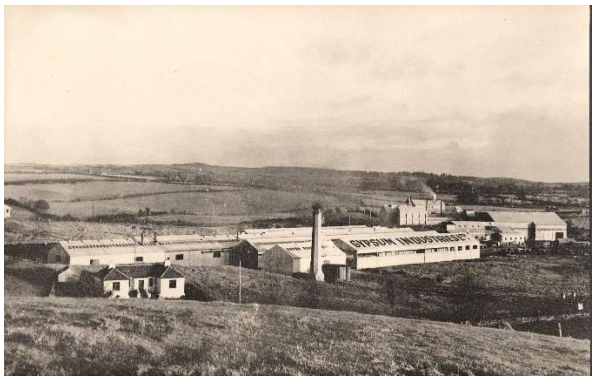

Figure 1: Gyproc Ireland circa 1940s
Gyproc | Saint Gobain (saint-gobain.ie)

There is a large deposit of gypsum at Knocknacran, Co. Monaghan where it is mined and processed at Kingscourt. Worldwide about 250 million t are mined each year. If you've ever broken an arm or leg you'll also be familiar with gypsum: Plaster of Paris is $CaSO_4.0.5H_2O$, a white powder which when mixed with water, hydrates to form gypsum, which sets solid to form a hard, plaster cast. It is relatively soft, as is gypsum, so the cast can easily be cut off. This is less common now and alternative materials are used as casts. It is also used to plaster walls and to make plaster mouldings. It was first made in Paris from the local gypsum deposits, hence the name. Gypsum is heated to drive off part of the water of crystallisation to give the hemihydrate (Plaster of Paris). Further heating drives off the remaining water to give anhydrous calcium sulfate, known as anhydrite.

$$CaSO_4.2H_2O \xrightarrow{\Delta} CaSO_4.0.5H_2O \xrightarrow{\Delta} CaSO_4$$

Gypsum Hemihydrate Anhydrite

The structure of gypsum (Figure 2) consists of SO_4^{2-} tetrahedra bonded to Ca^{2+}, in layers held together by water molecules through hydrogen bonding. This explains why gypsum is a soft substance.

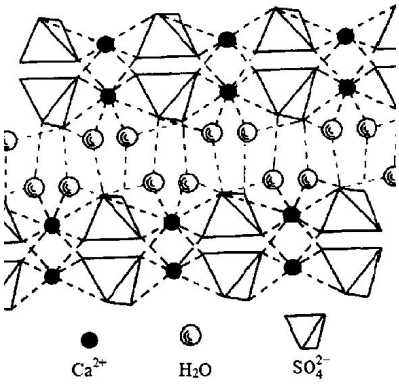

Figure 2: Crystal structure of gypsum

The main use of gypsum is to make plasterboard and plaster. 3-5% is added to cement clinker to control the setting time. World production of cement clinker is 4.1 billion tonnes which would need between 120-200 million tonnes of gypsum per year.

Gypsum is found naturally in many different forms (Figure 3).

Figure 3: Many forms of gypsum
Gypsum | Common Minerals (umn.edu)

Alabaster is a white rock, which is either made of gypsum and is therefore soft or of calcite (calcium carbonate) which is hard.

Figure 4: Alabaster gypsum

Alabaster is easily worked and so can be made into sculptures and statues (Figure 5).

Figure 5: Calcite alabaster: The tomb of Tutankhamun (d. 1323 BC) contained a practical *objet d'art*, a cosmetics jar made of Egyptian alabaster, which features a lid surmounted by a lioness (goddess Bast). Alabaster - Wikipedia

Rose gypsum

Rose gypsum or the desert flower is a rose-coloured mineral which looks like a flower and occurs in dry countries like Tunisia (Figure 6).

Figure 6: File:Desert flower.jpg - Wikimedia Commons Laura Peña
This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

When you see the different forms and the varied uses of gypsum, it really is an amazing mineral.

