Contents #109

1. Contents
2. Editorial #109
3. In this issue
4. Education News and Views
5. TIMSS 2015
10. PISA 2015
13. STEMERG Report
18. TY Science Module: Medicines in my life — Sarah Hayes
20. Proceedings, ChemEd-Ireland 2016
21. In a Little You Can See a Lot — Bob Worley
28. SCIENCE & Environmental News: Acrylamide back in the news; Plastics waste and recycling: an urgent societal problem; Types of plastic; The circular economy
32. Elementary Chemistry
36. Learning about the nomenclature of organic compounds by creating stop-motion videos — Moritz Krause and Ingo Eilks
39. Authentic Research in Everyday Life: Brand Name, Generic, or Home Remedy? Which Antacid Works Best for the Money? — Michele A. Whitecraft
48. Chemists you should knoiw #1 Amedeo Avogadro — Adrian Ryder
Diary
51. Classic Chemical Quotations:7 Amedeo Avogadro (9/8/1776-9/7/1856)
52. Inquiring into energy through simple experiments — Klemens Koch
57. Chemistry and chance: Clathrates — Peter E. Childs
58. Fifth Annual BASF Summer School for Chemistry Teachers in University College Cork Ireland — Declan Kennedy
60. The RDS Primary Science Fair at Mary Immaculate College, Limerick — Anne O' Dwyer, Maeve Liston, Miriam Hamilton
63. Chemlingo: Sharp stuff — Peter E. Childs
64. Information page

Disclaimer

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Editorial #109

A deluge of reports

You know what they say about buses – you wait a long time for one, and then three turn up together. The end of 2016 saw 3 important reports published within a month. First came the long-awaited STEM Education Review Group (STEMERG) Report (Nov. 24th), then the 2015 TIMSS report (Nov. 29th) and finally the 2015 PISA results (Dec. 6th). All of them are featured in this issue, with particular attention on the STEMERG report.

The future of STEM in Ireland

The STEMERG report was launched on Nov. 24th in Dublin in a very low-key way. Richard Bruton announced that 21 of the Report's 47 recommendations would be given priority (although on the website only 19 are listed). On p. 13 you can find the recommendations of the report, with the ones mentioned for priority action shown in bold. This is an important report and should be widely read.

I think it is a pity that the opportunity was not taken to have a more public launch, perhaps at a conference to present and debate the recommendations of the report, with a wide representation from the science education community. There did not seem to be an explicit link to and assessment of the 2002 report of the Task Force on the Physical Sciences, which surely should have provided the starting point for this Review. How do the two sets of recommendations relate to each other? What happened as a result of the 2002 Report and what were the problems in implementing its (excellent) recommendations? I would have thought that these were questions worth addressing.

However, as we have said before, the group was not fully representative of science education or teachers. It was due to report within 6 months and it has taken 3 years. This means that its views were not taken into account in the new JCSA Science course (now started in schools) or in the revision of the LC science courses. It would seem sensible first to review the situation and make recommendations, then to implement them in the revision of the JCSA science course, and finally to revise the LC science courses in the light of the new JCSA course. In fact what has been done is the exact opposite of this.

There is a major need for integration of the new, shorter junior cycle course and the LC science courses that will follow it in 2019 (at the earliest). This needs to be made clear to teachers and at the moment there is a lack of information in the public domain about the revision of the LC science courses, and how they will link to the new JCSA courses. There are still big questions about assessment and in particular the assessment of the practical component. The unwillingness of teachers to assess their own students will be a key factor in whether it is feasible and practicable to have in-school assessment of practical work in all three LC science courses biology, chemistry and physics. The logistical and financial implications of giving in-school practical assessments to over 40,000 students are horrendous. As far as I know, the syllabus committees have been disbanded and further development work on the three courses is solely in the hands of the NCCA.

International comparisons

The TIMSS and PISA reports both were based on surveys conducted in 2015. They thus provide a snapshot of how Irish students compare with students from other countries. The TIMSS survey looks at 4th class in primary school and 2nd class in secondary school students. For more detail on these reports (see p. 5 for TIMSS and 10 for PISA). In general in both surveys Irish students are holding their own in international comparisons, but as so many school reports say: "Could do better." You could argue, that given the relatively poor funding of education in Ireland and shortage of resources at primary and secondary level, that Ireland is punching above its weight.

Peter E. Childs
Hon. Editor

In this issue:

I want to highlight some of the items in this issues and their potential for chemistry teachers.

There is considerable focus at the start on three important reports two international reports on student performance (PISA and TIMSS) and the national STEM Education Review Report.

Elementary chemistry throws up the issue of aluminium recycling. Al cans are easy to collect and recycle and present massive savings of energy and raw materials. How many cans are used in your school each week? The answer may surprise you. How would you conduct the survey? What mass of aluminium does this represent? (p.33-34)

The chemical definition of an element is something that cannot be created or destroyed, or turned into anything simpler. If this is so, how can elements be endangered? (p. 35) We talk about running out of oil, but is it possible to run out of certain elements? Get your LC chemistry class to adopt and research an endangered element. What can we do about it?

An even bigger issue is raised by the problem of waste plastic, particularly microplastics and their effect on the oceans. This would make an interesting TY project. How much plastic does the average household use and dispose of in a week? How many plastic bottles are one-use only? (p.29) How many plastic bottles and what mass of plastics are produced in your school each week? What sort of plastics are involved? This helps introduce and revise the plastics recycling symbols. (p.30) Are all plastics equally valuable and easily recycled?

Get your LC chemistry or TY class to research the topic of the Circular Economy and look for ways in which waste in Ireland could be recycled and reused. (p.31) Estimate the production of coffee grounds in Ireland and where it could be used.

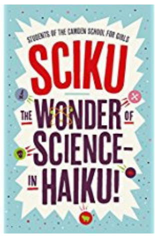
Consumer chemistry has several dimensions: the environmental impact of products (see microbeads in cosmetics) and the source of raw materials, but another one is value for money and the 'best buy'. The article by Michelle Whitecraft on 'Which antacid is best' (p. 39) is a nice example of simple chemistry, which also connects to economics and introduces nature of science in a relevant context.

Thermochemistry is one of those topics which is conceptually difficult and it is always useful to have some nice experiments or activities. On p. 52 Klemens Koch, a Swiss chemistry teacher and teacher educator, gives three ideas for thermochemistry-related experiments or demonstrations.

Teaching organic nomenclature can be a drag for teachers and pupils. The article by Moritz Krause and Ingo Eilks on p.36 shows how to harness smart phones or tablets to teach nomenclature.

Last but not least, Bob Worley (p. 21) introduces some excellent ideas for using microchemistry in the chemistry classroom and laboratory. His thesis is that you can do a lot with a little, and in the process save money, reduce risks and minimise waste disposal.

'Chemists you should know' is a new historical series by Adrian Ryder, following on his previous series on famous chemists. (p. 48) Why not use these articles in your teaching and get the class to research a famous chemist and make a poster or presentation on them and why they are important. This might be an interesting way to learn some chemistry and some history at the same time. Use the Classic Chemical Quotations series to make some classroom posters. Your students could use the idea to make their own.



Chemistry can be creative. Can you get your students to come up with some good chemical poems or limericks or haikus? This can be a stimulating way to learn some chemical ideas in a creative way. I came across an article by Simon Flynn 'Sciku: writing science in haiku' in *School Science Review* 97(359), Dec. 2015, based on a school project, which led to a book of haikus (see picture above), available on Amazon. This is an example of a chemical haiku.

The element of surprise
Oxygen went out
With magnesium today
I'm like OMg!

Education News and Views

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

STEMERG Report

http://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf

As mentioned in the Editorial, the STEM Education Review Group report was published on Nov. 29th 2016, having been ready for over a year. On p. 13 below we give the list of 47 recommendations in the Report. The devil is not in the detail but in the implementation. Will the Minister for Education and Skills act quickly and decisively on the 21(?) recommendations he said he would deliver as a priority. Evidently early in 2017 the Minister will produce a policy paper on STEM education, building on the findings of the report. One of the problems in the past in implementing reports has been in-fighting between interested parties as to who should get the cake and the contracts.

A good case in point is the general recommendation

- *Establish a National STEM Education Research Centre, comprising a small number of regionally distributed nodes (based on the highly successful UK Science Centre model). This national centre would act not only as a centre of excellence for research and innovation in STEM education, it would also provide locations for delivery of CPD programmes for teachers.*

Such a National Centre was established in Limerick in 2008, the National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL), now renamed EPI-STEM. The Centre runs the successful up-skilling programme for out-of-field maths teachers. However, there is also a large STEM centre in DCU (CASTeL), recently strengthened by the merger of DCU and the Dublin primary education colleges. There is also significant STEM education activity in DIT, TCD, UCC, WIT, LIT, NUIM and NUIG.
I would have liked to have seen more links to the important Task Force report of 2002, so we could learn from prior experience. There was very little detail on the ongoing activity in science education research and the work of the number of active science education centres around the country.

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Science teacher numbers

One interesting set of data in the STEMERG report (Table 5, p. 21) was the number of teachers recognised to teach various STEM subjects by the Teaching Council. An individual teacher may be qualified to teach more than one subject and usually are e.g. biology and chemistry, or physics and maths. Also the data refer to all recognised teachers and does not indicate whether they are employed or not, or whether they are permanent or temporary, full-time or part-time. The data does not necessarily reflect the active composition of the STEM teaching population, but it is still interesting.

Number of registered STEM teachers with the Teaching Council (STEMERG Report, 2016, p. 21).

Subject	No. Registered teachers (2014)
Agricultural Science	729
Applied Mathematics	420
Biology	3,694
Chemistry	2,305
Computer Studies	580
Construction Studies	1,352
DCG	1,215
Engineering	769
Mathematics	5,171
Physics	1,197
Physics and Chemistry	24
Technology	159

It shows, not unexpectedly, that biology teachers are most common, but does not show massive shortages of chemistry teachers or physics teachers, although twice as many teachers are qualified to teach chemistry than physics. We also need to remember that although nearly all schools offer LC biology, this is not true for LC chemistry and physics. Teachers qualifed to teach biology, chemistry or physics can also teach junior science.

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TIMSS 2015 Trends in Mathematics and Science Study

TIMSS (Trends in International Mathematics and Science Study) is a project of the International Association for the Evaluation of Educational Achievement (IEA). It assesses the mathematics and science achievement of pupils in the Fourth and/or Eighth grades (equivalent to Fourth Class and Second Year in Ireland). First conducted in 1995, TIMSS takes place every four years. The 2011 cycle – when Ireland participated in the Fourth grade component only – was the first time that Ireland had taken part since 1995. Ireland also took part in 2015, at both grade levels.

TIMSS is managed at an international level by the International Study Centre in Boston College. Within each participating country, a National Research Centre manages the study. In Ireland, this role is filled by the Educational Research Centre. The Centre is supported in this work by a National Advisory Committee at each grade level, chaired by the Department of Education and Skills, and with representatives from the main education stakeholders.

A major purpose of TIMSS is to provide background information that can be used to improve teaching and learning. For example, the study collects detailed information about curriculum and curriculum implementation, instructional practices, and school resources. The assessment is based on comprehensive assessment frameworks developed collaboratively with the participating countries. The frameworks specify in some detail the knowledge, skills, and understandings to be assessed.

The IEA is also responsible for PIRLS (Progress in International Reading Literacy Study). In 2011, the cycles for TIMSS and PIRLS coincided for the first time, giving countries the opportunity to take part in one or both assessments. Of the 63 countries that took part in TIMSS (at either Fourth or Eighth grade, or both) in 2011, 34 – including Ireland – also took part in PIRLS.

The initial Irish report on PIRLS and TIMSS 2011 was published in December 2012 (Eivers & Clerkin – PIRLS and TIMSS 2011: Reading, mathematics and science outcomes for Ireland) and a set of thematic analyses of the Irish data were published in 2013 (Eivers & Clerkin – National Schools, international contexts). The International Study Center also publishes international reports on the main results for mathematics and science. The main international results for TIMSS 2011 were published in December 2012. As some countries assessed the same pupils in PIRLS and TIMSS 2011, an additional international report, analysing the relationship between performance across the three domains of reading, mathematics and science, was published in October 2013.

The most recent TIMSS assessment took place in 2015. An initial Irish national report summarising Irish students' mathematics and science performance (at both Fourth Class and Second Year) will be published by the ERC on November 29th 2016, to coincide with the publication of the international mathematics and science reports by the IEA. http://www.erc.ie/wp/wp-content/uploads/2016/11/TIMSS-initial-report-FINAL.pdf

A series of more detailed analyses, discussing factors associated with achievement and the broader educational context in Ireland, will be published by the ERC in 2017.

http://www.erc.ie/programme-of-work/timss/

The latest TIMSS study of science and mathematics achievement looks at fourth class at primary level and second class at second level. The Irish report is available at: http://www.erc.ie/wp/wp-content/uploads/2016/11/TIMSS-initial-report-FINAL.pdf

Comparison of performance in all TIMSS studies (500 = mean score)

Year	4th class Maths Score (SE)	4th class Science Score (SE)	2nd. Class Maths Score (SE)	2nd Class Science Score (SE)
1995	523 (3.5)	515 (3.5)	519 (4.9)	518 (5.1)
2011	527 (2.6)	516 (3.3)	-	-
2015	547 (2.1)	515 (3.5)	523 (2.7)	530 (2.8)

Ireland participated in the previous TIMSS study (2011) for fourth class only but before that only in the 1995 study, for fourth and second classes. Unlike PISA, it is not possible to track the performance of Irish students consistently over the period TIMSS has operated. In each year Ireland has participated the scores have been above the mean value (500). The table above shows the Irish scores since 1995.

The key findings of the report include:

- Irish fourth class students ranked 9th out of 49 countries in maths (up from 17th out of 50 countries in 2011).
- Irish fourth class students ranked 19th of 47 countries in science (broadly consistent with 22nd position out of the 50 countries that participated in 2011).
- Irish second year students ranked 9th of 39 countries in maths, (there is no recent study with which to compare this).
- Irish second year students ranked 10th of 39 countries in science (there is no recent study with which to compare this.)

The material below is taken from the summary (ch. 9), but there is a lot of detail in the report that is worth reading.

Ch. 9 Summary (p57-59)

Source: http://www.erc.ie/wp/wp-content/uploads/2016/11/TIMSS-initial-report-FINAL.pdf

Overall performance at Fourth Class

Fourth Class pupils in Ireland achieved a mean score of 547 in mathematics and 529 in science, both of which were significantly above the corresponding TIMSS centre=points (500). Seven countries (including Singapore, the Republic of Korea, Hong Kong and the Russian Federation) had significantly higher mathematics performance than Ireland at Fourth grade, while 15 countries (including Finland, the United States, Slovenia and England, as well as those already mentioned for mathematics) significantly outperformed Ireland in science.

Pupils in Ireland performed significantly less well than pupils in Northern Ireland in mathematics, but significantly better in science. Fourth Class pupils in Ireland achieved significantly higher mean mathematics and science scores in 2015 than in 2011 (527 for mathematics and 516 for science) and 1995 (523 for mathematics and 515 for science). In Ireland, although boys achieved slightly higher mean scores than girls for mathematics (by four points) and science (five points) at Fourth Class, these differences were not statistically significant.

Across all countries that participated in TIMSS at Fourth grade in 2015, average mathematics performance was similar for boys and girls (505 for both boys and girls), while girls outperformed boys in science (508 and 504, respectively). Both boys and girls in Fourth Class have seen improvements in mathematics and science performance since 1995, with most of the gains in achievement occurring between 2011 and 2015. Boys in Ireland saw an improvement of 20 points in their mean mathematics score since 2011, and, since 1995, an improvement of 28 points in total. Similarly, the mean mathematics scores of girls in Ireland improved by 19 points since 2011 and 20 points since 1995.

For science, there was an improvement of 16 points for boys since 2011 and 1995, while the mean science performance for girls improved by 11 points since 2011 and 14 points since 1995. 14 As noted in earlier chapters, the centre-point for each domain represents the average of all participating countries in TIMSS 1995, and has been used since then as a constant reference point against which to measure change over time. It is not an international average for the current cycle. TIMSS 2015 in Ireland: Mathematics and science in primary and post-primary schools.

Overall performance at Second Year

Second Year students in Ireland achieved mean scores in mathematics (523) and science (530) which were both significantly above the corresponding TIMSS centre-points (500). Six countries (including Singapore, the Republic of Korea, Hong Kong and the Russian Federation) achieved significantly higher mean mathematics scores than Ireland, while seven countries significantly outperformed students in Ireland in science (including Slovenia in addition to the six countries that performed significantly better in mathematics). Although not statistically significant, Ireland's mathematics performance improved by about 5 points since 1995, while there was a significant improvement of 12 points in the mean science performance of students in Ireland.

While Second Year boys in Ireland outperformed girls by five points on mathematics (526 and 521, respectively) and girls had a mean score that was two points higher than that of boys on science (531 and 529, respectively), these differences are not statistically significant. Across all countries that participated in TIMSS, girls outperformed boys by ten points in science (491 and 481, respectively) and by three points in mathematics (483 and 480, respectively).

The mean mathematics score for boys in Ireland increased by one point since 1995, while girls saw an improvement of nine points. For science, boys' mean performance increased by two points and girls' mean performance increased by 21 points.

Distribution of performance

Mathematics and science performance can also be described in terms of the spread or the distribution of performance, from lower- to higher-achieving students. The general pattern in Ireland for both domains and grade levels is that the lowest-achieving students tend to perform relatively well, while performance among the highest-achieving students is somewhat poorer when compared to their peers in countries with similar overall performance.

At Fourth grade, the performance of the lowest-achieving pupils (i.e., those at the 5th percentile) in mathematics is somewhat higher in Ireland than that of the corresponding pupils in England (a country with similar mean mathematics performance to Ireland) but is similar to the performance of the lowest-achieving pupils in Northern Ireland (who had significantly higher overall mathematics performance than pupils in Ireland). On the other hand, the highest-achieving (i.e., those at the 95th percentile) pupils in mathematics at Fourth grade in Ireland are underperforming relative to their peers in England and Northern Ireland. There have, however, been improvements in the mathematics performance of lower- and higher-achieving pupils in Ireland since 1995, although the improvements are particularly marked among the lower-achieving pupils.

For science at Fourth grade, the lowest-achieving students in Ireland are performing relatively better than their counterparts in Australia (a country with similar overall science performance at Fourth grade) and in Northern Ireland (who performed significantly less well overall in science than pupils in Ireland). On the other hand, while the performance of the highest-achieving students in science in Ireland is somewhat better than that of pupils in Northern Ireland, it is very slightly lower than the performance of these pupils in Australia. Since 1995, there has been a considerable improvement in the performance of lower-achieving students in science at Fourth grade in Ireland, but a slight disimprovement among the higher-achieving students.

A similar pattern emerges for mathematics at Eighth grade. The lowest-achieving students in mathematics in Ireland performed somewhat better than their counterparts in the United States and similarly to the corresponding students in England (two countries with similar overall mathematics performance to Ireland at Eighth grade). On the other hand, the performance of the highest-achieving students in Ireland is somewhat lower than their counterparts in England and the United States. The performance of the highest-achieving students in Ireland is similar to the performance of these students in Australia and New Zealand, two countries that had lower overall mean mathematics performance compared to Ireland. Also, performance of the lowest-achieving students in mathematics in Ireland has improved since 1995, although there has been a small disimprovement among the higher-achieving students in this time.

For science at Eighth grade, the lowest-performing students in science in Ireland are performing at similar levels to those in the United States, but slightly less well than the corresponding students in England, two countries that have similar overall science performance to Ireland. At the other end of the achievement distribution, the performance of the highest-achieving students in science in Ireland is somewhat lower than their counterparts in England and the United States. As with mathematics, there has been an improvement in the performance of lower-achieving students in science at Second Year, while performance has declined somewhat among the highest-achieving students.

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ISTA Conference

This year's ISTA Conference is being hosted by the Kildare branch and will be held in NUI Maynooth, 7-9th April. For details and registration:
http://www.ista.ie/ista-conference-2017/

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ISTA Senior Science Quizzes

- Regional Rounds Thursday 16th November at 13 venues nationwide.
- National Final Saturday 25th November in Trinity College Dublin.

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ESERA 2017

ESERA is the largest science education research conference in Europe and is held every 2 years. In 2017 the conference is being hosted by Dublin City University, in collaboration with the University of Limerick. The conference attracts over 1,000 researchers and runs from August 21-25 in DCU. For more information:
http://www.esera2017.org/

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TEMI workshops

The TEMI project officially finished in August 2016 but the UL TEMI team offered to run workshops in the 2016-2017 school year for ISTA branches. After a slow start workshops are planned for 2017 in Clonmel, Ballybofey, Sligo, Galway, Clare and Limerick, as well as a workshop at the ISTA conference in Maynooth in April. The workshops take the form of a circus of mysteries, where science teachers get to try out a number of scientific mysteries, which can be used to engage students and introduce them to inquiry. If we haven't exhausted the market by April, ISTA branches that would like a workshop after Easter should contact Laurie Ryan (laurie.ryan@ul.ie) to arrange a visit.

The TEMI project produced two TY modules based on the TEMI idea, written and trialled by 2 4th year science education students from UL. Copies will be made available online or by emailing: laurie.ryan@ul.ie.

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Circulation of Chemistry in Action!

A reminder that from this issue, we will no longer be mailing out individual copies of Chemistry in Action! to teachers, because of the increase in postage costs. If you want to get sent electronically send your email address to Marie Walsh at marie,walsh@lit.ie

The magazine and back issues will also be available on a website.

Hard copies will still be printed, in reduced number, and will be given out (while stocks last) at the ISTA and Chem-Ed Ireland conferences each year.

There is also an option, available to ISTA branches and science teacher training institutions, to order bulk copies of Chemistry in Action! The minimum order is 10 copies at €5 per subscription, which will cover 2 copies plus extras, sent to one address. Thus 10 copies to one address would cost 10 x €5 = €50 for 2 issues. If you are interested in this option, please send your order plus cheque (payable to Chemistry in Action!) to Marie Walsh, School of Science, Limerick Institute of Technology, Moylish, Limerick.

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6th Annual BASF Summer School

The sixth annual BASF Summer School for Chemistry teachers will be held on Tuesday 27 June and Weds 28 June 2017 in the Eureka Centre, University College Cork. Full details will be sent to chemistry teachers nearer the date.
Contact Declan Kennedy at d.kennedy@ucc.ie

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New Energy teaching materials

SEAI has produced a set of teaching materials on energy, 'Energy in Action' for the new Junior Science course. Energy in Action is a new programme for teachers to help young people learn about energy through the Junior Cycle curriculum. Subjects included in this are Science, Home Economics, Geography and CSPE. There are four strands in total and you can either download the strand in full or pick the activities you want and download them individually. They can be accessed at the website below. The four strands are:

A. Energy and sustainability
B. Heat energy
C. Energy awareness
D. Problem solving in the real world

http://www.seai.ie/Schools/Post_Primary/Energy-in-Action/

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ChemEd-Ireland conferences

This year's ChemEd-Ireland conference will be held on Saturday October 21st. at the University of Limerick. It will be held in the new Analog Devices Building, part of the Bernal Institute. The local organizer is Dr Sarah Hayes (sarah.hayes@ul.ie). The theme will be 'Chemistry and Society' and more details will be given later. The day will consist of lectures and workshops of interest to teachers of chemistry.

The ChemEd-Ireland conferences for chemistry teachers were started in 1982 by Dr Peter Childs at Thomond College of Education and continued after the merger with UL at the University of Limerick. After running 25 conferences in Limerick, the conference went on the road from 2006 and has moved between several institutions, on the east and west coasts. The organisers at each institution decide on the programme for each year. The Proceedings of the conference are published in the Spring issue of *Chemistry in Action!* as a permanent record.

This year's conference returns to the University of Limerick and will be organised by Dr Sarah Hayes and her team. The conference is held on the Saturday prior to the mid-term break and this year it is on October 21st 2017.

The venues and organisers for the next few years are as follows:

2017	UL Sarah Hayes
2018	TCD John O'Donoghue
2019	DIT (Grangegorman) Claire McDonnell
2020	UCC Declan Kennedy
2021	DCU Odilla Finlayson
2022	LIT Marie Walsh

TCD is a new venue and has been added in to reset the calendar so that DCU hosts it in an odd year,so that it does not clash with the biannual SMEC conferences. John O'Donoghue is the RSC Education Officer for Ireland based in the Department of Chemistry at TCD.

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11th Chemistry Demonstration Workshop at UL

This year's Chemistry Demonstration Workshop at UL will be run a week later than usual from July 3-7. Teachers who have attended this course over the past 10 years have found it very enjoyable and beneficial in their teaching. The course also includes half a day on simple physics demonstrations. At the end of the coruse participants, working in pairs, present a science magic show based on the work they have done during the week. The workshop usually includes a number of final year science education students.

This is a residential course and the cost of €100 includes meals and accommodation on campus. For details and an application form contact:
Sarah.hayes@ul.ie

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Chempics

The American Chemical Society magazine C&ENews is famous for its excellent illustrations. The ACS has a website with the best of these pictures at cen.chempics.org.

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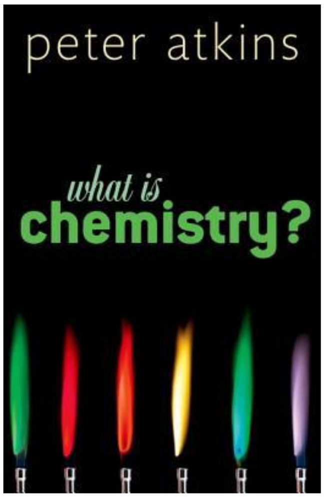
What is chemistry?

Peter Atkins (2013) OUP



"Chemistry, I have to admit, has an unhappy reputation. People remember it from their schooldays as a subject that was largely incomprehensible. Fact-rich but understanding-poor, smelly, and so far removed from the real world of events and pleasures that there seemed little point in coming to terms with its grubby concepts, spells, recipes, and rules."
Peter Atkins from the Preface

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PISA 2015

Programme for International Student Assessment
http://www.erc.ie/studies/pisa/

The mathematics, reading and science results from PISA 2015 were launched on Tuesday, the 6th of December 2016 at St. Patrick's College, DCU. The National Report is available online at http://www.erc.ie/wp/wp-content/uploads/2016/12/PISA2015_FutureReady.pdf

Press summary

(http://www.erc.ie/wp/wp-content/uploads/2016/12/PISA-2015-ERC-Press-Release-2.pdf)

The results of the sixth cycle of the Programme for International Assessment (PISA), sponsored by the Paris-based Organisation for Economic Cooperation and Development (OECD) (of which Ireland is member) were released today. The PISA 2015 assessment was administered to over 500,000 students in 72 countries/economies.

PISA 2015 is the first cycle in which PISA has been administered entirely on computer in most participating countries, including Ireland. PISA is implemented in Ireland by the Educational Research Centre (ERC) on behalf of the Department of Education and Skills. In March 2015, the PISA tests of science (the major assessment domain in this cycle), reading literacy and mathematics (the minor domains) were completed by 5,741 students in 167 schools. The students also completed questionnaires, as did their parents and school principals. The tests were administered by members of the inspectorate of the Department of Education and Skills and test administrators working on behalf of the ERC. Students completed the tests on computer. In addition to the move to computer-based assessment, PISA 2015 incorporated a number of additional changes including the transition to a new (hybrid one- and two-parameter) scaling model, a new approach to defining the calibration sample (the sample of students on which links to earlier cycles depend), and the way in which not reached items at the end of a test section and country by item interactions are treated. The design of the PISA tests also changed, with equivalent numbers of units and items in major and minor domains completed by most test takers (thereby strengthening the content coverage in the minor domains).

Students in Ireland achieved a mean score on PISA 2015 science (503 points) that is significantly higher than the average for OECD countries (493). Ireland ranked 13th of 35 OECD countries, and 19th of 70 participating countries . On reading literacy, students in Ireland achieved a mean score (521) that is also significantly higher than the corresponding OECD average (493), with a ranking of 3rd among 35 OECD countries, and a ranking of 5th of 70 participating countries. Students in Ireland achieved a mean score of 504 on mathematics, which is significantly higher than the average for OECD countries (490.0). (PISA scores are scaled to an OECD average of 500 and a standard deviation of 100 in the first cycle in which they are a major domain (2000 for reading literacy, 2003 for mathematics, and 2006 for science).

Ireland ranks 13th of 35 among OECD countries, and 18th among 70 participating countries. Singapore ranks first in all three domains, while Japan, Estonia, Chinese Taipei, Finland, Hong-Kong China and Macao China finished in the top six in two domains. In each domain, there were fewer lower-achieving students in Ireland (those achieving below Proficiency Level 2) than on average across OECD countries. On the other hand, the proportions of high-performing students (those achieving Proficiency Levels 5-6) were slightly below the corresponding OECD proportions in science and mathematics. More students in Ireland than on average across OECD countries performed at the highest levels on reading literacy. In Ireland, female students achieved a significantly higher mean score than males on reading literacy (by 12 score points), while male students significantly outperformed females by 11 points on science, and 16 on mathematics. The gender gap in reading literacy was smaller than on average across OECD countries, while it was greater for science and mathematics.

The science activities in which students in Ireland participated most frequently include watching TV programmes about science, visiting websites about science topics, and following news of science, environmental or ecology organisations via blogs or microblogs. However, engagement in such activities is lower than on average across OECD countries. Students in Ireland have higher mean scores than on average across OECD countries on enjoyment of science, instrumental motivation to learn science, and interest in science topics. They also have higher mean scores on environmental awareness and environmental optimism. However, male students outperform females on all of these except instrumental motivation where there is no difference between genders.

Students in Ireland also had significantly higher mean scores on measures of interest in ICTs (Information and Communication Technologies), higher levels of perceived ICT competence, and higher perceived autonomy with regard to ICT than on average across OECD countries. However, they engaged significantly less often with ICT at school in general, and with ICT use outside of school for schoolwork. Again, male students in Ireland had higher mean scores than females on a number of ICT measures including interest in ICTs and perceived ICT competence, interest in science topics, science self-efficacy, environmental awareness and environmental optimism.

PISA facilitates comparison between major domain and major domain (for example, science in 2006 and 2015), between major and minor domain (reading in 2009 and 2015, mathematics in 2012 and 2015), and between minor and major domain (science in 2012 and 2015), with the OECD indicating that major to major domain yields the most stable comparisons. There was a small and non-significant drop in science performance in Ireland between 2006 and 2015 (by 6 score points), which was marginally bigger than the OECD average drop of 5 points. Between 2012 and 2015, the mean score of students in Ireland dropped by 19 score points. Twelve of the top 30 countries in PISA 2012 science also had significantly lower scores in 2015, with mean performance in Hong Kong (-32 points), Poland (-24) and Korea (-22) also falling. On average across OECD countries, performance fell by 8 score points. Among the reasons for these declines are the transition to computer-based testing, and, in particular, the inclusions of new items, including items linked to interactive virtual experiments, in the 2015 item pool. An analysis of percent correct scores showed that students in Ireland struggled on the new science items, and especially on items described as interactive. It is unclear to what extent lack of engagement with computers at school or at home for schoolwork impacted on the performance of students in Ireland. In general, those countries with the highest drops in performance in 2015 tended to have had high mean science scores in 2012. This was true of Ireland which had a mean score of 522 in PISA 2012 science. Finally, mean performance on reading literacy and mathematics in Ireland was at about the same level in 2012 and 2015. This may arise because unlike science, all items in these domains were taken directly from earlier paper-based assessments and transferred to computer with minimal change.

The scores of female students in Ireland fell back to a greater extent than male students in science between 2012 and 2015. In mathematics, the mean scores of both male and female students increased by similar amounts, while in reading between 2012 and 2015, male students improved by 2 points, while female students fell back by 5 points.

The Educational Research Centre plans to publish a number of additional reports over the next few years on such themes as home environment and science performance (drawing on the PISA parent questionnaire) and ICTs and science performance. It is also planned to publish a guide on similarities and differences between PISA and TIMSS (the Trends in International Mathematics Study in which students in Fourth class and Second year in Ireland participated in 2015).

Further information: The national report on PISA 2015 in Ireland can be accessed at www.erc.ie

International reports on PISA 2015 can be accessed at www.oecd.org/pisa

Sample science items can be viewed in the national report for Ireland. They can be taken interactively at www.oecd.org/pisa

For further information, contact: pisa2015@erc.ie or 01 837 3789

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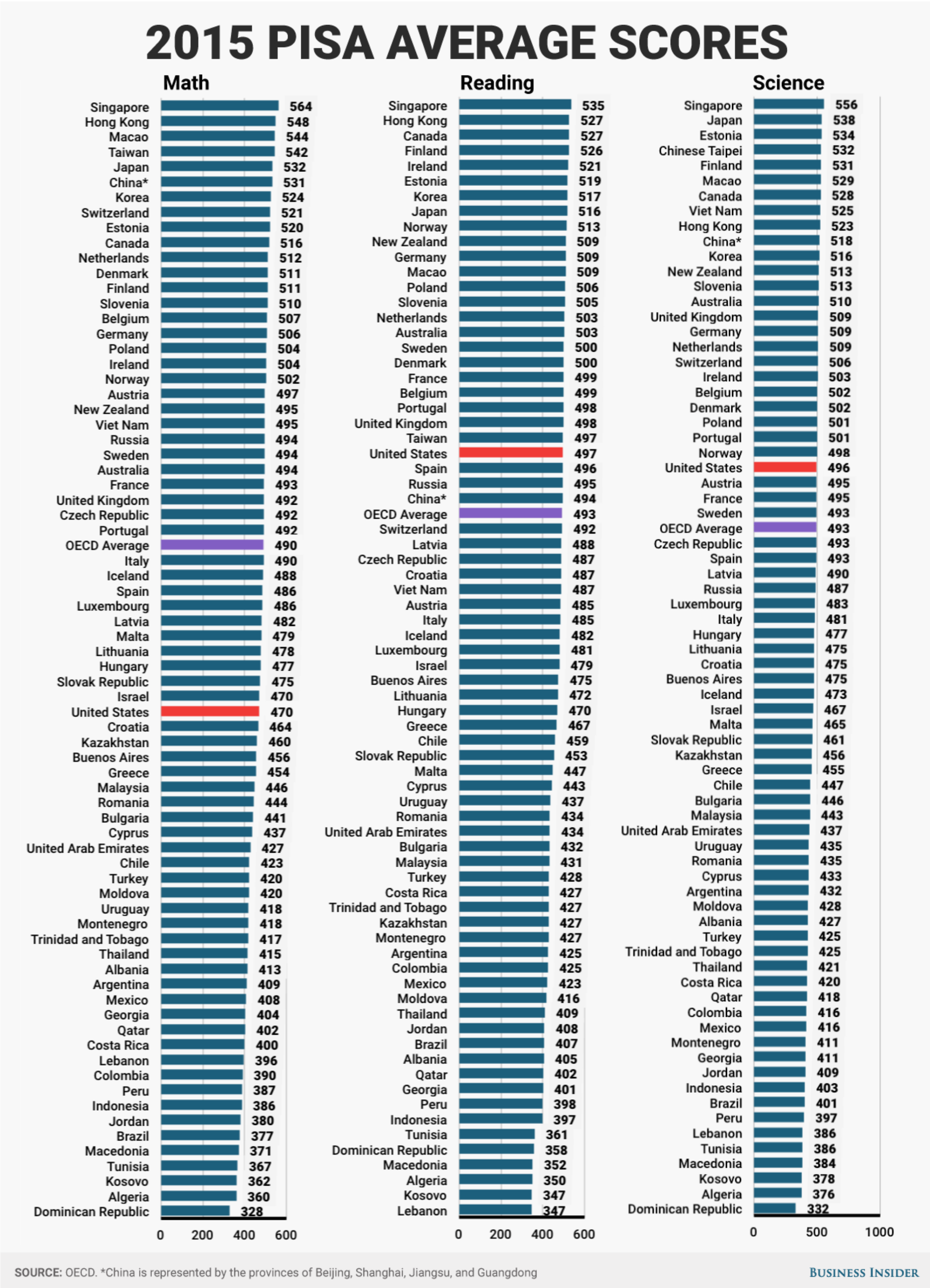
2015 PISA AVERAGE SCORES
Math
Singapore 564
Hong Kong 548
Macao 544
Taiwan 542
Japan 532
China* 531
Korea 524
Switzerland 521
Estonia 520
Canada 516
Netherlands 512
Denmark 511
Finland 511
Slovenia 510
Belgium 507
Germany 506
Poland 504
Ireland 504
Norway 502
Austria 497
New Zealand 495
Viet Nam 495
Russia 494
Sweden 494
Australia 494
France 493
United Kingdom 492
Czech Republic 492
Portugal 492
OECD Average 490
Italy 490
Iceland 488
Spain 486
Luxembourg 486
Latvia 482
Malta 479
Lithuania 478
Hungary 477
Slovak Republic 475
Israel 470
United States 470
Croatia 464
Kazakhstan 460
Buenos Aires 456
Greece 454
Malaysia 446
Romania 444
Bulgaria 441
Cyprus 437
United Arab Emirates 427
Chile 423
Turkey 420
Moldova 420
Uruguay 418
Montenegro 418
Trinidad and Tobago 417
Thailand 415
Albania 413
Argentina 409
Mexico 408
Georgia 404
Qatar 402
Costa Rica 400
Lebanon 396
Colombia 390
Peru 387
Indonesia 386
Jordan 380
Brazil 377
Macedonia 371
Tunisia 367
Kosovo 362
Algeria 360
Dominican Republic 328
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Estonia 519
Korea 517
Japan 516
Norway 513
New Zealand 509
Germany 509
Macao 509
Poland 506
Slovenia 505
Netherlands 503
Australia 503
Sweden 500
Denmark 500
France 499
Belgium 499
Portugal 498
United Kingdom 498
Taiwan 497
United States 497
Spain 496
Russia 495
China* 494
OECD Average 493
Switzerland 492
Latvia 488
Czech Republic 487
Croatia 487
Viet Nam 487
Austria 485
Italy 485
Iceland 482
Luxembourg 481
Israel 479
Buenos Aires 475
Lithuania 472
Hungary 470
Greece 467
Chile 459
Slovak Republic 453
Malta 447
Cyprus 443
Uruguay 437
Romania 434
United Arab Emirates 434
Bulgaria 432
Malaysia 431
Turkey 428
Costa Rica 427
Trinidad and Tobago 427
Kazakhstan 427
Montenegro 427
Argentina 425
Colombia 425
Mexico 423
Moldova 416
Thailand 409
Jordan 408
Brazil 407
Albania 405
Qatar 402
Georgia 401
Peru 398
Indonesia 397
Tunisia 361
Dominican Republic 358
Macedonia 352
Algeria 350
Kosovo 347
Lebanon 347
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Science
Singapore 556
Japan 538
Estonia 534
Chinese Taipei 532
Finland 531
Macao 529
Canada 528
Viet Nam 525
Hong Kong 523
China* 518
Korea 516
New Zealand 513
Slovenia 513
Australia 510
United Kingdom 509
Germany 509
Netherlands 509
Switzerland 506
Ireland 503
Belgium 502
Denmark 502
Poland 501
Portugal 501
Norway 498
United States 496
Austria 495
France 495
Sweden 493
OECD Average 493
Czech Republic 493
Spain 493
Latvia 490
Russia 487
Luxembourg 483
Italy 481
Hungary 477
Lithuania 475
Croatia 475
Buenos Aires 475
Iceland 473
Israel 467
Malta 465
Slovak Republic 461
Kazakhstan 456
Greece 455
Chile 447
Bulgaria 446
Malaysia 443
United Arab Emirates 437
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Romania 435
Cyprus 433
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Moldova 428
Albania 427
Turkey 425
Trinidad and Tobago 425
Thailand 421
Costa Rica 420
Qatar 418
Colombia 416
Mexico 416
Montenegro 411
Georgia 411
Jordan 409
Indonesia 403
Brazil 401
Peru 397
Lebanon 386
Tunisia 386
Macedonia 384
Kosovo 378
Algeria 376
Dominican Republic 332
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SOURCE: OECD. *China is represented by the provinces of Beijing, Shanghai, Jiangsu, and Guangdong
BUSINESS INSIDER

STEM Education in the Irish School System

Report of the STEM Education Review Group (STEMERG)
Nov. 2016
(http://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf)

The long-awaited report of the STEM Education Review Group (STEMERG) was launched on Nov. 24th in Dublin by Richard Bruton, the Minister of Education and Skills, three years after it was inaugurated in Nov. 2013. He said that **21** of the 47 recommendations would be prioritised (highlighted in bold below), although on the website below only **19** are listed.
http://www.education.ie/en/Press-Events/Press-Releases/2016-Press-Releases/PR2016-11-24.html

Ch. 7 Conclusions and general recommendations (p. 47-53)

Introduction

Our aim as a nation should be to ensure that STEM education in Ireland is of the highest international quality. Our review has identified both positive elements and serious deficits in the current STEM landscape in Ireland. The positive features are to be found in both formal (e.g. curricular reform) and informal education developments, but many are taking place in an uncoordinated, independent fashion, rather than as part of an overarching, coherent, cooperative strategy. On the deficit side, the highest-level concerns are the absence of a clearly articulated STEM education strategy and the levels of performance achieved in international assessments.

The overall levels of performance and engagement in STEM subjects are not good enough if we aim to provide the best for our nation's children, and if we wish to sustain our economic ambitions for the future. A step-change in STEM performance and outcomes is required throughout the educational system if we are to move our STEM education performance up to the highest levels.

The focus of this report has been to identify pathways to achieving that step-change so that, through implementation of our recommendations, the quality of STEM Education in Ireland will be enhanced considerably and sustainably.

It is clear, and unsurprising, that the role of teachers is central to the changes required. In that regard, it is crucial that a comprehensive, properly-resourced structure is established in order to support teachers in enhancing their role and in embracing the changes that are needed.

Consideration should be given to recognising, by way of an honours system, those teachers who proactively engage and in some instances are leading the changes that are needed.

In making our recommendations regarding STEM education, it is not intended to diminish the significance of any other disciplines. The degree of prioritisation accorded to STEM education is a matter for Government, ideally taking account of available evidence and international best practice.

A Vision for STEM Education in Ireland

Our vision is to provide students in Ireland with a STEM education experience of the highest international quality; this provision should underpin high levels of student engagement, enjoyment, and excellent performance in STEM disciplines.

Achieving the vision for STEM education articulated here will require commitment, investment and early action, together with partnership across all the primary stakeholders in both the formal and the informal learning sectors. It is clear that the most effective approach will involve a coalition of committed partners across government departments (especially DES) and agencies, the enterprise sector, professional and learned societies, teachers and communities. In particular, the enterprise sector has an important role to play in supporting Government in ensuring the provision of a high-quality graduate output aligned with national economic needs. In conclusion, the Review Group believes that this Vision for STEM Education in Ireland is achievable through active and early implementation of the Specific Proposed Actions detailed earlier in the report (associated with each Term of Reference) and the following, overarching General Recommendations: (NOTE – those in bold have been identified by the Minister of Education and Skills for priority implementation.)