Sources

Gypsum - Wikipedia

https://geology.com/minerals/gypsum.shtml

Gypsum | Common Minerals (umn.edu)

□

Why not start a mineral collection in your school using the information in this series and the articles by Adrian Ryder on gemstones. Modern society is literally built on and of minerals, which are a non-renewable and often energy-dependent resource.

The sulfur story: devil's gold or essential element?

4. Hydrogen sulfide and sulfides

Hydrogen sulfide, H_2S

The smell of rotten eggs is powerful and hard to forget, even though we don't seem to get many rotten eggs these days. Chemists of a certain vintage will remember the small of rotten eggs from the school laboratory and the Kipps' apparatus, used to generate H_2S gas for use in qualitative inorganic analysis.

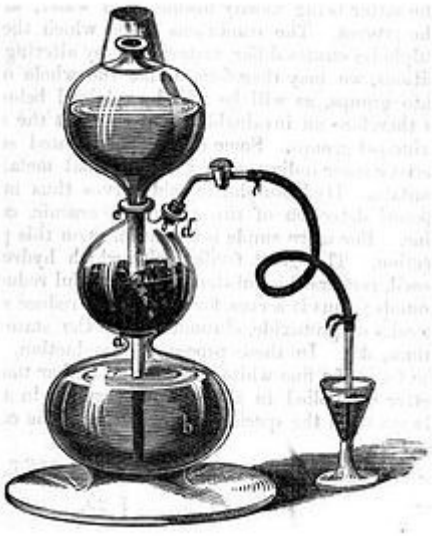

Figure 1: A Kipp's apparatus in use
[Kipp's apparatus - Wikipedia]

The gas is present in the gas over slurry pits and in volcanic areas from hot springs. Once smelled, never forgotten. It is also poisonous and is the main cause of death in slurry pits and sewers.

Hydrogen sulfide gas is produced when sulfur compounds decompose under anaerobic (reducing) conditions. When sulfide ions meet metal ions underground they often form insoluble metal sulfides, which form the ores of metals like zinc and lead. Iron (II) sulfide is also known as fool's gold from its brassy appearance. Ireland is and has been in the past a major producer of sulfide metal ores.

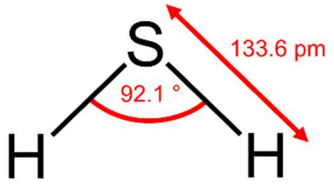

Figure 2: The structure of H_2S

Hydrogen sulfide (strictly it should be dihydrogen sulfide) is the sulfur analogue of water. Although heavier than water molecules, H_2S is a gas due to much weaker hydrogen bonding. It dissolves slightly in water and is a weak dibasic acid.

$$H_2S_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HS^-_{(aq)}$$

$$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + S^{2-}_{(aq)}$$

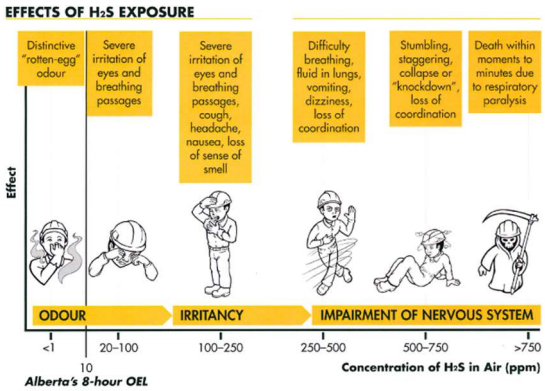

Figure 3: Effects of exposure to H_2S

Metal sulfides

Many metals form insoluble metal sulfides, many of which are important minerals such as galena (PbS) and sphalerite (ZnS) and chalococite (Cu_2S). On exposure to air these are oxidised to sulfates and if they meet acids, hydrogen sulfide is produced. Ireland

is a major producer of zinc and lead from Boliden Tara Mines in Navan (Boliden Tara - Boliden), and in the past Cu, Fe, Pb, Zn and Ag have all been mined in Ireland from sulfide ores and active exploration for new mines is underway. Some common sulfide minerals are shown in Figure 4. Silver is often found as an impurity in lead mines.