General recommendations

- **Produce an integrated National STEM Education Policy Statement with input from, and relevance to, all stakeholders across the continuum of education in Ireland (primary, secondary and third level). This Policy Statement should include a detailed implementation plan with responsibilities and timelines clearly outlined.**
- **Introduce computer science (including coding) as a Leaving Certificate curriculum subject. This is critical to address the ICT skills deficit in Ireland.**
- **Establish the STEM 2020 Partnership - a fixed-duration, public-private (enterprise-exchequer) partnership to create a fund to support a prioritised set of agreed, specific initiatives consistent with the recommendations of this report. This would entail pooling of resources from enterprise partners, philanthropy and crowdsourcing with resource-matching by the exchequer (DES, DJEI, SFI) over a five-year period. A fund of €8M per annum for five years, equally subscribed from public and private interests, is envisaged.**
- Establish STEM education research as a national research priority with multi-annual, sustained funding commitment through SFI. (The following recommendation would be an excellent means of achieving this).
- Establish a National STEM Education Research Centre, comprising a small number of regionally distributed nodes (based on the highly successful UK Science Centre model). This national centre would act not only as a centre of excellence for research and innovation in STEM education, it would also provide locations for delivery of CPD programmes for teachers.
- Create an annual 'Excellence in STEM Teaching' award scheme to recognise those teachers who are pioneering innovations in STEM education and who are outstanding educators.
- While this report has focused almost exclusively on the STEM disciplines and STEM Education in general, it is now well established that the intersection of these areas with the Arts (visual and performing) and Design offers great potential in terms of both cultural advancement and economic development opportunities. With this is in mind, it is important that any future strategy for STEM in Ireland takes account of the STE(A)M hybrid, where A represents the Arts and Design (including design thinking). It is proposed, therefore, that the Royal Irish Academy play a formal role in advancing the thinking on this topic in the Irish context with a view to influencing future policy decisions regarding STEM Education.

All Proposed Actions

Term of Reference 1: Preparation of teachers (at primary and post-primary level) for STEM education in Ireland

Proposed Actions:

- The ongoing supply of 'qualified STEM teachers' (at post-primary level) should be a particular focus of the Teaching Council in its planned report on teacher supply to the Minister for Education and Skills.
- The development of specialist STEM teachers ('STEM Champions') should be encouraged in primary schools. Such specialists would work with colleagues to disseminate insights and best practice in STEM Education. A 'STEM Champion' should hold a recognised postgraduate qualification (e.g. in Mathematics Education, Science Education, Technology Education, STEM Education). Support should be provided to primary teachers to gain such qualifications.

- **All STEM teaching in post-primary schools should be delivered by qualified STEM teachers (as defined by the Teaching Council), and the imbalance in the proportions of teachers qualified in biology, physics and chemistry should be addressed as a matter of urgency (see TOR 2).**
- **The minimum entry requirements into the B.Ed. degree programme (for primary teachers) should be reviewed as soon as possible with a view to creating greater equity across core subject areas.**
- Students of ITE (primary) programmes should undergo an audit of subject-matter knowledge (SMK) in STEM subjects (mathematics and science) over the course of their programme. Selfor peer-evaluation may be helpful in this regard. Supports should be provided to ensure that students address deficits in their knowledge, e.g. mathematics-learning support.
- Offer incentives (e.g. targeted bonus points per STEM subject up to a maximum of two subjects, for example) to Senior Cycle students seeking to enter concurrent STEM Teacher Education degree programmes (for post-primary) generally but especially in mathematics, physics, chemistry and engineering.
- **Support all primary teachers (in ITE) in building their subject matter knowledge (SMK) and pedagogical content knowledge (PCK) in science, mathematics and technology as part of a broader professional portfolio of expertise and related activities.**
- Require all primary teachers in ITE to pass all STEM-methodology-related subjects (without compensation) in final examinations, where this is not currently the case.
- Include a formal consideration of STEM education during mentoring of student teachers during their primary school placement.
- Support the active engagement of schools with STEM-related industries across a broad range of fronts (e.g. the possibility of optional placements in STEM industries during primary and post-primary teacher preparation phases should be explored).

Term of Reference 2: The best methods of supporting the current cohort of STEM Teachers within the system (with a particular focus on Continuing Professional Development)

Proposed Actions:

- **Develop a coherent policy framework for CPD in STEM education, recognising that this may be part of a broader CPD framework for teachers. The DES, together with partners such as the NCCA, Teaching Council, HEIs, SFI, subject associations and the private sector, should address this as a matter of urgency.**
- Support STEM teachers (primary and post-primary) financially and through appropriate career opportunities to embrace CPD and lifelong learning in their STEM disciplines (and related pedagogy) as a means of advancing their professional development.
- Develop a common currency for assessing and accumulating CPD elements in STEM education for accreditation purposes. Such currency units (such as credits or points) should be used in defining professional recognition from the Teaching Council.
- Develop CPD programmes for primary teachers to expand their knowledge in STEM subjects in order to build capacity in schools for the role of 'STEM Champions'.
- **Working with the Teaching Council, all stakeholders should ensure that a comprehensive suite of STEM CPD programmes is available to post-primary teachers as part of their professional learning requirements under the forthcoming Teaching Council Framework for Continuous Professional Learning.**
- **Develop STEM up-skilling programmes in physics, chemistry and biology for science teachers (post-primary) so that they can upgrade their registration status to a level of being qualified to teach in these subjects. Such programmes could build on the successful DES blended education model developed for the out-of-field teachers of mathematics (at UL).**

- **Maintain a strong CPD programme in mathematics, because mathematics is fundamental for all STEM education.**
- Link formal and informal STEM education providers under a national initiative, such as SFI Discover, to create opportunities for non-traditional CPD for STEM teachers (e.g. museums, zoos, science galleries).

Term of Reference 3: The introduction of new teaching and learning modalities that would enhance STEM education in our schools

Proposed Actions:

- **Put essential measures in place to support the implementation of inquiry-based learning as part of the revised curricula for STEM subjects. Innovative assessment that aligns with inquiry-based teaching and learning should be developed.**
- **Develop a means of recognising participation in informal (extra-curricular) STEM events and activities (e.g. Science Fairs, BTYSTE, SciFest, CoderDojo, Intel MiniScientist) into the STEM curriculum and assessment at Primary and Post-primary levels, e.g. in an e-portfolio of achievement. Such digital archives of learning and personal development need to become part of the assessment for learning. The model used for the Science Foundation Ireland Discover Primary Science and Maths programme at primary school could be explored.**
- **Develop extensive curricular materials for teachers that operationalise learning outcomes in STEM subjects at primary and post-primary levels.**
- Promote real engagement with fundamental science concepts and principles through application to real-life situations and practical work.
- Foster evidence-based STEM education research in Ireland in order to support the introduction of new modalities in STEM teaching, learning and assessment.

Term of Reference 4: The use of technology to enhance STEM learning

Proposed Actions:

- Develop a suite of 'Technology-Enhanced Learning' (TEL) CPD programmes in STEM disciplines for teachers at primary and post-primary levels.
- Exploit advances in digital technology to support multiple approaches to learning, including personalised and adaptive learning pathways that will enable students to learn in a manner optimised for their own personal needs.
- **Support the establishment of online communities of Learning and Practice and provide support for the creation of rich multimedia educational content.**
- Support the introduction of digital technology to facilitate international collaboration in STEM subjects between schools, and between schools and research facilities (e.g. remote telescopes, remote laboratories).
- **Provide a central (cloud-based) repository for digital learning and teaching resources in STEM subjects, approved by the Department of Education and Skills and teaching bodies. This should also include a collaborative space for teachers and learners with a focus on active and inquiry-based learning.**
- Exploit digital technology in promoting and facilitating new engagements between schools and enterprises, e.g. the use of online mentors to assist schools/learners with their STEM activities; using digital technology to bring real science and engineering into the classroom; new forms of CPD to educate teachers in computer science.
- **Promote and facilitate hardware-enabled approaches to technology learning, e.g. Tablets, Maker boards and kits; 3D Printers etc.**

- Support the development of a system of IT Learning Support in schools. This would act as a resource to staff and students in the ongoing introduction of new digital technology.

Term of Reference 5: The promotion of STEM careers and the identification of methods to enhance the engagement of students in STEM subjects

Proposed Actions:

- STEM disciplines should be promoted as being crucial to personal development and citizenship in the 21st century.
- **The career possibilities for students who follow a STEM career path should be highlighted not only to students but also to parents. Parents have a strong influence on students' subject choices. Market STEM qualifications with an emphasis on future economic needs and as a pathway to important, challenging and well-paid careers.**
- STEM curriculum and assessment should be linked to wider ethical, legal, and societal issues, such as STEM's role in addressing global challenges (food, water, and energy security; biodiversity loss; etc.).
- **Ambitious targets and a sustained, multi-faceted action plan for addressing the gender imbalance in specific STEM disciplines should be established and implemented as a matter of urgency. Particular emphasis should be placed on the marketing strategies and language used in this regard.**
- Engineering and technology should be integrated into the structure of science education at all levels, according the core ideas of engineering design and technology with the same status as core ideas in the other major science disciplines.
- Identify and promote the range and diversity of career opportunities available to STEM graduates as early as possible in primary and post-primary schools.
- **Avail of partnerships with STEM enterprises (e.g. within the national Smart Futures initiative) to promote STEM careers at all levels in education.**
- Promote and facilitate the 'adoption' of a school, or a cluster of schools, by a local STEM industry/enterprise. The support of IBEC and the American Chamber of Commerce in Ireland ('AmCham') may be important in this regard.
- The planned Exploration Station at Earlsfort Terrace, Dublin should be supported by Government as an effective means of stimulating interest in, and engagement with, STEM topics.

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The importance of STEM education

Michael Duffy ***Irish Times*** 15/11/16

The importance of a knowledge economy to Ireland's future is hard to measure, but it should not be underestimated.

While we may not know with any certainty what the new jobs in 20 or 30 years will be, our education system has to prepare for them now. The subjects of science, technology, engineering and maths (Stem) are rightly seen as critical to meet this challenge.

However, we do not teach science purely for those who will seek a career in this area. It is important that our education system helps to create the basis of a scientifically literate society, so that we all have a shared understanding that is fundamental to how we live our lives.

This has never been more important, as the interaction of science, technology and society will only increase for future generations.

Ireland doesn't have a national policy in the area of Stem education. A new education review group report is under way which will finally define the type of Stem education we should be planning for at primary and post-primary level.

It is expected the recommendations of this much-anticipated report will lay out how we should get there and will be central to discussions regarding future Government policy in this area. But policy alone cannot bring about a new culture of Stem education.

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TY Science Module: Medicines in my life

Sarah Hayes
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The Synthesis and Solid State Pharmaceutical Centre (SSPC), funded by Science Foundation Ireland (SFI) and based in the Bernal Institute at the University of Limerick (UL), has launched their Medicines In My Life initiative. The purpose of the initiative, which includes a website and resources for teachers and pupils, is to support the SSPC's innovative educational programme for post-primary teachers and pupils, entitled 'Innovation in Medicines', a module designed to introduce students to the world of medicine.

Figure 1: SSPC Innovation in Medicine Transition Year Module

The SFI Discover funded initiative, closely linked to the SSPC module, material and medicine research programme, introduces Transition Year and Senior Cycle pupils to real world science and research in the area of pharmaceutical manufacturing, development and innovation.

Pupils taking the module in their Transition Year will take the knowledge learned through the module and website and translate this into an exhibit for their school/local library/SciFest or a public space in their local community. The exhibitions should be interactive and approach different aspects of medicines in our lives, and the development of medicine through advances in scientific research and in industry. 'Medicines in my Life' supported teacher training and development of materials to enable Transition Year Science Teachers to teach 'Innovation in Medicines' (the SSPC's Transition Year module) to their pupils.

Figure 2: One of the exhibitions developed through the project with two students (Lizzie Donovan, left, and Molly Durack, right) from Castletroy College.

The project addresses Science Foundation Ireland's goal to have an engaged and scientifically informed public in Ireland and addresses the promotion of STEMM career pathways.

Figure 3: At the launch, L to R: Dr Mary Shire, VP Research, UL; Lizzie Donovan, Castletroy College; Dr Sarah Hayes, SSPC; Senator Maria Byrne; Molly Durack, Castletroy College; Prof. Luuk van der Wielen, Director of the Bernal Institute

Dr Abigail Ruth Freeman, Director of Strategy and Communications at Science Foundation Ireland said:
"The exciting module 'Innovations In Medicine' not only helps post-primary students make career decisions, it also takes STEMM education beyond the confines of the classroom. As an SFI Discover Programme, we are delighted to fund and support such an initiative and to see the website being

launched, will help shape the fundamental aspect of the project".

Speaking at the launch, Senator Maria Byrne and Dr Mary Shire, Vice President Research at the University of Limerick, not only highlighted the importance of such initiatives for Science, Technology, Engineering, Mathematics and Medicine (STEMM) education but also how they support and encourage females early in their careers. The programme, designed to engage students with learning materials and activities, will explore students' thoughts on medicine, and shows the possibilities and the opportunities available in an ever growing sector in Ireland, and globally.

The pharma industry in Ireland directly employs 24,500 individuals and approximately 24,000 people indirectly. Pharmaceutical exports account for over 56% of all Irish exports. 9 out of the 10 top pharmaceutical industries are based in Ireland, making Ireland the number 1 European location for international pharmaceutical investment. This module explores the many stages of drug development and manufacture taking pupils through the process from the molecule to the material to the medicine. The module consists of 7 units:

1. Introduction to medicine
2. Quality control
3. Crystallisation in medicine
4. Formulation
5. Bioavailability
6. Pharmacokinetics
7. Nano in our bodies

The Innovation in Medicine Transition Year module is now available through SSPCOutreach@ul.ie or through www.innovationinmedicines.ie.

If you are interested in participating in the wider project with your Transition Years, please email us and we will do our best to help set you up with a kit, and support you in the development of the exhibit.

About the SSPC

The Synthesis and Solid State Pharmaceutical Centre (SSPC), a Global Hub of Pharmaceutical Process Innovation and Advanced Manufacturing, funded by Science Foundation Ireland and industry, is a unique collaboration between 24 industry partners, 9 research performing organisations and 12 international academic collaborators.

The SSPC transcends company and academic boundaries and is the largest research collaboration in Ireland, and one of the largest globally, within the pharmaceutical area. The role of the SSPC is to link experienced scientists and engineers in academia and the pharmaceutical industry, to address critical research challenges.

The SSPC leads the way for next generation drug manufacture and spans the entire pharmaceutical production chain from synthesis of the molecule, to the isolation of the material, and the formulation of the medicine. The aim of the SSPC is to deliver industry relevant solutions, which result in job growth and retention within the pharmaceutical industry in Ireland.

Point of contact:

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The Centre's contacts:
http://www.sspc.ie/contact_sspc
Website: www.sspc.ie
Twitter: @SSPCentre #MedicineinmyLife

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Future Skills Needs of the Biopharma Industry in Ireland
August 2016
http://www.skillsireland.ie/media/egfsn101115-Biopharma_Pharmachem_Skills.pdf

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Proceedings ChemEd-Ireland 2016
Oct. 22nd Dublin City University

The 2016 ChemEd-Ireland conference was held in DCU on Saturday October 22nd and was organised by Dr Odilla Finlayson. The programme for the day is given below. As is usual, the Proceedings of ChemEd-Ireland are printed in the Spring issue of *Chemistry in Action!* or as many of the talks that can be obtained. We were only able to obtain one talk, that by Bob Worley, in time for this issue. The programme had the usual mix of lectures and workshops. The talk and workship by Bob Worley was a highlight as it was directly relevant to chemistry teachers and amny of his ideas could eaily be used in school.

Programme:

The 2016 Keynote demonstration lecture will be presented by Robert Worley, *Chemistry Adviser at CLEAPSS, Brunel University Science Park, UK.*

9:00-9:30	Registration and coffee
9:35-10:35	**Keynote talk** *In a little you can see a lot": Variety and impact of practical microscale chemistry*, Robert Worley, Chemistry Adviser at CLEAPSS, Brunel University Science Park, UK
10:35-11:05	Coffee
11:05-11:40	*Chemistry for Microscopy*, Prof. Tia Keyes, School of Chemical Sciences, DCU
11:40-12:10	*Inorganic Chemistry in Medicine*, Dr. Andrew Kellett, School of Chemical Sciences, DCU
12:10-13:10	Choice of workshops*
13:10-14:00	Lunch
14:00-15:00	Choice of Workshops*
15:00-15:30	*Chemistry of Sensing*, Dr. Aoife Morrin, School of Chemical Sciences, DCU
15:30-16:00	*Learning resources from the RSC*, Dr. John O'Donoghue, Royal Society of Chemistry in Ireland
16:00	Close of conference

**Choice of Workshop includes:*

- **Microscale Chemistry**, workshop lead by Robert Worley, CLEAPSS.
- **An Introduction to DNA Damage and Repair**, workshop lead by Dr Andrew Kellett, DCU
- **Microplastics: What are the, where do they come from and where do they go?** workshop lead by Ivan Maguire, Gillian Duffy, Fiona Regan, DCU.
- **Performing health diagnostics without needles:** Dr. Aoife Morrin

Bob Worley in action in his workshop

In a Little You Can See a Lot

The impact of practical microscale chemistry on chemical education

Bob Worley (Semi-retired chemistry adviser with CLEAPSS[1] in the UK)
bobworley4@gmail.com

The microscale approach to practical chemistry is not new. I remember semi-micro analysis in my A-level practical in the 1960s. However, those techniques are all but lost to teachers of today. Of course chemists carry out microchemical activities naturally, such as melting point determination and Thin-Layer Chromatography.

In the 1980s, many American Organic Chemists in Universities made a conscious effort to go microscale using novel equipment (Figure 1)[2] and still do, although it less popular in the UK. At school level, it was the pioneering effort by Professor John Bradley in S. Africa, which was taken up by UNESCO (Figure 2), expanded to other sciences and sent to many developing countries around the world[3]. Success in implementing microscale is not as overwhelming as UNESCO would like and John Bradley has recognised this[4]. The issue is with governments.

Figure 1: Microscale organic reaction flasks

Figure 2: Microscale kit in use in South Sudan

The kit was sent to every school in the UK by the Royal Society of Chemistry in 1999 accompanied by an excellent book[5]. Many of our traditional chemists looked at the kit, made a rude remark and threw it in the drawer or worse. There is still a belief that it is cheap plastic, not real chemistry ("no Bunsen burner") but more importantly it is not recognised as a *bone fide* method by examination boards and text book authors. There are still a few schools that make use of the kit. It was sent to schools in Ireland as well. The problem with such kits is maintenance, training and credibility, plus it constrains further innovation.

I began using Microscale and Reduced Scale Procedures to enable experiments to be carried out safely but the use of modern materials extended my interest into other areas of chemical education. I made one basic decision. It was not to be a kit but should use readily available modern materials and equipment. I also came at the subject from a different direction: safety.

In 1984 in the UK, after a violent explosion, a group of children were sprayed with concentrated sulfuric acid, used to dry hydrogen, prior to burning it, in an experiment to reduce copper(II) oxide copper. This teacher was the first to be fined under Health and Safety Law. Looking for a safer, alternative procedure, I found the methods of Bruce Mattson[6] inspiring. See Figure 3. There were other experiments causing issues, so much so that some employers wanted them banned. The normal scale catalytic cracking reaction (Figure 5) can lead to violent suck-back implosions caused by cold water in contact with a hot glass test tube. This just cannot happen with a glass Pasteur pipette. You can read more about these in my website.[7]

For example, the iron/sulfur reaction (Figure 5a) was causing distress to asthmatics when performed poorly. I was able to use small scale chemistry to perform the reaction and do a comparison of the mixture and compound (Figure 5b).

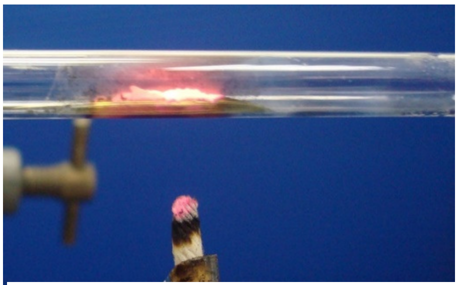


Figure 3: Reduction of copper(II) oxide with hydrogen

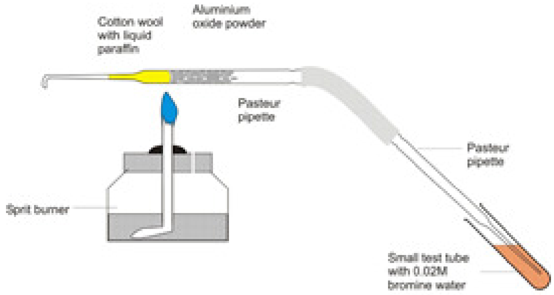


Figure 4: Catalytic cracking set up

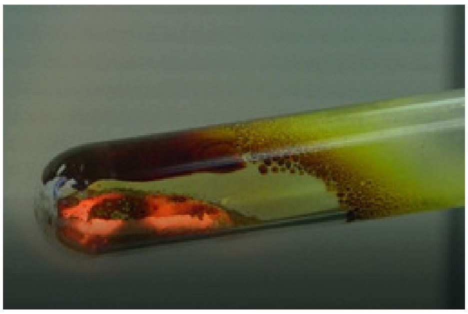


Figure 5a : 0.2 g of iron/sulfur mix ignites

Figure 5b: Comparing the reactions of the compound and the mixture

Teachers often think that the microscale approach saves money on chemicals. This is true to some extant as 250 g of X will last longer, but in fact it is often in equipment where the money is saved most by going microscale. Schools in the UK often report that the platinum electrodes on the Hofmann voltameter have come off. They are very expensive to replace but by using platinum wire, a microscale version has been devised (Figure 6). This equipment uses sodium sulfate solution as the electrolyte rather than sulfuric acid. This is not only safer but now, by using an indicator such as bromothymol blue, the acidic and alkaline environment around the anode and cathode respectively is easily demonstrated. And the ratio of gas by volume is 2:1, hydrogen:oxygen. It also uses a novel method of drawing off the gas, using plastic 3-way taps which can be attached to plastic syringes. The Lego® support for the colorimeter may grab the headlines but it is the remarkable property of LEDs that when light strikes a Light Emitting Diodes (LED), a voltage is produced[8]. We found that light from a coloured LED has a narrow wavelength so no filters are required and an IR LED will respond to any wavelength of light of a shorter wavelength to produce a voltage read on an inexpensive multimeter (Figure 7).