Figure 5: Some metal sulfide minerals
5.3 Mineral Groups – Physical Geology – H5P Edition (opentextbc.ca)

H_2S and sulfides are important parts of the natural sulfur cycle (Figure 6) in anaerobic conditions.

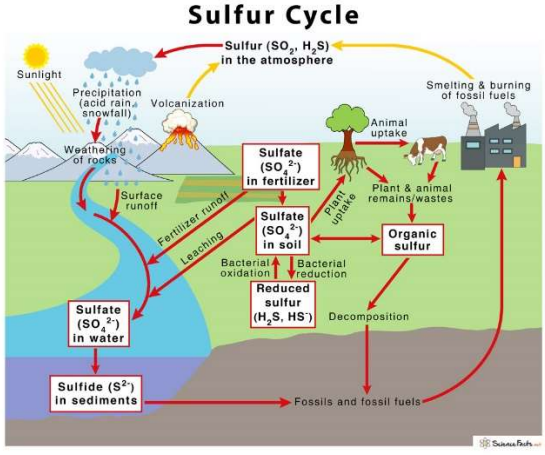

Figure 6: A simplified sulfur cycle
Sulfur Cycle with Diagram – Definition, Steps and Importance (sciencefacts.net)

Converting sulfide ores into metal involves a process known as smelting, which uses heat and often a reducing agent, to liberate the metal. In doing this the sulfide ions are converted into sulfur dioxide, which can be a major air pollutant. Often it is captured and turned into sulfuric acid. In the 19th century Avoca Mines were a major source of iron pyrites for making sulfuric acid.

Other environmental problems associated with metal sulfides are acid mine drainage (AMD) and the current problem with pyrite in blocks. When metal sulfides meet water and air they are oxidised and converted into soluble sulfates and sulfuric acid. The drainage from old metal mines like Avoca or old coal mines (iron Pyrite, fool's gold is a common impurity in coal) is often very acidic and contains dissolved heavy metals. When this flows into rivers or lakes it is a major pollution problem.

Iron pyrite present in the mineral aggregate used to make blocks can oxidise and react when exposed to water and air, leading to expansion and the cracking of building blocks. (See Amazing Minerals #1 Iron Pyrites, pyrite, Fool's gold, *CinA!* #120 Autumn 2022 pp 48-51).

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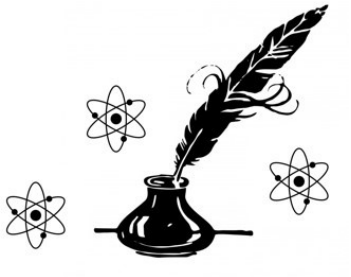
Quirky Elemental Facts in Rhyme



Helium…plus a bit about Polonium!

This super-cool element's a true Big Bang article,
It's high pitch'd and noble, so inertly hierarchical;
Is becoming more rare,
Still balloons fill the air,
Just avoid its dense core, alpha particle!

This super-cool element's a true Big Bang article,

Helium was one of the three fundamental elements formed during the Big Bang; the other two were hydrogen and lithium. Helium has an ultra-low boiling point of –269°C, making liquid helium an effective super coolant. This super coolant is necessary for superconductors to produce the powerful magnetic fields needed for specialist equipment, such as the MRI scanners hospitals use.

It's high pitch'd and noble, so inertly hierarchical;

In hierarchical terms, helium sits at the very top of the group of noble gases (group 18) on the periodic table. It's a lighter-than-air and chemically unreactive (known as *inert*) gas. These traits made it perfect for inflating airships and an ideal replacement for the flammable hydrogen that was used previously. When inhaled, helium makes your voice high pitched and squeaky because the speed of sound in helium is three times faster than it is in air.

Is becoming more rare,
Still balloons fill the air,

Helium is the second most abundant element in the universe, accounting for approximately one quarter of its mass. But it's only the 71st most abundant element in Earth's crust, where it forms during the radioactive decay of uranium and thorium and is then extracted along with natural gas. Invariably, the demand for helium (including its use in buoyant party balloons!) exceeds supply, and global reserves of the element are currently decreasing.

Just avoid its dense core, alpha particle!

When atoms of some large, unstable elements, such as uranium, thorium, radon, and polonium, undergo radioactive decay, they break up into fragments. One such fragment is a small particle with a dense core that contains just two protons and two neutrons. Known as an *alpha particle*, it's essentially a helium atom without its two electrons; in other words, an alpha particle is simply a helium nucleus (He^{2+}). Alpha particles are highly reactive and will whizz through the air in search of the pair of electrons ($2e^-$) they need to become neutral helium atoms.

$$He^{2+} + 2e^- \rightarrow He$$

Outside the body, these tiny reactive particles pose little threat; yet if they somehow manage to get inside your body, they can cause big trouble, as evidenced by the case of the notorious death of the disaffected dissident KGB agent, Alexander Litvinenko, in London in 2006. Litvinenko died in agony three weeks after drinking from a cup of green tea spiked with a few micrograms of polonium-210. The polonium, once ingested, swiftly moved via his bloodstream to the cells of his organs, where it emitted its highly reactive and ferociously destructive alpha particles. A UK judicial inquiry in 2016 affirmed a long-held claim that Litvinenko's poisoning was carried out by those working on behalf of his former Russian employers, an accusation they staunchly refuted. The case highlights polonium's notoriety as one of the deadliest of all substances: its maximum safe body burden is a mere 7 picograms (pg, or 7×10^{-12} g or 0.000000000007 g).

From chemistry lecturer to chemical entrepreneur

Henry Lyons
henrylyons66@gmail.com

Prelude

Dr Henry Lyons

I am often asked how an old-fashioned chemistry lecturer ever became involved in developing chemical enterprises based on marine algae. No, I cannot claim that I was tempted by watching the Breaking Bad TV series as I started dabbling in marine algal extracts in 1984 and filthy lucre never motivated me.

I can trace back my interest in natural resources to an event in the winter of 1965 when I was a second-year chemistry student in UCD and Professor Eva Philbin came into the lecture theatre, accompanied by a very distinguished grey-haired man wearing a long black overcoat. She introduced him as Professor Tom Dillon, retired Head of Chemistry Department in UCG and her former mentor and asked him to address the class. It was a most memorable, inspirational and motivational address as he outlined all the opportunities out there ahead of us as chemistry graduates. He emphasised the importance of both terrestrial and marine plants and the several valuable compounds that could be derived from them. It was later that I discovered that Tom Dillon was a direct descendent of John Blake Dillon, Young Irelander and orator and that the Chemistry Department in Galway was a leading research centre in carbohydrate chemistry. The second International Seaweed Symposium had also been held in Galway in 1956.

Professor Eva Philbin

Professor Tom Dillon

Fast forward to the 1980s when I was listening to David Hanley interviewing Michael Dillon (Farming journalist in RTE), son of Tom Dillon. During the interview, Michael stated that his father's biggest disappointment was that the Irish seaweed industry had never been successfully developed, as the dried product was all exported 'on the hoof' and the value was added overseas.

First Steps

The early to mid-1980s were times of high unemployment and economic depression in Ireland and nowhere more so than in Tralee, following the closure of Kingdom Tubes and the Burlington textile plant, with massive job losses. Tralee Chamber of Commerce called a special meeting to look for ideas for new enterprises and I was invited to attend as Head of School of Science in Tralee RTC (now MTU).

Brendan O'Sullivan from the local IDA office approached me after the meeting and stated that he had been approached by coastal community people who complained, that unlike Connemara and Donegal, there were no outlets for seaweed harvesters in Kerry. Over a pint in the bar afterwards, he half-jokingly challenged me to do something about it. I threw the ball back in his court and offered to have a go if he got me a decent Feasibility Study grant. To cut a long story short, I applied for the grant and was approved for about £2k and I was on my way. Sometime earlier on I had read two articles on seaweed by Michael Guiry (UCG) and Gerry Blunden (Portsmouth UK) in *Technology Ireland*, and I started to look at options other than alginate /agar/carrageenan manufacture using marine algae, available in abundance off the west coast of Ireland.