Figure 6 Hofmann Voltammeter

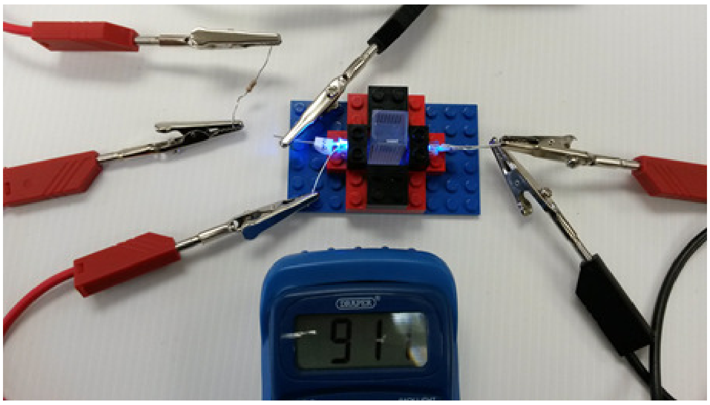
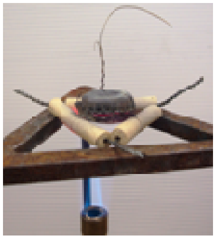
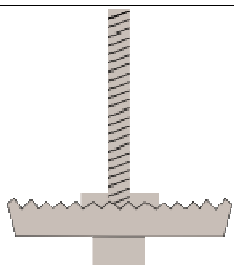


Figure 7: Lego colorimeter

Crucibles were never designed for the quantitative combustion of magnesium. They were designed for precipitates in ashless filter paper used in analytical chemistry and more recently for taking samples of molten steel prior to analysis. Surprisingly to teachers, they are designed for single use only. This is why they often crack under intense heat. Students find it difficult to remove the cover to let oxygen in. The use of bottle tops with the plastic insert burnt away in a fume cupboard or outside. As a replacement for crucibles, the bottle tops gives extremely good results (Figure 7). For magnesium combustion, two bottle tops are sandwiched together and there is no need to touch them with tongs during heating as air can get inside the arrangement. For analysis of hydrated salts a nut and bolt arrangement is used (Figure 8) and the bolt can be held over a spirit burner (avoids further decomposition of the anhydrous salt) with tongs, a clamp or better still pliers from the hardware shop. To weigh this apparatus, the digital balances, often available for less than 10 Euro from online suppliers, mean that a class set can be bought for the cost of a traditional balance. The one shown (Figure 9) has a capacity of 100g and reads to 2 decimal places; and it can be calibrated!

 **Figure7: Quantitative oxidation of magnesium**	 **Figure 8: Adaption to a Crucible**	 **Figure 9: Inexpensive digital balance**

It is here I hit a problem. Despite giving superior results to crucibles, some teachers claimed the use of bottle tops, Lego colorimeters, etc, are not established equipment and would disadvantage students should they come across questions in an exam. I am assured this is not true by exam boards but the suspicion survives.

I then began to receive anecdotal comments that these methods increased speed and efficiency in lessons, as well time saved in clearing up, thus allowing more time for teaching. The cracking procedure (Figure 4), as well as being safe, could be set up and completed in 20 minutes, allowing time to discuss the chemistry.

Printed plastic worksheets
Working on procedural worksheets inserted into a polypropylene plastic folder, reactions could be carried out in the hemispherical droplet. When Professor Bruce Mattson at Creighton University saw this he christened it “Puddle Chemistry” after using it with his students. In Figure 9, 3 to 4 drops of each buffer is placed in the columns of the first 5 rows. The indicators are then added across the row. In the fourth row, the indicators are mixed which makes a universal indicator which can be compared to a manufactured version. Finally these mixed indicators can distinguish between distilled water, often acidic because of dissolved carbon dioxide and tap water, often containing hydrogencarbonate ions.

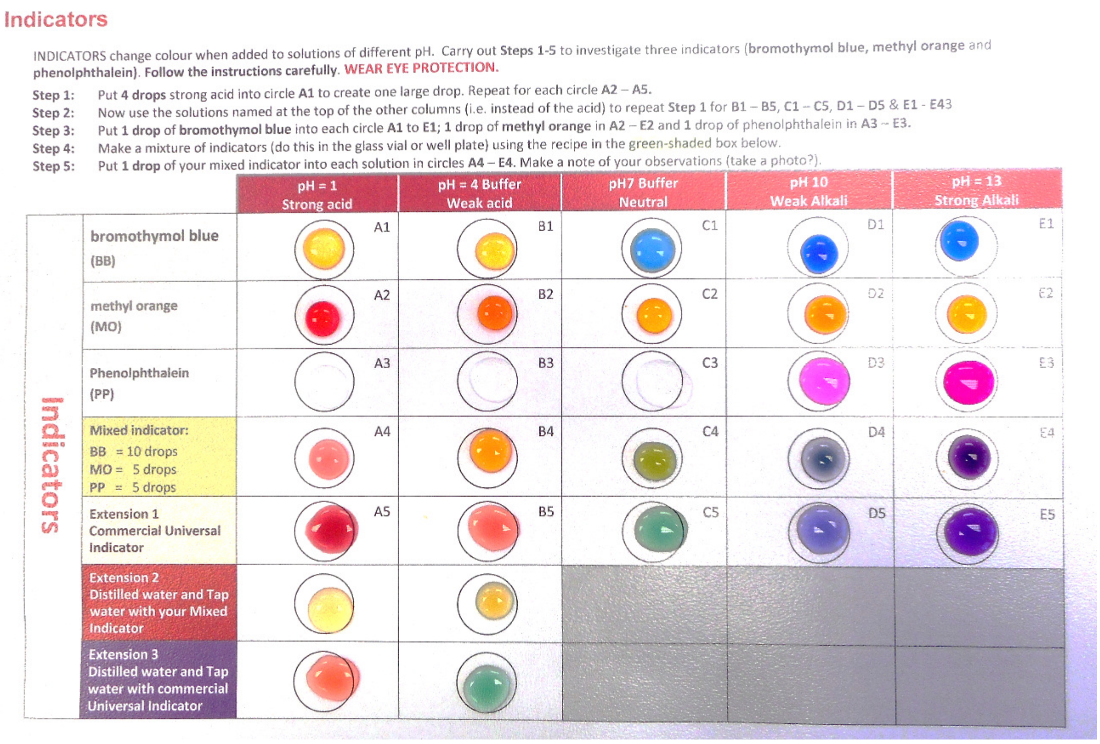
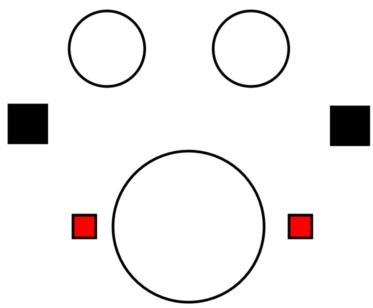


Figure 10: Indicators changing colour with pH

Displacement and precipitation reactions can also performed on plastic sheets. In doing these activities, it became apparent that teaching and learning was being enhanced. Precipitation reactions appear as magic to most children; they are presented to them as two clear and colourless liquids, which on mixing in a test tube, a white or sometimes coloured (e.g. yellow with silver or lead iodide) solid appears. Try this little procedure yourselves and think what is going on, how does this happen, can I produce a visual model of what is happening? You will need to photocopy/download/print the page and insert the page into a plastic folder or laminate it. You will need distilled water, a 3 mL plastic pipette, wooden splint, scissors, solid potassium iodide and solid silver nitrate (don't worry about cost, only a little is used; lead nitrate can also be used but this might not be allowed!) With the scissors, the end of the splint can be cut off to avoid contamination after use in transferring a solid or stirring.

A microscale investigation for you

Place enough solid to cover one of the black squares and the other solid on the other black square Add water with the pipette to fill the two small circles. With the splint move half of the solids to the water in the small circles respectively and use the splint to stir. (Cut the end of the splint away to after each mixing to avoid contamination. Now mix the two clear liquids. Now move the rest of the solid to the nearest red squares. Add water to the large circle. Cut the splint in half and move the solids into the edge of the liquid from either side. (Do not stir but wait for about 30s to see the wonderful diffusing precipitate.) It is even better with lead nitrate. Other solids can be investigated as well	

The spectacular and colourful macro observations in chemistry make the subject very popular with students. It becomes less popular when teachers begin to introduce explanations at the symbolic and sub-micro or nano level as exemplified by the famous Johnstone Triangle (Figure 10), which summarises the difficulties of teaching chemistry. I hope the macro observation you made in your experiment is explained by Figure 11.

Figure 10: The Johnstone triangle

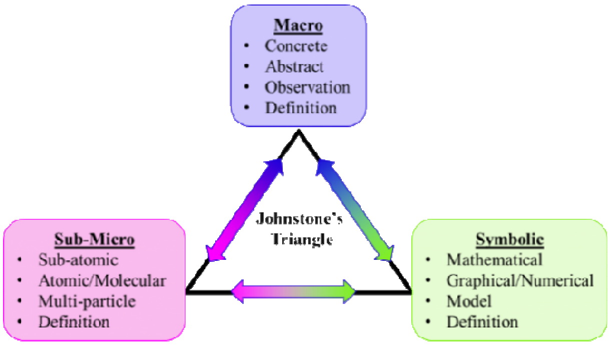
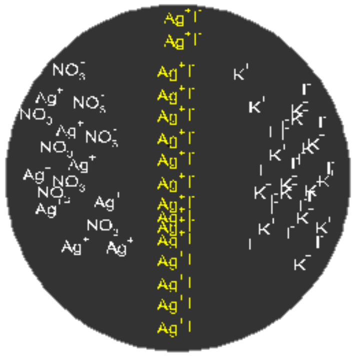


Figure 11: Ionic Model of the diffusing precipitate



But where is the evidence for ions? The evidence can be shown by the conduction of an electric current and CLEAPSS have made a small conductivity indicator which can be made for less than £10.

Figure 12a

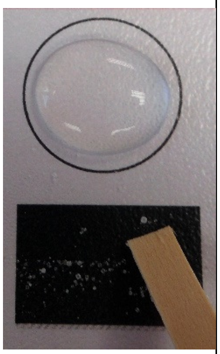


Figure 12b

Figure 12c

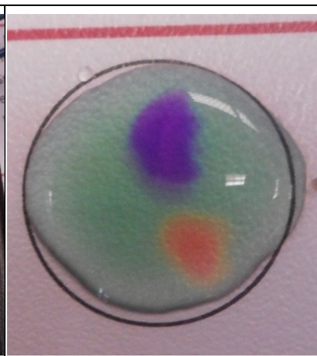


Figure 12d

Figure 12a shows the indicator with a red LED which is connected to a 330 to 500Ω resistor and 9 volt battery. The electrodes are carbon fibres, available from online kite and hobby shops. In distilled water the LED does not light but in tap water (Figure 12a), it does. Figure 12b shows the addition of 1 grain of salt to a puddle of distilled water. With a little stirring the LED lights up showing the solution is now conducting and addition of Universal indicator shows that chemical reactions are taking place (Figure 12d) at the electrodes (electrolysis). When doing these experiments in the USA, a teacher suddenly said *"Gee, in a little you can see a lot!"*

There is still an issue though. Is the solid made of ions or do the ions occur with the addition of water? The evidence here is that a molten salt conducts electricity (Fig 13a). The microscale approach now comes into its own, although leap of faith has to be made from sodium chloride (Mpt 804°C) to silver bromide (Mpt 432°C). Not only does a LED light up but the bromine is seen at the anode (Fig 13b) and so little is produced that it can be carried out in the classroom. The glass tubing is 7 mm medium borosilicate tubing which is bent slightly using the heat from a Bunsen burner.

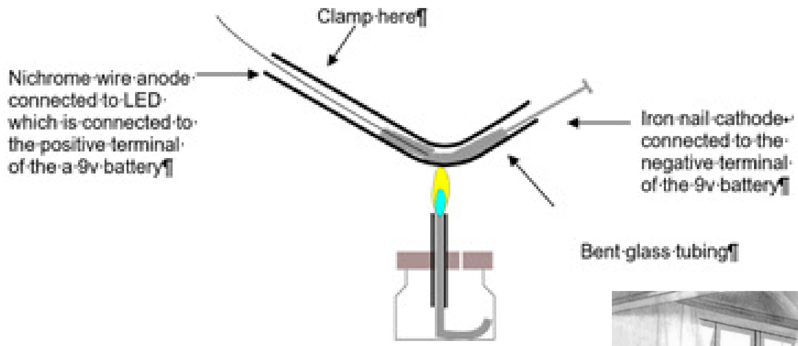


Figure:13a

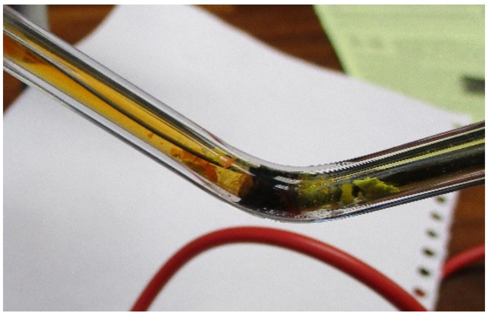


Figure: 13b

Figure 15: School Chemistry laboratory 1917

Another aspect of the microscale approach is that it removes much of the paraphernalia which can confuse students in a practical lesson[9]. Practical work has a "noisy start" with much going on, which obscures the point the teacher is trying to make. Class teaching involves a simple idea which is elaborated on.

Titration is one such subject which combines all three aspects of the Johnstone triangle, along with skills in handling volumetric flasks, pipettes and filler, filling and using burettes. Added to that is for students a very difficult calculation involving balanced chemical equations. Microscale titration can deliver a simple introduction. It uses very fine pipettes which deliver 50 drops to the mL. These act as the burette (Figure 14). The clamp is turned so that drops are delivered one at a time until the indicator just changes colour. The measurements are made by weighing **not** by volume and the lap of faith is to assume that the density is 1 g cm^{-3}. By carrying out 3 weighings, the calculation can be carried out. The skill involved in using the professional equipment can be taught later. Having said that, the results are extremely good and the technique can be used for measuring yields in organic chemistry preparations and determining equilibrium constants.
It has been observed that the speed and efficiency shown by students working on plastic sheets, microscale cocking and titration does overloading students with too much information (ie, short-term working memory) before a practical.
The photograph in Figure 15 above shows students carrying practical chemistry, 100 years ago, in 1917. The same equipment is available still (in many cases the same experiments). We cannot say the same about biology equipment and experiments. I feel we have to use modern materials and efficient methods to make practical chemistry relevant to students and purposeful in delivering an understanding of subject.

Figure 14: Microscale titration

At last these techniques such as microscale electrolysis of copper(II) chloride (Figure 16) are being recognised by examination boards in the UK as exemplar experiments. To those who claim it is too small to be seen, modern projection equipment now has web cams, usb microscales and visualizers to aid the teacher. You may be fortunate in obtaining copper crystal growth from the cathode as shown in Figure 17.

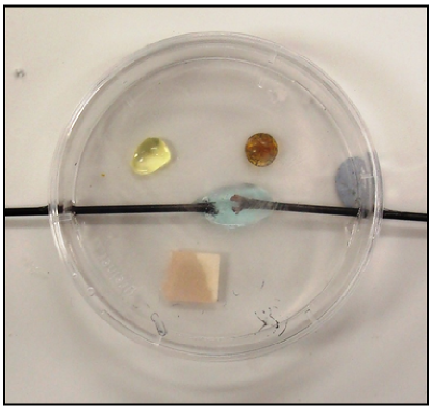


Figure 16: Electrolysis of copper(II) chloride solution. Chlorine diffuses from the anode to react wit 0.5M potassium bromide solution and 0.1M potassium iodide solution and bleaches dam blue litmus paper.

Figure 17: Copper crystals forming at the cathode during electrolysis. This was taken with an expensive Dinolite USB microscope (http://www.gtvision.co.uk).

There is a website I have made which shows goes into more detail[10] and there are videos on the CLEAPSS You-tube channel[11].

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3 http://www.iocd.org/WhatWeDo/microscience.shtmL
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5 *Microscale Chemistry: Experiments in Miniature*, John Skinner, RSC, 1998, ISBN-13: 978-1870343497
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7 www.microchemuk.weebly.com
8 Based on work by L Kvittingen et al, *J. Chem. Educ.,* 2014, 91 (7), pp 1037–1039
9. Johnstone, A.H. & Wham, J.B. (1982). *Education in Chemistry*, 19 (7) p. 71-74.
10. www.microchemuk.weebly.com
11. https://www.youtube.com/user/CLEAPSS

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Science & Environmental News

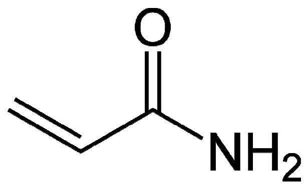
Acrylamide back in the news

In 2002 (see below) there was a health scare over cooked foods like chips, crisps etc., when it was discovered that high temperature cooking of carbohydrates produced a chemical called acrylamide (prop-2-enamide). There were concerns at the time as to whether this was carcinogenic or not. The evidence is inconclusive and it still classed as a probably carcinogen. The UK's Food Standard Agency (FSA) is launching a campaign to cut the levels ingested by frying, toasting, baking, grilling or roasting to a light gold rather than dark brown colour, as a precautionary measure.
https://www.food.gov.uk/science/acrylamide-0

Chemistry & Chance

Acrylamide in crisps and other foods

A big environmental scare in 2002 was the accidental and unexpected discovery that crisps and other cooked starchy foods contain significant levels of acrylamide, a suspected carcinogen. Swedish researchers were looking at possible contamination of laboratory workers who use polyacrylamide gels, and they found acrylamide bound to haemoglobin in their samples. They then went to check the background levels by measuring levels in people who hadn't been exposed to the gels. They found, to their surprise, high levels in unexposed people, but not in wild animals. They suspected it must be coming from the diet, rather than being an environmental or laboratory contaminant. They checked various foods for possible contamination, to find out if it was coming from the food packaging. They found high levels in crisps, chips and other processed foods and initially this triggered a food scare as it was thought to be a contaminant. It turned out to be a natural product of cooking.



Acrylamide (prop-2-enamide)

This led to a massive research effort to find out what foods contained acrylamide and then to see how it was formed and what health effects it has. One thing is certain - everyone who eats cooked food is ingesting acrylamide and this means that humans have had it in their systems since the discovery of fire and cooking. Just because we can identify something in food and measure its concentration does not mean it is necessarily toxic. It is the does that makes the poison and almost certainly humans have adapted to low levels of acrylamide in the diet.

The acrylamide is now known to be a product of cooking at high temperatures > 120°C e.g. baking or frying, and is due to the Maillard reaction between asparagine, a common amino acid, and reducing sugars, like glucose.

The Mailllard reaction was discovered by the French chemist Louis-Camille Maillard in 1912, while attemtpting to reproduce biological protein synthesis. It is non-enzymatic browning caused by recation between a protein and a carbohydrate at high temperatures, and is distinct from caramelization (the browning of sugars on heating).

Acrylamide is used industrially to make polyacrylamide and is a restricted substance as it is highly toxic to rats. This discovery is a good example of scientists looking for one thing and finding something totally unexpected.

References

The Scientist 2/9/02 16(17) 26-28
'Plastic in my French fries?' Barry A. Palevitz
Acrylamide in food, June 2006, CAST Issue Paper #32, http://www.cast-science.org/websiteUploads/publicationPDFs/acrylamide_ip.pdf

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Plastics waste and recycling: an urgent societal problem

In January 2017 a report on *The New Plastic Economy: rething the future of plastics* was launched by the Ellen McArthur Foundation in Davos. It is an attempt to grapple with the problem that most of the plastics we use end up being dumped in one way or another after only one use. A large amount ends up in the oceans. Plastics in their many formsd have become an indispensable part of modern life, with many useful properties. However, many products are only used once and then discarded and only a small amount is recycled. The amount that is 'lost' represents a waste of valuable natural resources (oil) and presents a massive environmental problem, as most plastics do nto degrade in the environment. Of course, it is people who cause pollution not the plastic items themselves. In Ireland and the UK most of the plastic water bottles we use are thrown away, and some are recycled. In Germany such bottles have a levy on them and can be returned in supermarkets and the levy recovered. This is a system that seems to work very well. The plastic bag levy in Ireland and in the UK has reduced dramatically the number of plastic bags being used and thus the number being thrown away and ending up in the environment. Little actions can have big consequences. In 50 years, the use of plastics has risen from 15 Mt in 1964 to 311 Mt in 2014. Tje basic idea behind the report is that of the circular economy: where waste becomes the raw material for some other use. This idea is known as the circular economy (see below).

Summary

Plastics have become the ubiquitous workhorse material of the modern economy – combining unrivalled functional properties with low cost. Their use has increased twentyfold in the past half-century and is expected to double again in the next 20 years. Today nearly everyone, everywhere, every day comes into contact with plastics – especially plastic packaging, the focus of this report. While delivering many benefits, the current plastics economy has drawbacks that are becoming more apparent by the day.

After a short first-use cycle, 95% of plastic packaging material value, or $80–120 billion annually, is lost to the economy. A staggering 32% of plastic packaging escapes collection systems, generating significant economic costs by reducing the productivity of vital natural systems such as the ocean and clogging urban infrastructure. The cost of such after-use externalities for plastic packaging, plus the cost associated with greenhouse gas emissions from its production, is conservatively estimated at $40 billion annually – exceeding the plastic packaging industry's profit pool. In future, these costs will have to be covered. In overcoming these drawbacks, an opportunity beckons: enhancing system effectiveness to achieve better economic and environmental outcomes while continuing to harness the many benefits of plastic packaging. The "New Plastics Economy" offers a new vision, aligned with the principles of the circular economy, to capture these opportunities. With an explicitly systemic and collaborative approach, the New Plastics Economy aims to overcome the limitations of today's incremental improvements and fragmented initiatives, to create a shared sense of direction, to spark a wave of innovation and to move the plastics value chain into a positive spiral of value capture, stronger economics, and better environmental outcomes. This report outlines a fundamental rethink for plastic packaging and plastics in general; it offers a new approach with the potential to transform global plastic packaging material flows and thereby usher in the New Plastics Economy.

You can access the report at https://www.ellenmacarthurfoundation.org/assets/downloads/EllenMacArthurFoundation_TheNewPlasticsEconomy_15-3-16.pdf

On the next page you can see the most common plastics and their uses in packaging.