Challenges in Natural Product Chemistry

As my own postgraduate research involved synthesis of air-sensitive organometaalic complexes using organic solvents in a nitrogen atmosphere, I was not expecting any great problems in the extraction and separation of compounds of interest from seaweed using aqueous media. However I soon realised that there was a new range of challenges including the following:

- *Natural raw material of variable composition*
- *Composition is a function of species, location, season etc.*
- *Complex biopolymers-cell walls & intracellular sites*
- *Degree of polymerisation*
- *Often found in combined forms e.g. glycoproteins, polyphenols bound to proteins*
- *Extraction processes may alter composition*

I concentrated on three species of brown macroalgae: *Laminaria digitata*, *Ascophyllum nodosum* and *Fucus vesiculosus* – and started looking at what ingredient/s could be extracted and commercialised.

Chemical components of seaweed

Seaweed extracts as plant biostimulants

To help me select a suitable niche option, requiring low capital investment but reasonably good added value and scalabilty, I contacted and engaged a Mr Ernest Booth, former Director of the British Seaweed Research Institute in Inverness, as consultant. He provided a detailed report recommending that I start with an aqueous

extract of *Ascophyllum nodosum* for use in agriculture and horticulture, as there was a ready market for such a product. Kerry Algae Ltd was the first company I registered for manufacturing purposes.

These extracts are called plant biostimulants, which have application rates of 2 to 3 litres per hectare and are totally different from fresh seaweeds, traditionally added to sandy soils in bulk quantities of tonnes per hectare, by island and coastal communities to create growth media.

The term "biostimulant" is defined as "a substance or microorganism that, when applied to seeds, plants, or on the rhizosphere, stimulates natural processes to enhance or benefit nutrient uptake, nutrient use efficiency, tolerance to abiotic stress, or crop quality and yield."

This was a niche product for several years, with no shortage of sceptics as the mode of action was not understood and the theories proposed (plant growth hormones etc.) were not credible. All of this changed with advances in Molecular Biology and new genetic techniques such as DNA Microarray Technology, which shows up regulation and down regulation of genes resulting from foliar application of seaweed biostimulants. So, there is now a sound reliable scientific basis for mechanisms underlying the modes of action of these extracts and it is thought that short chain oligosaccharides act as elicitors for plant growth and protection by activating a plant's own growth and defense mechanisms.

The new EU Fertiliser Product Regulations which came into force in July 2022 have a special category for plant biostimulants, in addition to NPK fertilisers and pesticides, so seaweed extracts are moving closer to becoming ***mainstream products.***

Ascophyllum nodosum

Future prospects for seaweed extracts in agriculture and horticulture are very promising due to new environmental legislation and the growing importance of sustainable agriculture. Climate change is another influencing factor, as seaweed biostimulants have been shown to provide protection from abiotic stresses, such as those arising from drought, excess heat, frost and salinity.

Enhancement of nitrogen metabolism and fixation has become a desirable benefit of using biostimulants in recent years, as it has been shown that a 25% reduction in application rates is feasible without any loss in yields. Reducing or replacing the use of agrochemicals is likely to add to the acceptance when further research on biopesticides is completed.

Seaweed treated sandy soil from Tralee Golf Course

Reflections and Lessons learned

Kerry Algae ceased operations around 2000 and two new independent enterprises - Brandon Biosciences (www.brandonbioscience.com) and Bioatlantis Ltd (www.bioatlantis.com) were established by former employees of Kerry Algae. Their combined turnover now exceeds €25 million, with over 100 employees. Both companies are in Kerry and export about 95% of their products to over 40 countries.

Having taken the early retirement option at 60 from IT Tralee, I became Technical Director of Brandon Biosciences in 2005, a position I held until I sold out my equity and stepped down as Director in 2016.