The types of plastics and their use in packaging

Source: Project MainStream analysis.

Plastics in the EU

The most recent report on plastics in the EU is available at: http://www.plasticseurope.org/documents/document/20161014113313-plastics_the_facts_2016_final_version.pdf

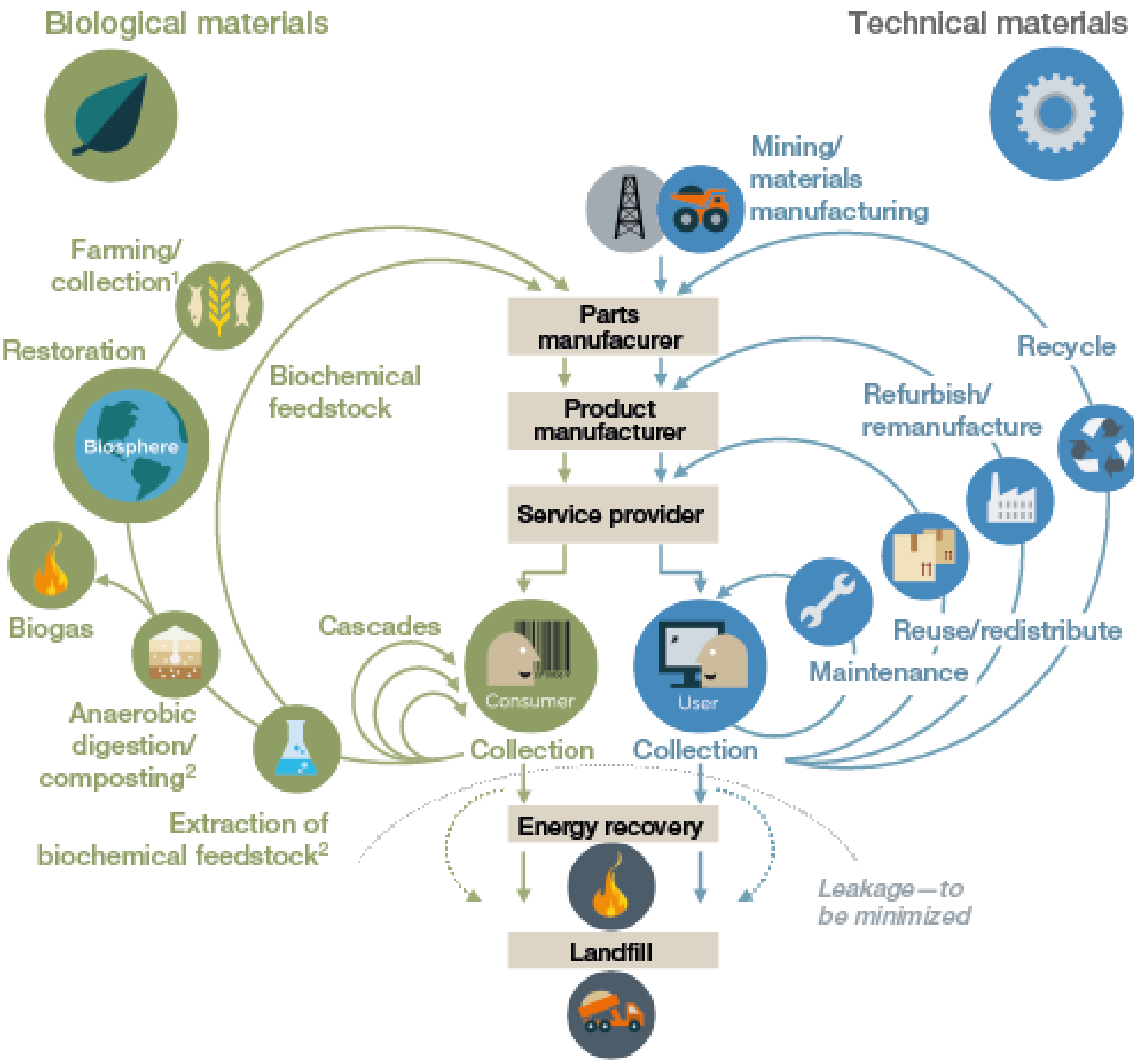
In 2014, 25.8 Mt of plastics ended up in the w aste stream. Of this, 29.7% was recycled, 39.5% was used as an energy feedstock and 30.8% went to landfill.

The Circular Economy

A circular economy is an <u>industrial economy</u> that promotes greater resource productivity aiming to reduce waste and avoid <u>pollution</u> by design or intention, and in which <u>material flows</u> are of two types: biological <u>nutrients</u>, designed to reenter the <u>biosphere</u> safely, and technical nutrients, which are designed to circulate at high quality in the production system without entering the biosphere as well as being restorative and regenerative by design. This is contrast to a <u>linear economy</u> which is a 'take, make, dispose' model of production.

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

The circular economy (The Ellen McArthur Foundation)



From coffee bean to firelog

I came across an intersting example of the Circular Economy in the *Sunday Times*, 19/2/17. Arthur Kay started a company Bio-bean to turn waste coffee grounds into firelogs, called Coffee Logs, available through Amazon, with a revenue of €8.8 m. Bio-beans slogan is 'Powered by coffee' (www.bio-bean.com/). The factory can process up to 50,000 t of grounds/year, about 10% of the U's production.

Elementary chemistry

A Periodic Poem

The RSC website has a poem by a student on the hiustroy of the Periodic Table.Check it out. http://www.rsc.org/news-events/175-stories/2016/oct/chemistry-poetry/

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A new elements song

Many of you will be familiar with the Elements song by Tom Lehrer, now out of date, but still worth listening to. (For an animated version see https://www.youtube.com/watch?v=zGM-wSKFBpo) I came across a new version which goes to element 118, but doesn't have the names of the last 4 new elements. Worth listening to and shwoing to your students.

https://www.youtube.com/watch?v=VgVQKCcfwnU

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The Discovery of the Elements

An excellent but out-of-print book on the history of the chemical elements is *The Discovery of the Elements* by Mary Elvira Weeks.
You can access and donwload an electronic copy of the 6th edition free-of-charge at: https://ia902609.us.archive.org/2/items/discoveryoftheel002045mbp/discoveryoftheel002045mbp.pdf

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Elementary limericks

We have published several of Peter Davern's limericks based on the elements. Peter has decided to turn these into a book and we will will have to wait for this before we can read the rest of them. Watch this space for details!

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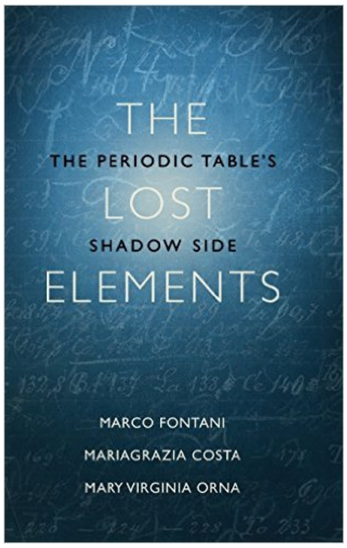

The Lost Elements

I just came across this book, published in Nov. 2014, called *The Lost Elements:The Periodic Table's Shadow Side* byMarco Fontani, Mariagrazia Costa, and Mary Virginia Orna, published by OUP (hb)and available from The Book Depository for €32.12.

"Throughout its formation, the periodic table has seen false entries, good-faith errors, retractions, and dead ends; in fact, there have been more elemental "discoveries" that have proven false than there are current elements on the table.
The Lost Elements: The Shadow Side of Discovery collects the most notable of these instances, stretching from the nineteenth century to the present. The book tells the story of how scientists have come to understand elements, by discussing the failed theories and false discoveries that shaped the path of scientific progress."

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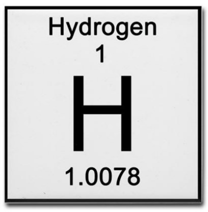
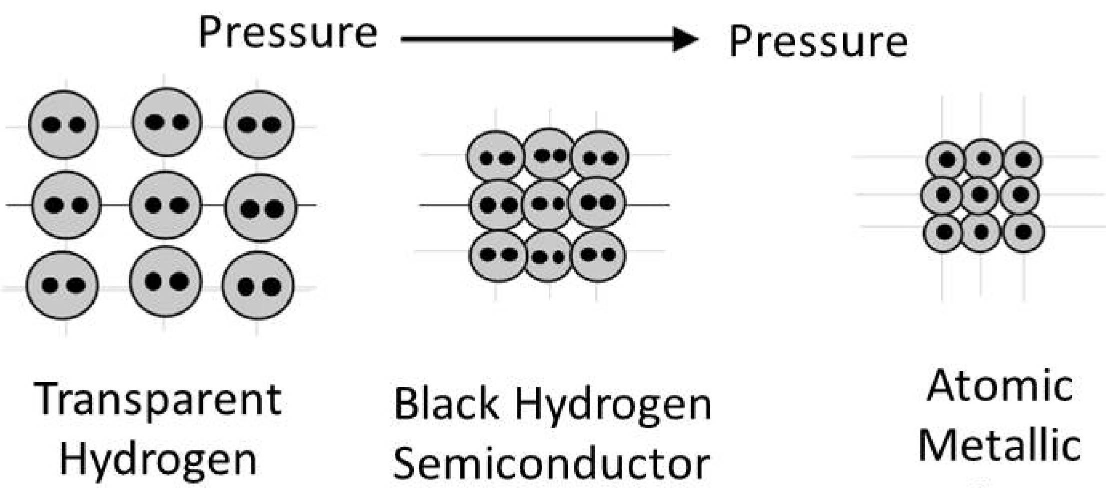
Hydrogen turned into metal



Hydrogen is the lightest element with only one valence electron, $1s^1$. For this reason it is often located in the Periodic Table at the top of group 1, elements whose outer electron configuration is s^1.

The group 1 elements are metals and there has been a theoretical prediction since 1935 that hydrogen should trun into a metal under high enough pressure. Hydrogen exists as H2 molecules even in the solid but when put under extreme pressure, the molecules are pushed together so that the molecules are split and the electrons on the single atoms interact to form a metallic bond. Professor Isaac Silvera and Dr Ranga Dias at Harvard University squeezed a sample of hydrogen between diamond anvils at a pressure of 495 gigapascal, or more than 71.7 million pounds-per-square inch and have claimed that metallic hydrogen was produced. The discovery was described as 'The holy grail of high-pressure physics." "One prediction that's very important is metallic hydrogen is predicted to be meta-stable," Silvera said. "That means if you take the pressure off, it will stay metallic, similar to the way diamonds form from graphite under intense heat and pressure, but remains a diamond when that pressure and heat is removed." Read more at: https://phys.org/news/2017-01-metallic-hydrogen-theory-reality.html#jCp

See the scientists describe their work at: https://www.youtube.com/watch?v=1qitm5fteL0



It is thought that liquid metallic hydrogen may exist inside the heavy planets Jupiter and Saturn.

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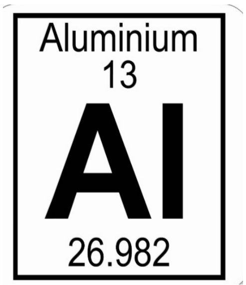
Aluminium smelting in the UK the death of an industry



The UK used to be a major producer of primary aluminium, with smelters at Holyhead (140,000 tpa), Lynemouth (178,000 tpa) and Fort William (47,000 tpa). Holyhead closed in 2009 due to prospective closure of the Wylfa nuclear power station; Lynemouth closed in 2012, despite having its own coal-fired power station, due to the cost of energy and EU regulations on greenhouse gas emissions. That left Lochaber, near Fort William in Scotland, using hydroelectric power, as the only remaining aluminium smelter in the UK. The future of the Lochaber plant was also in doubt but in Dec. 2016 it was announced that it had been bought by the Liberty Group and SIMEC from Rio Tinto for £330m, who would invest £120 in the plant, securing its jobs. The new company will be called Liberty British Aluminium and aims to retain the current 170 jobs and create 2,000 more in spin-off industries. The nearby smelter at Kinlochleven was closed in 2000.

Scotland was the site of the first aluminium smelters in the UK as the British Aluminium Company Ltd opened its plant at Foyers on 7 May 1894. The same company opened two more hydroelectric powered smelters in the Highlands at Kinlochleven in 1909 and Lochaber in 1929. Initially the bauxite, the raw material for aluminium, was imported from N. Ireland, but the supplies were not sufficient and bauxite was then obtained from France and then Guiana. The original Foyers plant at Invergordon closed in 1981. In 1907 Scotland produced 1/3rd of the world's primary aluminium. Today it produces 47,000 tpa out of a global total of 41,400,000 tpa, 0.1% - how are the mighty fallen! Another Irish connection was that Aughinish Alumina in Co. Limerick used to supply alumina to Lynemouth, when both were owned by Alcan.

A critical analysis of the case for closure of Lynemouth was produced by the Civitas think tank by David Merlin-Jones in 2012. (http://www.civitas.org.uk/content/files/aluminium2012.pdf) It concluded that the combination of UK government actions in increasing energy prices and EU pollution rules were major factors in the closures. The report concludes:

"This report is a eulogy with a warning. While the primary aluminium industry is all but dead, there are still many other energy-intensive industries left in the UK, such as glass, chemical and ceramic manufacturing. Together, these are worth £75 billion and employ 700,000 people, and they are just as vulnerable to the future rises in energy costs. The government has allowed the primary aluminium sector to die, but it should not let this happen to other sectors, most pressingly because it cannot afford to: these are some of the most valuable industries Britain retains and their growth is vital to the economic rebalancing the government is supposedly championing."

Aluminium consumption and production in the UK

(BGS Metals Fact Sheet 2015)
file:///C:/Users/User/Downloads/mpfmetals.pdf

Year	Al primary production	Al secondary production	Al consumption	% supplied by national production
2009	252,000	129,800	615,590	62.0
2013	45,000	148.800	590,400	32.8

The table above shows the impact of the loss of national Al production on imports of Al. The majority of Al now has to be imported – up from 38% in 2009 to 67.2% in 2013.

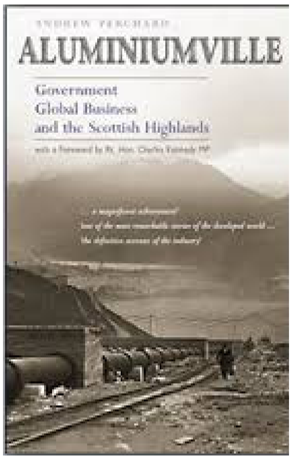
Aluminium is a metal which is very expensive to make but only requires 5% of the original energy to recycle. The UK has a thriving secondary aluminium industry.

65% of aluminium cans are recycled in the UK. In 2013 148,800 t of recycled aluminium was produced. In Ireland 55% of cans were recycled in 2013. (See http://www.alu-web.de/nc/en/home/industry/news-detail/news/7/1453443660aluminium-beverage-can-recycling-in-europe-at-new-record-high/ for EU figures). In Europe Finland and Germany tie as the best Al can recyclers at 99% and Croatia is the lowest with 12%. Recycling saves on raw materials and energy and in the case of aluminium it is a metal that is almost indefinitely reusable to its low corrosion rate.

Information on Lochaber:
http://www.aluminiumtoday.com/contentimages/features/Lochaber_History1.pdf

(http://www.greener-industry.org.uk/pages/aluminium/aluminium_8PM3.htm)

The British Geological Survey has published an up-to-date guide to metals in the UK. There are also fact sheets on other industries.
BGS Metals Fact Sheet 2015
file:///C:/Users/User/Downloads/mpfmetals.pdf



A recent book by called *Aluminiumville* by Andrew Perchard (2012, Carnegie Publishing) tells the story of the Highlands aluminium smelters. (Available from The Book Depository, pb. for €16.25)

"This is a story about the Highlands being at the centre of a global industry. On the eve of the First World War, Foyers and Kinlochleven accounted for 12% of the global production of aluminium. These Highland smelters were the backbone of the aluminium industry in the UK for the bulk of the 20th century."

http://www.aluminiumville.co.uk/

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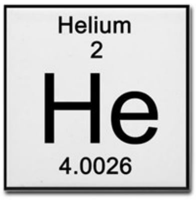
Helium supplies secured



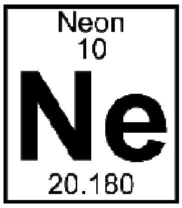
Helium is a non-renewable resource as supplies are limited and once it is released into the atmosphere it is gone, into outer space. It is produced in the earth's crust as a by-product of radioactive decay, as alpha particles convert into helium atoms. It is usually obtained as a by-product of oil and gas production and 78% was produced by the USA, which held large strategic stockpiles. Its major use is not for filling party balloons, but for cooling low temperature magnets for use in NMR machines and MRI machines, and other uses (see below). A new source has been found by geologists in Tanzania's rift valley and *"The team estimates that the reserve contains around 1.53 billion cubic metres – enough to fill 1.2 million MRI scanners, and seven times the amount of helium consumed annually."* (*New Scientist* 27/6/16) Current supplies were due to run out in 10-20 years time, which would be disastrous. People are now more careful about conservation and recovery of a rare resource. The supply has been accumulating over billions of years of earth's history and we may burn through it in 100 years.

See also: Endangered helium: bursting the myth. http://www.thechemicalengineer.com/~/media/Documents/TCE/free-features/870helium.pdf

What helium is used for:

- It is used in the space industry to keep satellite instruments cool, to clean out rocket engines and was used to cool the liquid oxygen and hydrogen that powered the Apollo space vehicles
- Helium is used as a cooling medium for the Large Hadron Collider (LHC) and the superconducting magnets in medical MRI scanners
- Helium is often used to fill party balloons, weather balloons and airships because of its low density
- A mixture of 80% helium and 20% oxygen is used by deep-sea divers and others working under pressurised conditions.
- Helium-neon gas lasers are used to scan barcodes at supermarket checkouts (http://www.bbc.com/news/science-environment-36651048)

The shortage of supply has raised the price of helium and this in turn has encouraged investment. Linde, the industrial gases company, will start to extract helium from natural gas in South Africa in 2018.



Neon is also in short supply and Linde will invest money to capture 40 million L a year of neon from air at its plant in La Porte, Texas. Neon is used in neon lighting tubes but is also crucial in the production of semiconductor chips, which is now its main end-use. Unlike helium, neon is heavier and thus remains in air as a trace component and can be extracted in the process of separating nitrogen and oxygen from air.

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Endangered elements

"Of the 118 elements that make up everything—from the compounds in a chemists arsenal to consumer products on the shelf—44 will face supply limitations in the coming years. These critical elements include rare earth elements, precious metals, and even life essentials like Phosphorus. Research into more abundant alternatives, more efficient uses, recycling and recovery will help mitigate risks and move industry towards sustainable supply chains."
https://www.acs.org/content/acs/en/greenchemistry/research-innovation/research-topics/endangered-elements.html

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Learning about the nomenclature of organic compounds by creating stop-motion videos

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Abstract
Today, almost all students aged 12-19 years own a smartphone and/or tablet PC. Unfortunately, these devices are often used for private communication and searches on the Internet only. But these devices are so 'smart' that they offer a variety of other chances to support learning. In this article, we present an example of how the making of stop-motion videos can be used to make the learning of the nomenclature of organic compounds a different and creative experience.

Introduction
Stop-motion videos are animated movies formed by a sequence of pictures that are put one after each other and then presented in a certain speed [1]. The pictures can be easily made with smartphones or tablet-PCs. Apps for the creation of stop-motion videos put the pictures in a chronological sequence and allow for export of the result as a short video clip. Experiences in the classroom show that students generally learn very quickly how to use such stop-motion apps after a short phase of introduction and practice – if they do not possess corresponding skills already.

An example of applying the creation of stop-motion videos in chemistry classes may concern the learning about the nomenclature of organic compounds. The introduction to nomenclature according to IUPAC rules is an important part of organic chemistry in secondary chemistry in most curricula. The IUPAC rules are made to provide clear and unambiguous names for any organic compound. However, the identification of the correct name is not always easy for students [2] and needs knowledge of the corresponding rules and training on how to apply them. Therefore, it has also previously been suggested that the introduction and exercising of the nomenclature of organic compounds should use creative and collaborative teaching approaches [e.g. 3-5].

The nomenclature of organic compounds is determined using several rules to be followed step by step to specify the technically correct IUPAC names. Generally, the introduction to organic chemistry nomenclature starts with simple and branched alkanes, before substituents or functional groups are added. This article describes how to progressively apply the rules of naming organic compounds in a creative practice, by means of making stop-motion videos.

Stop motion videos on the nomenclature of alkanes
An introduction to the nomenclature of organic compounds requires that students possess already some knowledge about the structure of simple organic compounds, at least the straight-chain alkanes. Subsequently, the question arises how branched alkanes with various side chains are to be named.

The students get a worksheet with the first simple IUPAC rules and a sketch of an unknown branched alkane. There is also a paper template of hydrocarbon puzzle pieces to cut. With the help of these hydrocarbon pieces, the pupils puzzle their own version of the alkane (Figure 1).

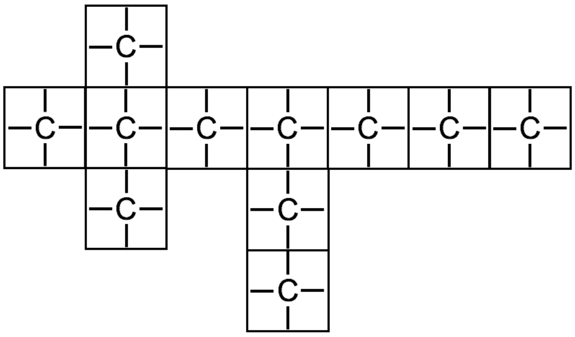

Figure 1. Sketch of a branched alkane puzzled by the hydrocarbon puzzle pieces.