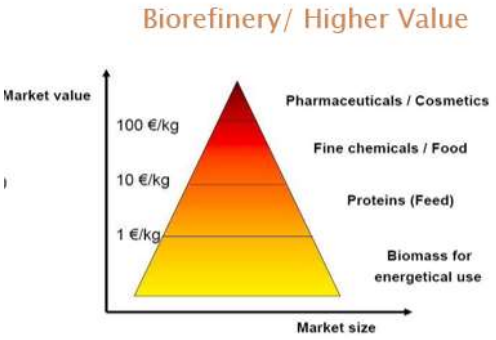
The obstacles encountered in building life science enterprises should not be underestimated. They are entirely different from IT and knowledge-based ventures, where a spare bedroom and a PC/laptop and a modem linked to broadband is all that is required to get started. Chemical and life science enterprises require suitable buildings, plant/equipment and expensive laboratory instrumentation, and their promoters must deal with planning applications, effluent treatment, emissions controls, plus a whole plethora of regulations, directives and registration requirements. I would never have started down that road if I had known what was ahead of me, but I must admit that it was my investors and colleagues who worked in the company who did most of the heavy lifting. I advised on all matters chemical and quality control and was often referred to in jest as their 'spiritual director', although I preferred to be called the catalyst.

Having got all of that off my chest I must say that the several positive outcomes and benefits resulting from what started from a very low or zero base, have made it all very worthwhile. The combined turnover and employment figures mentioned above have given a very significant boost to the local economy in Kerry and the companies continue to show healthy growth rates.

Academic outcomes include several interesting undergraduate and postgraduate projects of a practical nature, some of which resulted in new product and process developments. Several long-lasting partnerships with both public and private sector research institutes have been established at national and EU levels.

Marine Algal Biorefinery

In recent years there has been very strong interest in marine macro- and microalgae, with several high profile and well-funded projects at both national and EU levels. The emphasis has shifted from single compound extractions to a 'Biorefinery' approach, which involves the recovery of several components. For example, in the last century alginate was the only high value ingredient obtained from brown macroalgae. Manufacturing plants operated by Kelco in San Diego and Alginate Industries in Girvan in Scotland, extracted the alginate fraction and pumped the remaining solids and solutions out into ocean and sea. This meant that bioactive components such as fucoidan, laminarin , polyphenols and mannitol were flushed away and discarded.



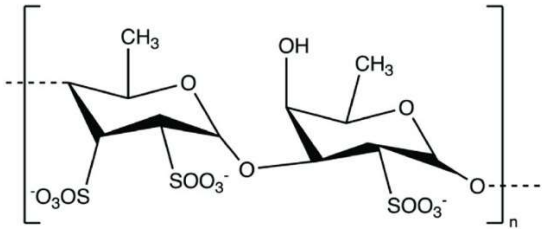
Market value versus market size for a biorefinery

There are several interesting unique biopolymers in Irish seaweeds, which are known to have important applications in functional foods, nutraceuticals, medicines, cosmetics, plant care and perhaps bioenergy in the future. Research and development work has been ongoing in recent decades and marine algae are now the subject of a concerted effort by public and private sector research laboratories for commercialisation purposes.

Recent enterprise developments

Nutramara

In 2017 I was contacted by a local serial entrepreneur, who was interested in starting a new seaweed venture to manufacture high value marine ingredients for use as nutraceuticals, food supplements and as ingredients in cosmetics and pharmaceuticals. This got me out of my retirement from seaweed affairs and a new company Nutramara Ltd was established (www.nutramara.com). The first ingredient selected was Fucoidan –a sulphated polysaccharide - and working with Shannon ABC/MTU, Moorepark Technology and the Teagasc Food Research Centre in Ashtown at laboratory, pilot and full scale, a novel biorefinery process was developed. The process is totally aqueous with zero waste as two further bioactive components are recovered and the remaining solids and filtrates are transferred to a sister company for use in agriculture and forestry.



The structure of fucoidan (a biopolymer)

Laminarin – a marine beta glucan – is a second ingredient, which is being isolated and undergoing further development in conjunction with the School of Pharmacy in TCD.