The task is to name the alkane from Figure 1 step by step by applying the IUPAC rules. At this point the creation of the stop-motion video starts. For making the stop-motion video it is suggested to put a writable surface (a sheet of paper) on the table and to fix it with adhesive strips so that it cannot slip. The alkane structure is laid onto the paper. The first picture might be already taken just having the alkane structure. The paper provides a good background for the pictures and allows comments to be added in written form, e.g. adding the numbering for the longest carbon chain; but also adding any other information in written form, either on the paper or on mobile paper scraps. Students can also use movable arrows to highlight relevant points in the molecule. The smartphone or tablet PC should take up a fixed position, for example, with the help of a tripod, so that every picture has the same focus. The image should be arranged so that the entire document is within the focus of the camera (Figure 2).

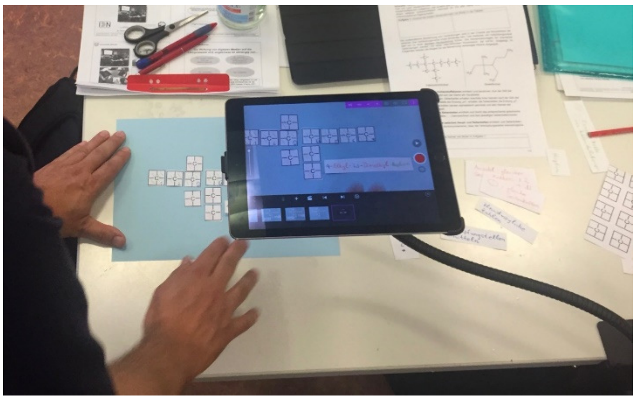

Figure 2: Creation of a stop-motion video with an iPad fixed with a flexible tripod.

The students shall start by numbering the longest carbon chain. The students then can add small cards naming the methyl- and ethyl-groups. Also coloring of the carbon atoms can be used to differentiate the central chain and any different side groups. After each step, a photo is taken. The photos are joined together at the end to form the stop-motion video. The students have developed a first step-by-step guide to the naming of a branched alkane.

Depending on the achievement level, or for internal differentiation, various alkanes can be named by different groups of students. E.g., the example in Figure 3 requires two additional naming rules. In this alkane it must be noted that the substituents counted from both sides have the same numbers (3 and 5). To identify the right numbering the rule has to be applied, that the order of names of various alkyl-substituents has to be given in alphabetical order without considering the prefixes (di, tri, ...). In the event that the smallest number is achieved from both ends of the longest chain, the name is to be selected, which overall leads to the smallest numbers. After the first rule therefore it is not 3,3-dimethyl-5-ethylheptane, but 5-ethyl-3,3-dimethylheptane; according to the second rule this name is also right in relation to the potential name 3-ethyl-5,5-dimethylheptane.

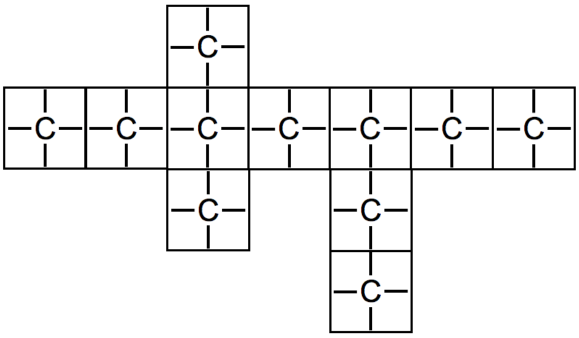

Figure 3: For higher achievers or for the purpose of differentiation 5-ethyl-3,3-dimethylheptane can be given as a task since it needs application of further IUPAC rules.

In a second phase of learning, the students are asked to create their own branched alkane that has at least twelve carbon atoms. They are asked to puzzle it out using the hydrocarbon puzzle pieces, to name it according to the learned rules, and to create another stop-motion video. Of course, depending on the learning objectives and students' prior knowledge, corresponding videos can also be made based on including puzzle pieces with simple substituents (such as bromine or chlorine) or functional groups (such as alcohol groups or double bonds) (Figure 4). The necessary additional rules may be searched on the Internet by the students.

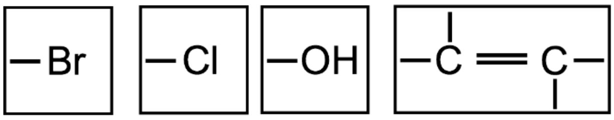

Figure 4: Extending the puzzle for including further IUPAC rules.

Experiences in the classroom

To avoid the situation that the stop-motion video will become too fast at the end, the speed should be adjusted. A speed of two seconds per image proved to be very suitable. If necessary, single photos can be displayed longer; this can be done through adding a pause at the corresponding image.

For the creation of the stop-motion videos, a group size of three to four students worked well. In this way, every learner has chance to contribute to the group work. Classroom observation showed that there is usually an intense and constructive exchange between the learners. It turned out that students involved in the production of the first stop-motion video produced already good experiences in the design and application of the IUPAC rules. This led the learners to start more goal-oriented when creating the second video and also showed generally good skills in applying the IUPAC nomenclature.

The variety of the stop-motion videos produced offers also a series of further training opportunities. The stop-motion videos from the second round can be provided to all learners, e.g. via DropBox. So the students can get homework assignments to name further molecules and to use the stop-motion videos for help and assessment.

Apps for making stop motion videos

For iOS the free app "Stop Motion" is available. The basic version contains already all necessary functions to create a stop-motion video. The app can be installed and used on both iPads and iPhones. For Android the same app is also available. However, you will find the app under the name "Stop Motion Studio". Sample videos and a download of the puzzle pieces are available at www.digitale-medien.schule.

Acknowledgment

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Authentic Research in Everyday Life: Brand Name, Generic, or Home Remedy? Which Antacid Works Best for the Money?

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Abstract

Traditional, introductory, general chemistry labs typically involve "canned" processes that remove the student from the authentic process that we, as scientists, employ not just in our experimental design, but to evaluate claims in our everyday life, as well. These recipe-like experiments have their place in teaching valuable skills, in working with equipment and in understanding assumptions inherent in any experiment. After all, most of us were cooks who followed the recipe before we became chefs. In other words, it wasn't until we knew how the equipment worked and how the ingredients complemented each other, that we were able to create that magnificent dish - without a recipe. Even if our students do not become scientists, we want that "magnificent dish" to empower them to evaluate a claim and intelligently question what they are told… yes, even by the scientists themselves. This lab activity was designed to teach the nature of science (NoS) by evaluating the claim we have all heard: "As long as the amount and kind of active ingredient are the same, the generic version works as well as the brand name." Quite surprisingly, students find out that context does matter and that the "fillers" and/or processing (including particle size) play a role in the lack of effectiveness and/or availability of a compound. Additionally, this lab activity addresses the validity of a "home remedy", while helping the student to understand and question everything, including experimental design, in context. Ultimately, students perform a cost-benefit analysis that leads them to see the bigger picture - that is, if the context is right!

Introduction

In the October 2015 edition of *The Science Teacher,* field editor Steve Metz reminded us that the nature of science *"need[s] to be intentionally targeted in classroom activities and laboratory investigations and incorporated into all our science teaching."* This lab experiment does just that. Additionally, with the advent of the computer age, students seem to be thinking less and less and are becoming further removed from the problem-solving process. They "google" answers instead of reasoning through the process, cut and paste answers, take pictures off the board instead of writing notes down on their own, and believe claims on the internet without considering the source. "Canned" labs often further exacerbate our students' ability to think critically by making it appear that systematic approaches to solving problems are only used by "real" scientists. Making educated decisions in everyday life and intelligently questioning what students are being told in the media, are important life skills that empower students and enhance the quality of life. This activity is designed to help students see that science answers the practical questions they have in everyday life - and that they can intelligently question and research what they have been told - sometimes, even by the scientists themselves!

This lab activity employs active learning techniques that foster student discovery, and an understanding of process and application of new information to problem solve (McKinney 2014) in a more authentic setting. With the teacher as facilitator, students are guided into a more authentic experience of the nature and process of doing science. In this activity students answer questions that are important in everyday life:

1. Is the generic brand of an antacid as effective as a brand name if the kind and quantity of the active ingredient are the same?
2. Does the context matter?
    a. Does the filler play a role in the effectiveness of the antacid?
    b. Is it fair to use conclusions drawn *in vitro*, to *in vivo*?
3. Does a home remedy have any merit?
4. What assumptions, inherit in all experiments, influence the conclusions that are drawn?
5. How does the outcome of an experiment influence our own choices?

This experiment uses relatively inexpensive materials and does not require sophisticated instrumentation (only an electronic balance and pH test strips are used instead of a pH meter). I have used this activity with great success with high school students and it has also been used to help middle and high school teacher candidates understand the nature of science in a college *Science Methods* course. Approximately 50 students working in groups of two or three have performed this activity. Depending upon the depth of the pre-lab discussion, this lab takes approximately 1 hour to complete (a double period).

The Activity

Students are prompted to discuss the following questions in their groups (20-30 minutes):

- Why do some people purchase the *store brand* antacid?
- Would you ever purchase a *store brand* antacid? Why or why not?
- Have you ever used a *home remedy* for an ailment? If so, what was it and did it work?
- What are the active ingredients in Tums, store brand, and baking soda antacids? What are the inactive ingredients?
- What is the 'normal' molarity of stomach acid?
- What is molarity anyway?
- What is pH?

Students are then asked to jot down their group responses in their lab notebooks. Once they have done this, students are asked to share what they talked about in their groups. We then discuss ways in which some of their "home remedies" could be scientifically tested. The focus is then turned to the analysis of the antacids and students are asked to answer the following prompt in *one* of the formats below:

Which antacid do you think will work the best and why?

Examples:

Of the three antacids, I predict that __________ will work the best because...

Of the three antacids, I predict ____________ and ____________ will work equally well because…

Of the three antacids, I predict they will all be equally effective because…

Before giving students the lab hand-out (see end of article), we discuss how an experiment could be designed to test their hypotheses.

Materials for the Activity

After the preliminary "literature review" (reading the labels for active and inactive ingredients; finding a generally accepted value for the pH of stomach acid; defining molarity and pH), students read through the procedures and list the materials for the lab activity (see rationale on lab sheet – end of article). I then check to see that each group of 2 has included the following:

Three 250 mL beakers and 3 stirring rods
One 50.0 mL graduated cylinder
One 500 mL reagent bottle of 0.1 M HCl
2 Mortar and Pestles (one for each tablet)
1 tablet of Tums
1 tablet of Equate (Walmart store brand) or other generic antacid e.g. Galpharm
1.0 gram of Baking Soda
10 – 13 Dip and read pH test strips with four different indicators which together give extremely accurate readings across the entire pH range.

Procedure (30-40 minutes)

Students pour 30.0 mL of 0.10 M HCl into each of the three clean 250- mL beakers using a graduated cylinder. They take the pH and record it. They then pulverize the generic Equate (or alternative) and Tums with separate mortar and pestles. One gram of each is dissolved in two appropriately labelled beakers. In a third beaker, 1.0 gram of baking soda (sodium bicarbonate) is dissolved. Students record their observations (see photo in abstract) from the dissolving process.

Using three new fresh pH strips, they then take the pH of the three different solutions and record their observations in the data table. They again add 30.0 more mL of 0.10 M HCl into each of the three 250-mL beakers and take the pH (this means that there is now 60.0 mL of HCl in each beaker). This process is continued in 30.0 mL increments until students have a clear "front runner" (after 90.0 mL).

Safety and Hazards

Despite the low concentration of hydrochloric acid, always have students wear safety goggles and gloves during the activity. Hydrochloric acid is one of the "nicer" acids; it itches before it burns. Regardless, have student wash their hands with soap and water after every experiment.

Results

The results of this experiment suggest that the filler and/or processing (including particle size/surface area) of the tablet ***does*** matter and that sodium bicarbonate is the most effective antacid *per dose.* The inactive ingredients in Tums and/or the processing of the tablet appear to enhance the ability of calcium carbonate to dissolve in the HCl (see photo in abstract) compared to Equate. Because the calcium carbonate more thoroughly dissolves in the hydrochloric acid, it does a better job at neutralizing it. Students conclude that even if the same type and amount of active ingredient are the same, the generic is not always as effective as the name brand. Processing and additives can affect the bioavailability, effectiveness and/or function of a compound.

Students are frequently shocked by the results of this experiment. The implications concerning generics are huge! As Michael McCoy (2002) reminds us, *"When it comes to generic drugs, the public and the major pharmaceutical companies wear their hearts on their sleeves: The public loves them for their low prices, and drug-makers hate them for what they do to profits"*. Perhaps, the low prices come at the cost of effectiveness. Although not all fillers and processing of generic drugs may affect the performance of a compound, it is an important consideration to weigh especially for more serious health problems.

Lastly, this lab activity gets students to question the methods through which scientific knowledge is investigated and reported. They come to realize that the experimental design in the lab may not adequately reflect what is happening in the body. Although they understand that the dosage of the contrived experimental design is excessive, and that the prescribed dose of the tablets is most likely the reactant in excess, they consistently choose the Tums because it "looks more efficient", "tastes better" and "you get what you pay for". For some students, this lab activity was the first time they even considered that organizations like USP (U. S. Pharmacopeia) might use experimental designs that do not fully honour the context (for more information on USP, see Lois R. Ember (2001), "Raising the Bar for Quality Drugs: Independent U.S. Pharmacopeia sets Legal Standards Enforceable by FDA").

Assessment

By the end of the activity students should be able to:

- Determine if the generic brand of an antacid is as effective as a brand name if the kind and quantity of the active ingredient are the same;
- State the impact of context as it pertains to:
    a) The role fillers play a role in the effectiveness of the antacid;
    b) Experimental conclusions drawn *in vitro* and *in vivo*;
- Provide evidence to determine if a home remedy has any merit;
- Discuss assumptions, inherit in all experiments, that influence the conclusions that are drawn;
- Provide scientific evidence that corroborates an everyday choice in antacids.

Although lab notebooks are collected and critiqued, my primary means of assessment for this activity is a formative assessment through class discussion.

Conclusion

In short, many "canned" labs have been developed to teach chemical concepts through the use of antacids. A classic example of using antacids to teach the "Factors Affecting Reaction Rate" was developed by the editors of the *Journal of Chemical Education* back in 1998. This activity, however, goes beyond the traditional teaching of chemical concepts to explicitly teach about the nature and process of doing science advocated by NRC (2012) and NGSS (2013). As Metz (2015) reminds us, "explicitly" does not mean didactically and learned by rote. With this lab activity, teachers have a practical example to foster an *explicit experience* in the nature and process of doing science. Students question what they believe, why they believe it and systematically test their hypothesis. They question the final design of the experiment and claims made by *in vitro* versus *in vivo* testing. More than 50 undergraduate and high school students have performed this lab with similar results and awe!

NGSS Matrix on NoS (NGSS, 2013)

Understandings about the Nature of Science
(NGSS 2013)

One goal of science education is to help students understand the nature of scientific knowledge. This matrix presents eight major themes in the left column. The first four are most closely associated with practice and the second four with cross-cutting concepts. The high school grade level understandings about the nature of science are in the right column with the explicit tie to "*Brand Name, Generic or Home Remedy? Which Antacid Works Best for the Money?"* written in blue immediately after it.

Category	High School
Scientific Investigations Use a Variety of Methods	1) Science investigations use diverse methods and do not always use the same set of procedures to obtain data. 2) New technologies advance scientific knowledge. 3) Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. *1-3 This experiment demonstrates types of assumptions scientists make, especially in pilot experiments and potential sources of error. (See: "this is a safe assumption provided beakers were scrupulously clean and the acid came out of the same bottle; when budget is a factor, scientists take a few short cuts on the pilot experiment. As always, additional confirmatory tests with more sophisticated equipment are warranted in a formal research project slated for publication.") "New" technologies (i.e. a pH meter) can give more sophisticated results in comparison to pH test strips.* 4) The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. 5) Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge. *4-5 You could have different "research groups" use different equipment by using a pH meter for one group and pH test strips for the other. A cost/precision/benefit analysis will help students understand decisions scientists continually make concerning experimental design.*
Scientific Knowledge is Based on Empirical Evidence	1) Science knowledge is based on empirical evidence. *Students use the data to corroborate their decisions.* 2) Science disciplines share common rules of evidence used to evaluate explanations about natural systems. *Students find that surface area and the ability to dissolve are factors that influence their experimental results.* 3) Science includes the process of coordinating patterns of evidence with current theory. *Various theories of acids and bases (Arrhenius, Bronsted-Lowry or Lewis theories) can be used to describe what the test strips and/or pH meters are measuring.*

	4) Science arguments are strengthened by multiple lines of evidence supporting a single explanation. *Different student research groups replicating the results can facilitate a consensus on the actual results in addition to a possible explanation as to why the brand name and the generic behave differently given the identical kind and quantity of active ingredient.*
Scientific Knowledge is Open to Revision in Light of New Evidence	1) Scientific explanations are subject to revision and improvement in light of new evidence. *Most physicians make the claim that as long as the amount and kind of active ingredient are the same, you will get the same results. This lab does NOT demonstrate that.* 2) The certainty and durability of science findings varies. *This lab now introduces the uncertainty and a level of skepticism for the claim that "as long as the kind and amount of active ingredient are the same, the generic is just as effective as the brand name".* 3) Science findings are frequently revised and/or reinterpreted based on new evidence. *Students use the data to confirm or refute the claim that "as long as the kind and amount of active ingredient are the same, the generic is just as effective as the brand name".*
Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	1) Theories are explanations for observable phenomena. *Various theories of acids and bases (Arrhenius, Bronsted-Lowry or Lewis theories) can be used to describe what the test strips and/or pH meters are measuring.* 2) Science theories are based on a body of evidence developed over time. 3) Laws are regularities or mathematical descriptions of natural phenomena. *The "Law" that the same ingredient will behave the same every time needs to be placed into context. Particle size and or processing of an ingredient can determine how the ingredient behaves.* 4) A hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory. *Students confirm or refute their hypothesis for a decision they make in everyday life.* The term "theory" as used in science is very different from the common use outside of science. *This lab provides the opportunity to discuss how the lay persons "My theory is…" should really be "My hypothesis is…"*
Science is a Way of Knowing	1) Science is a way of knowing used by many people, not just scientists.* *This experiment is performed by students to see how they can design an experiment that will empower their decision making in everyday life.* 2) Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge. *In this lab students do a "literature search" to use and extend their knowledge of their experimental design.* 3) Science is a unique way of knowing and there are other ways of knowing.

	Experimental evidence is used to confirm or refute students' hypotheses. Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review. *Experimental evidence is used to confirm or refute students' hypotheses. The data from this experiment makes students skeptical about the claim: "as long as the kind and amount of active ingredient are the same, the generic is just as effective as the brand name". They are also skeptical about the design of the experiment in that if the antacid is the reactant in excess, then the continual adding of acid is a flaw in the experimental design.* *Middle school outcome. 4) Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time. *Might we now revisit the claim: "as long as the kind and amount of active ingredient are the same, the generic is just as effective as the brand name"?*
Scientific Knowledge Assumes an Order and Consistency in Natural Systems	1) Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. *This lab demonstrates that although the natural laws operate the same always, the context does matter. No two people have the exact same physiology and what works for one person may not work for another even if the natural laws are the same. Additionally, although the exact same compound is being used the particle size, processing, and inactive ingredients may influence how the compound behaves.* 2) Science assumes the universe is a vast single system in which basic laws are consistent.
Science is a Human Endeavor	1) Scientific knowledge is a result of human endeavor, imagination, and creativity. *The laboratory design of this experiment demonstrates the creative approaches scientists use based on the equipment they have access to and can afford. Creative approaches can both help and hinder experimental results.* 2) Individuals and teams from many nations and cultures have contributed to science and to advances in engineering. *This lab demonstrates that even a high school student can inspire "real scientists" to question claims and provide reassuring evidence that "as long as the kind and amount of active ingredient are the same, the generic is just as effective as the brand name".* 3) Scientists' backgrounds, theoretical commitments, and fields of endeavor influence the nature of their findings. *In this experiment a "theoretical commitment" may be an allegiance to the taste of the brand name to an equally effective alternative as part of the decision making process.* 4) Technological advances have influenced the progress of science and science has influenced advances in technology. *Will the use of a pH meter alter our findings? Is "in vitro" as reliable as "in vivo".* 5) Science and engineering are influenced by society and society is influenced by science and engineering. *The entire generic pharmaceutical industry is motivated by providing a more inexpensive drug. Could society be getting a less effective product due to processing and/or filler choices?*

Science Addresses Questions About the Natural and Material World	1) Not all questions can be answered by science. 2) Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. 3) Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. *2 & 3 Ethical implications that can be taught with this lab might deal with people who cannot afford the brand name might be getting less effective drugs as well as the generic industry making billions of dollars from ineffective ingredients.* 4) Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. *This lab demonstrates that many people choose the generic just because they are told that generic is equally effective, not because they have actually seen the data. If a physician or someone you respect tells you something, demand evidence!*

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The sample lab handout, with comments, is given on the next page.

This is based on a paper given at the Nature of Science Symposium, University of Limerick, October 2016. Michele Whitecraft has been a chemistry teacher for more than 32 years and is currently a professor at Mansfield University, Mansfield, Pennsylvania.

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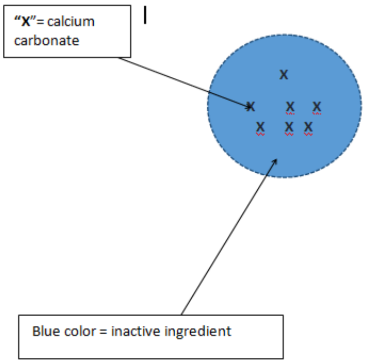
The diagram below illustrates how an inactive filler can slow down release of the active ingredient in a tablet.



This model helps students to understand how the inactive ingredient can prevent the active ingredient from reacting.

The circle represents a pulverized piece of antacid. The blue color represents the "inactive" filler. The "X"s represent the active ingredient (calcium carbonate). If the inactive filler (blue) does not dissolve (physical change), the active ingredient will not react with the acid (chemical change).

Brand, Store Brand, or Home Remedy? What Antacid Works Best for the Money?

(Comments to teachers in italics.)