Two satellite companies have also been spun out from Nutramara: Seabody Ltd. manufactures and markets a range of skincare and health supplements (www.seabody.com) and Blue Pet Co Ltd. has an exciting range of pet care supplements (www.bluepetco.com). Fucoidan from Nutramara is a core ingredient in both cases and a new manufacturing facility is nearing completion in Burtonport, Co. Donegal.

SEABODY™

BLUE PET Co

Future prospects

As an island with an extensive coastline of over 3000 km, it is not surprising that Ireland has a long and interesting history of seaweed use that is likely to continue. Its location in the North Atlantic Ocean, with mild climatic conditions arising from the warm waters of the Gulf Stream, ensures an abundant and diverse natural seaweed resource . Although many applications have been developed over the centuries, only a small fraction of the total biomass is being utilised, but that situation is about to change

as attention is now turning to the sea as a source of food , energy and basic raw materials for the chemical and pharmaceutical industries. The wild harvest will provide sufficient biomass for the foreseeable future, but the long-term prognosis based on global trends points to aquaculture.

Biography

Dr Henry Lyons obtained B.Sc(Hons) and PhD degrees in chemistry from University College Dublin and had over thirty years experience in third level academic institutions before moving to the private sector to commercialise some R&D work on developing novel products from natural resources.

He coordinated Teacher Refresher Courses for the Institute of Chemistry of Ireland and the Irish Science Teachers association for several years between 1975 and 2000 and later Chairman of the NCCA Senior Cycle Chemistry Curriculum committee.

After eight years as a Lecturer in Chemistry in the Dublin Institute of Technology he returned to Kerry to become the first Head of School of Science at the newly established Tralee RTC which was later known as the Institute of Technology, Tralee and is now part of Munster Technological University. In 1998 he became Head of Development at the Institute with responsibility for external liaison with public and private sector groups in the region as well as campus enterprise development. He was the main driving force behind the establishment of the Shannon Applied Biotechnology Centre.

He took the early retirement option in 2005 to become Technical Director of Brandon Products Ltd and in 2017 became the Scientific Director of Nutramara Ltd, a new marine biotechnology company which was set up to manufacture a range of food ingredients and nutraceuticals from marine macroalgae.

□

Note: It is hard to keep track of all the seaweed-based companies which have started up in Ireland in the last 20 years or so. A good source of information is the website seaweed.ie based at the University of Galway, which has a list with links of seaweed-based companies.
The Seaweed Site::Seaweed Suppliers in Ireland

See also:

(17) (PDF) The seaweed resources of Ireland: a twenty-first century perspective (researchgate.net)

For more on Professor Tom Dillion see https://www.universityofgalway.ie/about-us/news-and-events/news-archive/2019/september/centenary-celebration-of-chemist-revolutionary-and-academic

Dictionary of Irish Biography
Dillon, Thomas Patrick | Dictionary of Irish Biography (dib.ie)

Two useful posters for your laboratory:

How seaweed is used in Ireland (Heritage Council)

Seaweed Poster.indd (heritagecouncil.ie)

Chemlingo: A rose by any other name ..

Peter E. Childs

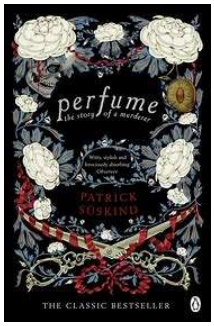
An earlier Chemlingo talked about the various words used for gases and mentioned perfume. Rose-scented perfumes may owe nothing these days to the rose and everything to the chemist's art for synthesising molecules with specific aromas. Synthetic chemicals (usually organic) are mixed to simulate the natural scent and fool the nose into thinking that we smell a real rose. Smell has always been important in chemistry, and not for nothing is chemistry known as 'Stinks' at school. Chemistry laboratories have a distinctive smell, particularly organic laboratories, where the walls and benches exude years of absorbed organic molecules.[1] Early chemists used smell and taste to identify chemicals, which were not without their hazards.