Introduction/Engagement:

Within your group, discuss the following and summarize your group response to each question in your lab notebook. Write your summary/answers to the following questions in your theories/background section. *(Actual student responses are attached in attached document)*

Why do some people purchase the *store brand* antacid?
Would you ever purchase a *store brand* antacid? Why or why not?
Have you ever used a *home remedy* for an ailment? If so, what was it and did it work?
What are the active ingredients in Tums, store brand, and baking soda antacids? What are the inactive ingredients?
Got an internet connection? What is the normal molarity of stomach acid?
What is molarity anyway? What is pH?

Purpose/Hypothesis:

Which antacid do you think will work the best and why?

Examples:
Of the three antacids, I predict that __________ will work the best because...
Of the three antacids, I predict ____________ and ____________ will work equally well because….
Of the three antacids, I predict they will all be equally effective because…..

Materials:

Outline the procedures below in your lab notebook. Decide what equipment you will need and collect it. *(Having students read through the procedures, parse out and list the equipment on their own serves two purposes. First, it assures they have read before they begin. Second, they pay closer attention to how the experiment is being done. I check their list before they gather the equipment. Additionally, procedures are required to be written out before they begin as a third way to assure understanding and safety.)*

Procedures:

1. Safety first! Wear goggles… HCl is being used!
2. Pour 30.0 mL of 0.10 M HCl into three clean 250 mL beakers. This will simulate your stomach acid on 3 different occasions.
3. Using pH paper, test the pH of **one** of the solutions (they will all be the same) and record in your data table.
   (Indicate that this is a safe assumption to make if the beakers were scrupulously clean and the acid came out of the same bottle; when budget is a factor, scientists take a few short cuts on the prototype experiment. As always, additional confirmatory tests with more sophisticated equipment are warranted in a formal research project slated for publication.)
4. Label each beaker T (for Tums), SB (store brand) and BS, for baking soda.
5. Using a mortar and pestle to pulverize the pill forms of the antacids, place exactly 1.0 grams of each antacid into each of the corresponding beakers.
   (Keep a separate mortar and pestle for each tablet brand to avoid cross contamination)
6. Stir each solution and record observations of the dissolving process.
7. Using pH paper, test the pH of each of the different solutions and record (record this in data table "A" in lab notebook).
8. Now add 30.0 *more* mL of 0.10 M HCl to each beaker. Stir thoroughly to be sure no antacid sticks to the side of the beaker. Test the pH of this solution and record (record this in data table "B" in lab notebook). Continue this process until you can ascertain the antacid that is the best—if, in fact one does act better than another with the addition of each 30.0 mL increment.

Data Table:

pH of acid in each beaker (simulating stomach acid)=________			
	Tums pH	Store Brand (Equate) pH	Baking Soda pH
A) 30.0mL			
B.) 60.0mL			
C.) 90.0mL			

Questions/Calculations:

1. Describe what you saw as each antacid dissolved. Draw a picture in your lab notebook of each beaker. *(The generic Equate does not fully dissolve compared to Tums and baking soda (see photo in abstract).)*
2. What factors may have influenced the extent to which each dissolved/reacted? *(The different "inactive" ingredients and/or particle size (surface area) play a role in the ability of the identical quantity active ingredient in Tums and Equate-- calcium carbonate-- to dissolve in the acids.)*
3. Given Tums costs \$1.90 for 30 tablets, Equate \$2.50 for 125 tablets and \$0.65 for 227 grams of baking soda, use dimensional analysis to show the cost per tablet/ dose of antacid.
   Sample student calculations in separate attachment.
4. Which antacid would you choose and why? *(Based on the "out of context" experimental data, most students who perform this lab choose baking soda first, followed by Tums. Reasons some students do not pick baking soda are typically due to flavour. Additionally, people on a low sodium diet may want to avoid baking soda.)*
5. How is a dose defined? Were we comparing "apples to apples" by comparing 1.0 gram of each tablet to 1.0 gram of baking soda? Why or why not? (*Because the tablets also contain filler (inactive ingredients) and the baking soda contained 100% active ingredient ($NaHCO_3$) we were not comparing equal amounts of active ingredients. Assuming the tablets were homogeneously mixed, it* ***is*** *a fair comparison to measure the pH results of Tums to the store brand, provided the same amounts were used.)*
6. What aspects of the experimental design are contrived and may affect the true effectiveness of the antacids? (*A beaker with HCl does not accurately mimic all stomach chemicals or body temperature; nor does the addition of acids in 30.0 mL increments. Additionally, the antacids are usually dosed in excess and not in one gram increments. Even if Equate does not neutralize all of the acid that Tums does, if it is administered in excess, it could be considered equally effective.)*

Conclusion:

Did you prove or disprove your hypothesis. Use evidence from the lab and information from the theories section to support/refute your hypothesis.

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Chemists you should know: #1
The aristocratic chemist
Amedeo Avogadro (9/8/1776 - 9/7/1856)

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The first member of this new series of names met with in the study of chemistry is Amedeo Avogadro, or to give his full title, Lorenzo Romano Amedeo Carlo Avogadro di Quaregna e di Cerreto which is a bit of a mouthful.

Avogadro was born on the 9th of August 1776 in the city of Turin in Italy, which was annexed in 1797 as part of the French Empire. His father, Filippo, who was Count of Quarenga and Cerrato, was an eminent lawyer and President of the Senate. Avogadro's mother was Anna Maria Vercellone, daughter of Count Amedeo Vercellone and a distant relation of Count Filippo Chiara Avogadro of Valdengo. Apart from Amedeo, named after his maternal grandfather, the couple had at least one other child, Felice. Count Filippo died in 1807 leaving Amedeo to succeed to the title of Count.

Educated privately at home at first, the Amedeo began his College education at the age of thirteen and graduated in 1792 at the age of sixteen. Continuing in College, he was awarded his Ph.D. in ecclesiastical law in 1796, practicing as a lawyer like his father. By 1801 his practice was well established and he became secretary to the prefecture of Eridano.

Law held little attraction for the young Amedeo and with the timely reopening of the Turin University in 1800, he took up instead the study of mathematics and physics in his spare time, under the guidance of Anton Maria Vassali-Eande (1761-1825). Entranced by the recently discovered voltaic pile, he involved his brother, Felice, with his experiments. The electricity experiments of the pair, prompted by the disagreements with their renowned compatriots, Galvani (1737-1798) and Volta (1745-1827), resulted in their first published paper on the electrical behaviour of salt solutions in 1803. This was noteworthy enough to get them both elected members of the Royal Academy of Sciences in Turin in 1804. Amedeo now discarded his legal practice to become a demonstrator in the Academy in 1806, teaching his favourite subjects, mathematics and physics. A second paper, again on electricity, was presented in 1807.

The above map shows the positions of the three Italian towns associated with Amedeo. The distance from Turin to Biella is about 100 km. The French border is about 63 km to the west of Turin.

In 1809 Amedeo was appointed Professor of Natural Philosophy at the Royal College of Vercelli (see above map northeast of Turin), where his family lived, and he held this position until 1820 when he became the first professor of mathematical physics at the University of Turin. This position chiefly involved the study of differential and integral calculus. It is during his time here in Vercelli that Amedeo developed his chemical theories, for which he is justly renowned. His first paper in Chemistry was on acidity and alkalinity, presented in 1809. This was followed in 1811 by the work for which he is famous, determining the relative masses of elementary molecules in a body. It is here that his law: 'equal volumes of gases, at the same temperature and pressure, contain the same number of molecules' was formulated and presented. This was followed by a paper describing the determination of the relative masses of molecules in simple bodies in 1814 by the application of his 1811 law.

Apparatus used by Amedeo in his work on gases now in the Milan museum.

Amedeo's work was not received very well at the time. He was not noted for his practical work and theoretical ideas on their own, without detailed practical experimentation to back them up, were not welcome. It was not until 1858, two years after Amedeo's death, that Stanislaw Cannizzaro (1826 – 1910) came upon a copy of his work and realised the truth of Amedeo's ideas and that the contribution of Amedeo's ideas to fundamental chemistry became accepted by the scientific community.

On November 21st 1821 Amedeo was elected a Resident Fellow of the Academy, Turin. As a member of the Academy he was responsible for the examination of works submitted for publication. He also had responsibility for checking the claims of privilege of existing patents.

The French annexation of the Italian area was not popular and Amedeo had sympathy for those opposing it. Disturbances and riots in the area in 1821 led to the University being shut and on the 23rd July 1822 his Chair was abolished and Amedeo found himself out of a job, but with a pension of 600 lira provided he did not have another job.

Not daunted Amedeo, was appointed Master Auditor at the Royal Room de' Conti (a judicial tribunal), where he served on legal and administrative matters. He presented a paper on the construction of a voltage multiplier to the Academy in 1823 and one on specific heats of solid and liquid bodies in 1833.

The University was re-established in 1832 but the professorial post was handed to a Frenchman, Augustin-Louis Cauchy (1769-1857), rather than to the politically incorrect Amedeo. However in August 1833 Cauchy left his post, going to Prague as tutor to the 13 year old Duke of Bordeaux, Henri d'Artois, the exiled crown prince of France. After another year, having failed to find a more suitable tenant for the post, Amedeo was reappointed on November 28th 1834. Amedeo kept this position until 1850 when he retired. Between 1837 and 1841 Amedeo wrote a series of four hand-books on physics for use in the University. A key section of the books was on thermal phenomena.

Amedeo married Anna Maria Felicita Mazzé (1795-1870) from Biella (see position on map) on June 9th 1815. Anna was the daughter of Count Giuseppe Mario Mazzé and Polissena Casea. The couple were to have eight children in all. Their names were Annetta (Anna) (1816-1909), Giuseppina (1817-1906), Filippo (1818-1847). Chiara(Clara) (1821-1901), Orsola (1823-1907), Luigi (1826-1900), Felici (Felicino) (1828-1907) and Edoardo (1835-1842). Luigi succeeded Amedeo as Count, his older brother Filippo having predeceased their father Amedeo. Both Luigi and Felici went on to become generals in the Italian army.

Amedeo lived quietly and did not travel abroad as most scientists of the era did. This, plus the fact that Turin was not regarded as a major scientific centre and thus was not visited by notable men from elsewhere, was largely responsible for the lack of fame accorded to Amedeo during his life. Later he was honoured by having the constant for the number of molecules in a mole (approx. 6.02×10^{23}) named after him.

An Italian stamp issued to mark the centenary of Avogadro's death.

Amedeo died in Turin on July 9th 1856 and was buried in the cemetery of Quaregna (of which he was Count) about 4 km northeast of Biella.
Death was not to be the end of Amedeo's work, with a number of publications appearing posthumously over the following 150 years:

Selected works, edited by Icilio Guareschi, Turin 1911.

Essays and memoirs on the atomic theory, 1811-1838, a cura di m. Ciardi, Florence, 1995.

Three unpublished manuscripts, a cura di m. Ciardi, Florence, 2006.

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Diary

2017

ASE Meeting
4-7 January
University of reading, Reading, UK
http://www.ase.org.uk/conferences/annual-conference/

6th New Perspectives in Science Education
16-17 March
Florence, Italy
www.conference.pixel-online.net

ISTA Annual Conference
7-9 April
Maynooth, Co. Kildare
http://www.ista.ie/ista-conference-2017/

Eurovariety in University Chemistry Education
27-29 June
Belgrade, Serbia
dtrivic@chem.bg.ac.rs

BASF Summer School for Chemistry teachers
27 &28 June Eureka Centre, University College Cork.
d.kenndey@ucc.ie

Chemistry Demonstration Workshop
3-7 July
University of Limerick
Sarah.hayes@ul.ie

ChemEd 2017
23-27 July
Sotuh Dakota State U., Brookings, SD, USA
www.sdstate.edu

ESERA
21-25 August
Dublin City University, Dublin
www.esera2017.org/

ChemEd-Ireland
21 October
University of Limerick
Sarah.hayes@ul.ie

ISTA Senior Science Quizzes
Regional Rounds: Thursday 16th November
National Final: Saturday 25th November in Trinity College Dublin.

Science Week Ireland
12-19 November
www.science.ie

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

Classic Chemical Quotations:7
Amedeo Avogadro (9/8/1776-9/7/1856)

"It must ... be admitted that very simple relations ... exist between the volumes of gaseous substances and the numbers of simple or compound molecules which form them. The first hypothesis to present itself in this connection, and apparently even the only admissible one, is the supposition that the number of integral molecules in any gases is always the same for equal volumes, or always proportional to the volumes. Indeed, if we were to suppose that the number of molecules contained in a given volume were different for different gases, it would scarcely be possible to conceive that the law regulating the distance of molecules could give in all cases relations so simple as those which the facts just detailed compel us to acknowledge between the volume and the number of molecules."

Count of Quaregna Amedeo Avogadro
'Essay on a Manner of Determining the Relative Masses of the Elementary Molecules of Bodies, and the Proportions in which they enter into these Compounds', *Journal de Physique*, 1811, 73, 58-76

Inquiring into energy through simple experiments:

a differentiation of concepts to strengthen energy literacy

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These three simple experiments illustrate the more subtle aspects of energy, especially in the way the energy concept is used in chemistry.

1. The Expanding Glove and the Reverse Glove

The first experiment shows a new variation of the well-known reaction between sodium carbonate and citric acid, emitting carbon dioxide. It is followed by the opposite reaction using calcium oxide to absorb the carbon dioxide. The experiment shows why enthalpy is a more convenient concept than energy for chemical reactions. One chemical reaction is releasing energy in form of pressure-volume-work and the opposite reaction is gaining the same amount of pressure-volume-work.

2. Hot and cold - Thermodynamics of a Rubber Balloon

The second experiment demonstrates the fundamental difference between work and thermal energy by tensioning and releasing a rubber balloon. Additionally it shows how heat and cold are released in the process and that creates interesting links to changes in aggregation state and to a refrigerator.

3. Aluminium/Air Battery (or Aluminium/Acid Battery)

The third experiment shows a very simple but modern aluminium-air battery concept. It explains the principles of galvanic cells releasing the most important form of energy: work. It offers a lot of ways to investigate how it works and how it can be made to work better.

The procedures for each of these experiments/demonstrations are given below.

1. The Expanding Glove and the Reverse Glove

Material: empty storage glass jar (minimum height 20 cm, opening about 8 cm, diameter about 12 cm), latex gloves. (See photo below for the experimental set-up.)

Chemicals: Sodium carbonate $Na_2CO_3.10\ H_2O(s)$, M = 286 g/mol or sodium hydrogen carbonate $NaHCO_3(s)$, M = 40.3 g/mol, citric acid $C_6H_8O_7.H_2O(s)$, M = 210 g/mol. Sodium hydroxide solution, NaOH (aq) about 30 wt% or calcium oxide CaO (s), M = 56.1 g/mol.

Quantities: For 1.6 l g CO_2 (1/15 mol): 7 g $NaHCO_3$ (1/12 mol) are mixed with 6 g $C_6H_8O_7.H_2O$ (1/12mol) and water added. For the reverse reaction about 4 g NaOH (dissolved in 20 mL water, cooled down to RT) are added.

The Expanding Glove

Add a heaped teaspoon of sodium hydrogen carbonate (about 7 g $NaHCO_3$) and one of citric acid (about 6 g $C_6H_8O_7 \cdot H_2O$) in the storage glass jar. Fill the glove with about 15 mL of water, put it over the rim of the glass so it forms a seal, letting the fingers hanging down outside. To start the reaction, pour the water into the glass bowl and move the bowl to start the reaction.

Observation: As the water mixes with the powders a gas start to evolve. The glove is expanding and standing up. Let the gas (air at the top!) out once or twice.

Explanation: When dissolved in water, the sodium hydrogencarbonate and citric acid are undergoing a chemical reaction to produce carbon dioxide. The gas is expanding the glove. The reaction is endothermic.

Subjects to discuss with this reaction: acid-base reactions; gases and pressure; pressure-volume work in the definition of enthalpy and necessity of a ‘new definition of energy’.

The Reverse Glove

Add sodium hydroxide solution (about 4 g in 10 mL of water) to the above glass jar and reseal with the glove.

Observation: The glove is reversed and pushed into the glass jar. (Figure 1(b))

Explanation: The sodium hydroxide solution absorbs the carbon dioxide and the pressure goes below atmospheric pressure. The atmospheric pressure pushes the glove into the glass bowl.

CO_2 (g) + H_2O (l) $\rightleftarrows$ H_2CO_3(aq)
H_2CO_3 (aq)+ 2NaOH (aq) $\rightleftarrows$ Na_2CO_3(aq) (sodium carbonate, soda) + $2H_2O$

Figure 1(a) **1(b)**

Alternative procedure: Add about 5 g (2 heaped teaspoons) of finely powdered calcium oxide (burnt lime) to the reaction mixture after the expanding glove and reseal the jar. Move the glass jar around but not too vigorously, so as not to cover the inner walls of the bowl with the white suspension. Or mix with a magnetic stir bar. You have to wait longer for the result.

Here calcium oxide absorbs the carbon dioxide:
CO_2 (g) + CaO (s) $\rightleftarrows$ $CaCO_3$ (s) (calcium carbonate, lime) + $2H_2O$

Partial reactions:
CaO(s) + H_2O $\rightleftarrows$ $Ca(OH)_2$ (aq)
CO_2(g) + H_2O $\rightleftarrows$ H_2CO_3(aq)
H_2CO_3(aq) + $Ca(OH)_2$ (aq) $\rightleftarrows$ $CaCO_3$ (s) + $2H_2O$

More experiments:
You can test the gas in the glass bowl with a burning candle or a burning match stick. The flames are extinguished by the carbon dioxide.

You can pour the gas in another beaker containing distilled water with the indicator bromothymol blue (add a little bit of lime-containing tap water to turn it slightly basic). The solution is blue at the beginning and starts to turn to green and yellow from the top by dissolution of carbon dioxide and formation of carbonic acid.

Sources:
Variation of an demonstration seen at the Europäischer Chemielehrerkongress 2013 in Wieselburg A and the Chemietage 2016 in Linz A, by W. Schatz & H. Wachtler

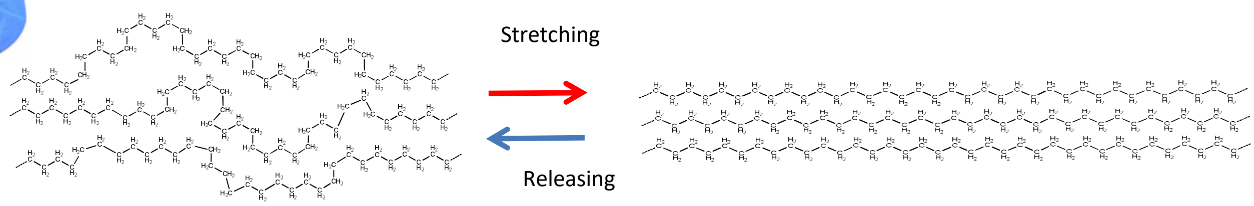
2. Hot and cold - Thermodynamics of a Rubber Balloon

The balloon skin is stretched and then released. The energetic effects are predicted, observed and explained.

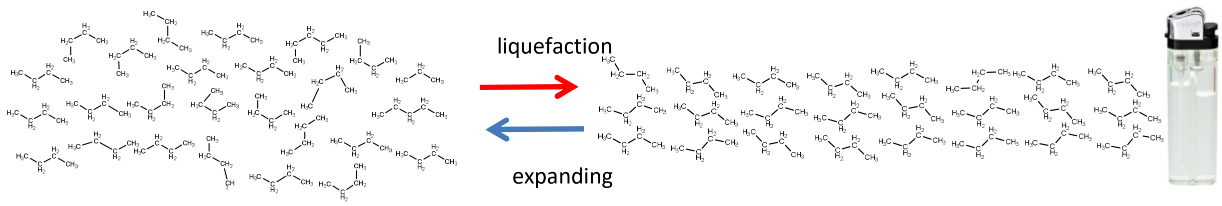
Procedure:
Read the instructions for the steps **a**)-d), put forward a hypothesis e) and then do the experiments along the steps a)-d).

a) Feel or measure (IR-thermometer) the temperature of the balloon skin with your upper lip
b) Stretch the neck of the balloon and feel or measure the temperature of the balloon skin again.
c) Keep the neck of the balloon stretched and let the temperature adjust to room temperature.
d) Release the balloon skin and feel or measure the temperature of the balloon skin again.
e) Make a hypothesis:
e1: How does the stretching of the balloon skin (**b**) influences the temperature? Why?
e2: How does the release of the balloon skin (**d**) influences the temperature? Why?

Explanation:
Stretching means approaching the molecules and aligning them in parallel. This releases energy as heat.



Analogous to the liquefaction of gases e.g. for gas lighters.



Stretching and releasing a balloon is analogous to change of state of aggregation e.g. in a gas lighter.

Releasing the balloon needs energy as heat (-> cold) like the evaporation from liquid to gas.

Stretching approaches the molecules like in the condensation process. That liberates energy as heat.

It is a model for a refrigeration machine where heat is absorbed by evaporation and released (outside the refrigerator) by condensation. As the condensation is not spontaneous the refrigeration machine has to do work by compressing the gas.

On the other hand it is a model for a heat pump. Heat is released by work and absorbed in another place.

Stretching is forcing molecules to approach and align in parallel by doing work. Approaching gives energy as heat.

Stretching (non-spontaneous):

ΔG = ΔH $-T\cdot\Delta S$

>0 (work!) <0 >>0 (<<0)

Releasing is letting separate molecules spontaneously and letting do work. It absorbs energy as heat what makes it cold.

But why are the molecules moving away from each other given that there is an attraction between? The explanation implies entropy. The entropy is rising in the rubber.

Releasing **(spontaneous)**:

ΔG = ΔH $-T\cdot\Delta S$

<0 (work!) >0 <<0 (>>0 entropy rises, does work!)

Thinking further:

- Compare the stretching and the releasing of the balloon skin with the solidification of a liquid and the melting of a solid (e. g. liquid water and ice). What is similar? What is different?
- Compare the stretching and the releasing of the balloon skin with the processes in a refrigerator. Or asked differently: Could you build a refrigerator based on a rubber skin?
- Stretched rubber can do work e. g. it can lift a mass against gravitation. Show with the GIBBS-equation above where this work comes from. Do you know machines with that kind of drive?
- You can hang a weight on a rubber band. Look at the GIBBS-equation and predict what should happen if you heat the rubber bad with a hair dryer.