Smells can bring back olfactory memories of days at school or university spent creating these smells. Olfaction is a fancy word for smelling and comes from the Latin *olfactus*, from the Latin *olere* to smell. The Greek *osme* for smell was used to name the element osmium, because its oxide has a disgusting smell. Bromine was also named because of its pungent smell from the Greek *bromos* = stench.

Smell, scent. aroma, fragrance, perfume are all words relating to the sensation produced in the nose by volatile chemicals. If a molecule can't get up our noses and trigger a response, then we can't smell it or taste it, as our experience of a cold tells us. Most organic compounds smell because they are volatile and so we can breathe them in, whereas most inorganic solids are not volatile and don't smell. Aroma (Greek and Latin *aroma* meaning sweet smell) is found in aromatic, a word coined to describe the sweet-smelling organic molecules related to benzene. Some compounds were named because of their smell, for example, cacodyl compounds containing the $(CH_3)_2As$ group – from the Greek *kakodes* = foul-smelling.

Fragrance comes from the Latin *fragrantia* = sweet-smelling. Fragrance and perfume go together and perfume comes the Latin *par fumum*, burning incense, which became French *parfum.* Perfumery is an industry, a science and an art, with a major chemical component and its own specialist language. The perfume or scent of a plant is due to a mixture of molecules, which the chemist can separate and identify using modern analytical techniques. Commercial perfumes are blends of many chemicals each with their own smell.

Patrick Süskind wrote a rather disturbing book called *Perfume* (made into a film), about a man obsessed by smells. He reminds us vividly of the power of smell, and a familiar smell can transport us in memory back to the past, as also did Marcel Proust in *Remembrance of Things Past.*
"Odours have a power of persuasion stronger than that of words, appearances, emotions, or will. The persuasive power of an odour cannot be fended off, it enters into us like breath into our lungs, it fills us up, imbues us totally. There is no remedy for it."[2]



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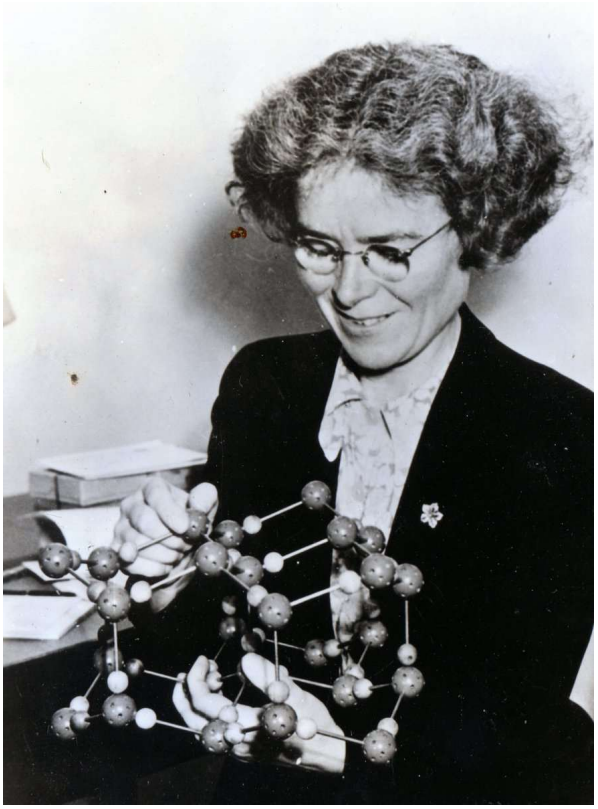
1. Childs, Peter E. , *Education in Chemistry*, 'Chemistry stinks!', July 1994, p.88
2. Patrick Süskind, (1985), *Perfume: the story of a murderer*

Chemical Quotes:
Kathleen Lonsdale 1903-1971
The importance of imagination in science



"Observation is not enough, and it seems to me that in science, as in the arts, there is very little worth having that does not require the exercise of intuition as well as of intelligence, the use of imagination as well as of information."

Kathleen Lonsdale

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In the next issue:

- **Great Irish Chemists: Eva Philbin**
- **George Wurtz**
- **Sulfates**
- **Proceedings ChemEd-Ireland 2024**

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