NOTE from Editor: This experiment can also be done with a rubber band. Stretch the rubber band and touch the lips to it and detect the temperature drop. Set up a thick rubber band on a retort stand and add a weight to stretch it. Use a hair dryer to warm the rubber band instead of expanding, as we might have expected, when we add heat it contracts.

Sources:

http://highschoolenergy.acs.org/content/hsef/en/energy-theories/energy-entropy-rubber-band.html

http://www.rsc.org/learn-chemistry/content/filerepository/CMP/00/000/530/cce-76.pdf

3. Aluminium/Air Battery (or Aluminium/Acid Battery)

Aluminium is oxidized by oxygen from air. This process releases energy. This does not usually happen due to the protective oxide film. The reaction of aluminium with oxygen is:

$4Al(s) \ + \ 3O_2\,(g/aq) \ \rightarrow \ 2Al_2O_3(s)$

oxygen reaction

The electrons going from aluminium to oxygen in this reaction can be used as electrical current and release energy in a galvanic cell. Batteries are formed from galvanic cells by linking them in parallel and/or in series.

Negative pole: $4Al(s) \ \rightarrow \ 4Al^{3+}\,(aq) \ + \ 12e^-$

Positive pole: $3O_2(g) \ + \ 12e^- \ \rightarrow \ 6O(-II)$

An aqueous solution of salt (NaCl,aq) serves as electrolyte.

Water can also release hydrogen cations, H^+, as an acid ($H_2O \rightarrow H^+ + OH^-$) and give way to the following alternative reaction:

$4Al(s) \ + \ 12H^+(aq) \ \rightarrow \ 6H_2(g)$

acid reaction

Negative pole: $4Al(s) \ \rightarrow \ 4Al^{3+}(aq) \ + \ 12e^-$

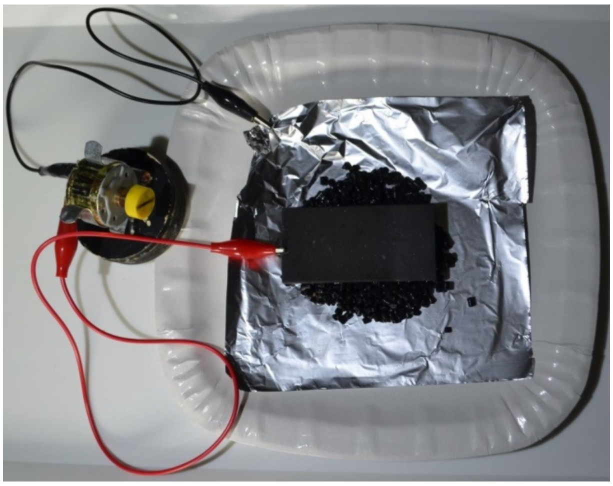
Positive pole : $12H^+(aq) \ + \ 12e^- \ \rightarrow \ 6H_2(g)$

Materials:

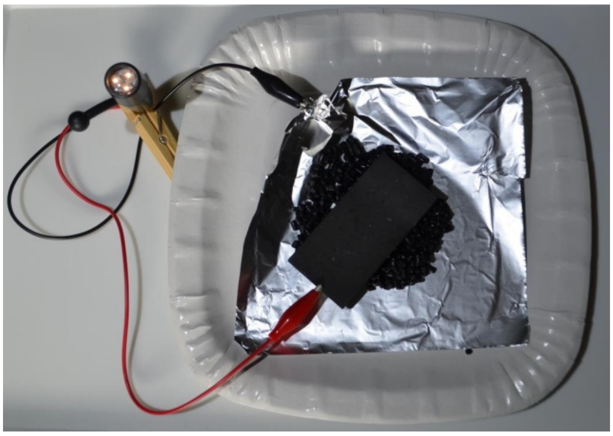
- **a)** Aluminium foil about 15 cm x 15 cm (the foil will be consumed)
- **b)** Disposable paper plate as a container
- **c)** Granular activated carbon (Pellets about 4 mm x 1 mm x 1 mm) from a pet shop (used in aquarium filters). It can easily be reused, washed if necessary and wetted again with salt water.
- **d)** Graphite plate electrodes (about 80 mm x 40 mm x 4 mm), e. g. from conatex.de
- **e)** Modified LED lamp (designed for one 1.5 V battery). The poles are connected directly to the contacts in the lamp by cables with crocodile clips or by soldering. A device ("Getaktete LED-Treiber" see http://www.led-treiber.de) in this lamp transforms low direct voltage into a sawtooth voltage which can be transformed up to the approx. 2-3 V necessary for the LED.
- **f)** **"Solar-electric motor".** It needs only a low starting voltage.
- **g)** Cables with crocodile clips

Procedure:

Put on a piece of aluminium foil (about 15 cm x 15 cm) about 40 mL of granular activated carbon wetted with salt water (about half saturated). Put on top of it a graphite plate electrode (about 70 mm x 40 mm). Connect a suitable electrical motor or an LED lamp to the galvanic cell: positive pole at the graphite plate electrode, negative pole at the aluminium foil.



2(a)



2(b)

Figure 2 (a) Aluminium/air-battery with electric motor and (b) LED-lamp respectively (Photos by Klemens Koch)

Alternative procedure: A battery in a matchbox.

Aluminium foil and granular activated carbon wet with salt water are packed in a match box so that you can introduce a smaller graphite plate electrode through the slit of the match box. Avoid any contact of the aluminium foil with the carbon electrode.

Observations:

The voltage between the graphite plate electrode and the aluminium foil is about 0.9 V and drives an electric motor or the LED Lamp. If it doesn't work you have to wet the activated carbon again.

The activated carbon can be reused and stored even wet in wide-necked flask.

The aluminium foil shows after use a fractal corrosion pattern where it has been consumed.

Remarks about technical and education aspects:

- There are two possibilities for the reaction at the positive electrode (cathode): oxygen or acid reaction. That is an interesting field of research: How can we differentiate between them?
- The reactions can be described very easily.
- The release of energy can be showed by burning aluminium powder in a flame. A similar process is going on in heat packs between iron powder and air.
- The aluminium/air battery is fast and easy to build and riskless with common materials.
- The galvanic cells can be connected in series or in parallel. The connections can be recognised and examined easily.
- The aluminium/air battery is an issue of modern research, e. g. for electric cars.
  Source: chargedevs.com/features/phinergy-ceo-explains-aluminum-air-batteries-for-1000-mile-range-extended-evs (25.2.17).
- The reactions are continuous and drive the motor or LED lamp for hours.
- A direct current is also running between the aluminium foil and the activated carbon (oxygen corrosion with local element effect). The aluminium foil shouldn't touch the wet activated carbon. A wet paper between the foil and the carbon can serve as a separator.
- The corrosion of aluminium in contact with copper can be examined in an electrolyte.
- The chloride ions in the electrolyte have a catalytic effect as in other oxidation processes of aluminium through the formation of tetrachloridoaluminate complexes.

Sources:

M. Tamez, J. H. Yu. (2007) Aluminum–Air Battery, *Journal of Chemical Education*, 84(12), 1936A

K. Koch. (2013) LED-Lampen mit einfachen galvanischen Zellen betreiben, c+b, *Bulletin des Vereins Schweizerischer Naturwissenschaftslehrerinnen und –lehrer VSN vsn.ch*, 1(13) .

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This article is based on a talk given at ECRICE in Barcelona, September 2016. Prof. Dr. Klemens Koch, works at the Pedagogical University of Berne and teaches at the Gymnasium Biel-Seeland. He is President of the Swiss Science Teacher Association (Biology and Chemistry).

Quotable quotes

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

Gertrude B. Elion Nobel Laureate 1988

"It is not the richest countries that invest in science and technology – i is the countries that have invested in science and technology that are now the richest."

Mariano Barbacid, molecular biochemist who discovered the first oncogene.

(*C&EN*, 8/8/16)

"That's why we love science. It's more than a school subject, or the periodic table, or the properties of waves. It is an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world, and to share this accumulated knowledge. It's a mindset that says we that can use reason and logic and honest inquiry to reach new conclusions and solve big problems. And that's what we are celebrating here today with these amazing young people."

President Barack Obama 23/3/16

Chemistry & Chance: The discovery of clathrates

Peter E. Childs

The first clathrate compound to be discovered was chlorine hydrate. When water saturated with chlorine gas was cooled crystals like ice formed, which on melting released chlorine. This had originally been thought to be a solid form of 'chlorine' and Humphrey Davy had shown in 1810 (1) that it contained a new element, which he named chlorine after its green colour. Later he asked Michael Faraday to investigate the crystals further and he discovered that they contained water as well as chlorine and he established the first formula, $Cl_2.10H_2O$.(2) Faraday also used the crystals to produce the first sample of liquefied chlorine by heating crystals of the hydrate in a sealed tube. The nature and structure of these compounds was not known at the time, but they are very common in nature.

Water at low temperatures and high pressure in the presence of small molecules like Cl_2, CH_4, C_2H_6, SO_2 etc. will crystallise with an open structure (unlike that of normal ice), which traps the molecules inside cages made of water molecules. The gases are released when the ice melts. These were the original host-guest molecules, where water is the host and other molecules its guests and are now considered as a class of inclusion compounds. The structures of such compounds between benzene and an ammonia-nickel complex were investigated using X-ray crystallography by H. M. ('Tiny') Powell in 1949 in Oxford (3) and he coined the name clathrate, from the Greek word for an iron bar, to describe how one molecule formed a cage or prison to hold in the other molecules.

Structure of a methane-water clathrate.
http://eatingjellyfish.com/?tag=methane-hydrates

In the 1930s natural gas pipelines in cold regions inexplicably became blocked with an ice-like substance, which when melted released methane gas. Methane clathrates had been formed and we now that these are ubiquitous in the environment – in cold regions where permafrost forms and in deep ocean sediments in many parts of the world. (4)There is twice as much carbon as methane trapped in clathrates as there is carbon contained in fossil fuels. The release of methane from permafrost in Siberia due to global warming is already occurring and will produce a positive-feedback effect, as methane has a higher global warming potential than carbon dioxide. Methane clathrates are also found in deep sea sediments and are a potential source of natural gas. (5)

1. Davy, H., (1811). Phil. *Trans. Roy. Soc.,* 101, 155
2. Faraday, M., (1823). *Quart. J. Sci*., 15, 71
3. Powell, H.M. & Rayner, J.H., (1949). Clathrate Compound Formed by Benzene with an Ammonia–Nickel Cyanide Complex. *Nature*, 163, 566-567
4. https://en.wikipedia.org/wiki/Methane_clathrate
5. http://geology.com/articles/methane-hydrates/

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Fifth Annual BASF Summer School for Chemistry Teachers in University College Cork Ireland

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The Fifth Annual BASF Summer School was held on Tuesday 28 June and Wednesday 29 June 2016 in the Eureka Centre UCC. The summer school is a collaboration between BASF, the Professional Development Service for Teachers (PDST), University College Cork and the Cork branch of ISTA. The BASF Summer School was initiated in 2012 when BASF responded in a positive and enthusiastic fashion to a request for sponsorship to run the summer school. Since that time, Frank McDonnell, Dr Dan McSweeney and Paul O'Driscoll of BASF have ensured that the summer school has become a fixed event in the diaries of chemistry teachers throughout Ireland. Initially, it was planned that the BASF Summer School would be a one-day event but so many teachers apply for places each year that it is run over two days each year. Due to the heavy emphasis on practical work, the numbers attending each day are limited to 30 teachers each day.

Each BASF Summer School is based around a particular theme on the Leaving Certificate chemistry syllabus in Ireland. The themes studied each year in the BASF Chemistry Summer Schools to date are summarised in Table 1.

Table 1. Themes of BASF Chemistry Summer Schools 2012 - 2016

Year	Theme of BASF Chemistry Summer School
2012	Assessment of Practical Work in the revised Leaving Certificate Chemistry Syllabus
2013	Key Practical Skills in Chemistry.
2014	Instrumentation in the Leaving Certificate Chemistry syllabus.
2015	Industrial Chemistry and Atmospheric Chemistry in the Leaving Certificate Chemistry syllabus.
2016	Teaching the Organic Chemistry section of the Leaving Certificate Chemistry syllabus.

The BASF Summer School is based each year in the laboratories and teaching rooms of the Eureka Centre of University College Cork. It is an ideal centre for providing in-service training to science teachers as it consists of state-of-the art science education laboratories, a Science Education Resource Centre, offices and a seminar room fully equipped with the latest audio-visual communication facilities. Funding for the Eureka Centre was provided by government sources, by the pharmachemical industry and by the College of Science, Engineering and Food Science (SEFS) in UCC. Funding to maintain the laboratories is provided each year by the School of Education UCC. The laboratories are fully equipped with all the apparatus and chemicals needed to teach the syllabi in Chemistry, Biology and Physics to Leaving Certificate standard.

The timetable for the 2016 BASF Summer School is shown in Table 2.

Table 2. Programme for Fifth Annual BASF Summer School

PROGRAMME
9.00 – 9.30 Registration. Tea / Coffee. 9.30 – 10.15 *The answering of Organic Chemistry questions on the Leaving Certificate examination* - Mr Pat Walsh, De La Salle Secondary School, Macroom, Co. Cork. 10.15 – 11.00 *The interface between Leaving Certificate Organic Chemistry and third level Organic Chemistry* – Dr Gerard McGlacken, Department of Chemistry, UCC. 11.00 – 11.15 Tea / Coffee. 11.15 – 12.00 *Just where do those curly arrows come from?* - Professor David Waddington, University of York, England. 12.00 – 1.00 *Organic Chemistry Laboratory practical session.* – Dr Declan Kennedy, Department of Education, UCC.

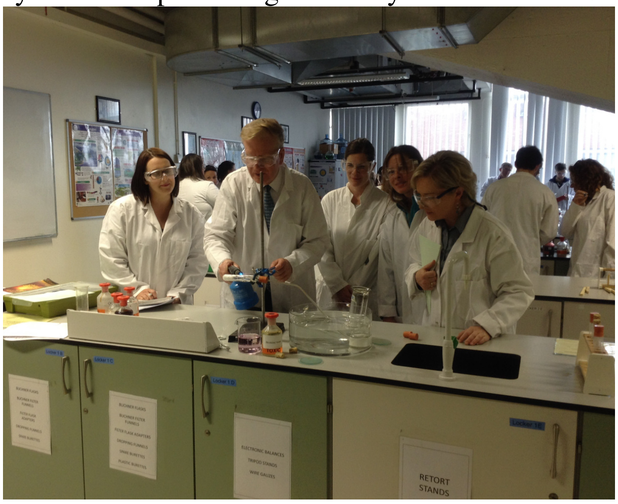
1.00 – 2.00 Lunch in UCC staff dining room.
2.00. Bus departs from UCC to Whitegate Oil Refinery. .
2.45 – 4.30 Visit to Whitegate Oil Refinery.
4.30 Presentation of Certificates of Attendance.

The Leaving Certificate Organic Chemistry practicals shown in Table 3 were set up for the laboratory practical session. This laboratory session proved very popular with teachers as it gave them the opportunity to try out some of the experiments and discuss very laboratory techniques with their colleagues. It was wonderful to see the experienced teachers sharing their craft knowledge with the younger teachers,who were teaching the Leaving Certificate syllabus for the first time.

Table 3. Organic Experiments BASF Summer School

Expt No.	**Title of Experiment**
1	To prepare ethene and examine its properties (combustion, tests for unsaturation using bromine water and acidified potassium manganate(VII) solution.)
2	To prepare ethyne and examine its properties (combustion, tests for unsaturation using bromine water and acidified potassium manganate(VII) solution.)
3	To extract clove oil from cloves by steam distillation.
4	To isolate clove oil (eugenol) from an emulsion of clove oil and water by liquid-liquid extraction using cyclohexane.
5	To prepare a sample of soap.
6	To study the reactions of ethanal with (i) acidified potassium manganate(VII) solution, (ii) Fehling's reagent and (iii) ammoniacal silver nitrate.
7	To study the reactions of ethanoic acid with (i) sodium carbonate, (ii) magnesium and (iii) **ethanol**.
8	To oxidise phenylmethanol (benzyl alcohol) to benzoic acid with potassium manganate(VII) solution (potassium permanganate) in alkaline conditions.
9	To recrystallise a sample of benzoic acid.
10	To measure the melting point of benzoic acid.

BASF was represented at the BASF Summer School by Frank McDonnell, who spoke of his delight that the BASF Summer School had proved so attractive to chemistry teachers and that all places had been filled each year with the demand for places exceeding the number of places available. He congratulated the teachers present on taking time out of their summer holidays to update themselves on new approaches to teaching organic chemistry. He also expressed the wish that the BASF Summer School would be of assistance to them in teaching the Leaving Certificate Chemistry syllabus and promoting chemistry in their schools.



Teachers working in the Eureka Centre Laboratories during the laboratory practical session.

At the end of the BASF Summer School, each teacher was asked to complete a feedback questionnaire. The feedback from the teachers was extremely positive. Typical comments were:

I really enjoyed the day - it was very well run. Many thanks to BASF for organising this.

Keep up the good work! I learned a lot.

Everything covered today was really useful for me in the classroom.

I enjoyed the hands on practical activities in the labs.

This was an excellent day - really informative and enjoyable.

The industrial trip was a great idea. I found it very insightful. It was my first time visiting an Oil Refinery.

I have found all parts of today extremely interesting and informative. I have learned a lot to bring back into the classroom. Well done all! A great day!

It was great to see all the experiments set up and working in the lab.

I have been to lots of in-service courses and this was among the best!

Thank you. The BASF Summer School was excellent as always.

I wish to express my sincere thanks to BASF, PDST, the staff of Whitegate Oil Refinery and to my colleagues in the Cork branch of the ISTA, for making the BASF Summer School such a successful event. I would like to give a special word of thanks to Mr Pat Walsh, Dr Gerard McGlacken and Professor David Waddington, for their excellent presentations.

I am very grateful to the chemistry teachers who attended the summer school each year in such great numbers and also to the teachers in the Cork Branch ISTA who help with the smooth running of the programme each year. This summer school is an excellent example of an Industry-Education partnership and I hope that it will continue to be an annual event in the calendar of chemistry education in Ireland.

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The RDS Primary Science Fair at Mary Immaculate College, Limerick

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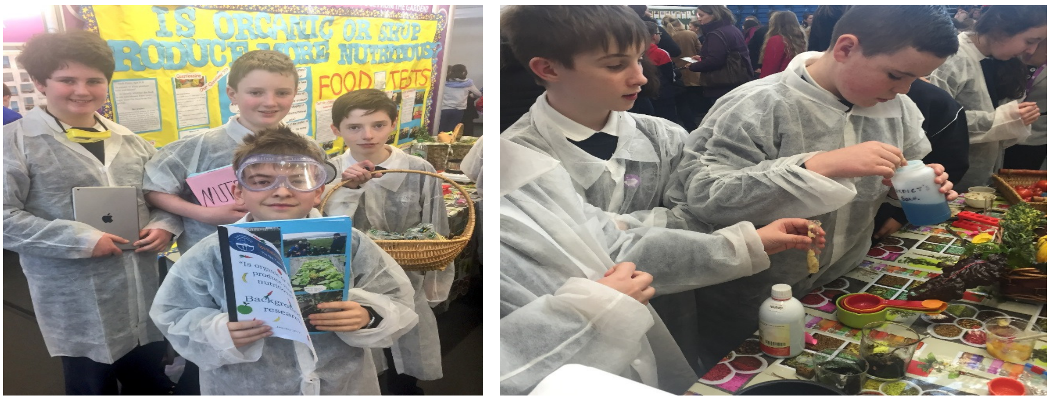
The RDS Primary Science Fair Limerick was hosted in Mary Immaculate College (MIC) from 19-21 January 2017. 3,000 primary school children exhibited their STEM (Science, Technology, Engineering & Maths) projects, spread over 3 days and involving 120 primary schools in the Mid-West. The RDS Primary Science fair, is a non-competitive forum, showcasing STEM investigations undertaken by primary school classes across Ireland. The aim of the fair is to equip students with science and maths skills. Developed and managed by the RDS, is a non-competitive event and looks to engage the entire class in a science related project. The fair taps into children's natural curiosity, encouraging students to engage and question the everyday world around them. Primary Science Fair Dublin was also hosted in the RDS in early Jan 2017 and the inaugural Primary Science Fair in Belfast will take place in June 2017.

The first RDS Primary Science Fair Limerick was held in November 2016.

Speaking at the official opening of the fair in MIC, Professor Eugene Wall, Acting President of MIC, welcomed the pupils and teachers from the 120 different primary schools to the event. *"Very much in line with the goals of the RDS, we have a strong track record in encouraging children's long term interest, understanding, knowledge and skills in STEM subjects - and developing primary school teachers' confidence, knowledge and skills in the teaching of STEM. Science education, and particularly the approach encouraged by this fair, is crucial in fostering wonderment in children and in helping them to develop scientific reasoning".*



Pupils from Spa NS, Tralee, Co. Kerry carrying out Food Tests in their project entitled: How can we compare the sugar level of produce in lunchboxes to produce from the garden?

Pupils from Scoil Mhuire, Co. Galway. The title of their project was "What causes the contamination of a toothbrush?"

In the Primary School Curriculum (DES, 1999a), Science is part of the Social, Environmental and Scientific Education (SESE) curriculum (DES, 1999b). There are four strands in the primary science curriculum: Living Things, Materials, Energy & Forces and Environmental Awareness & Care. Properties and characteristics of materials, mixing and changing and changes caused by heating and cooling are included in the Materials strand. The primary science curriculum is focused on enabling the learner to develop their knowledge, skills and attitudes as they develop an understanding of the world that they live in. Key scientific skills are developed e.g. questioning, observing, predicting, estimating, analysing etc., at each of the four developmental stages; from infants, through to first & second, third & fourth, and fifth & sixth class. There is also a focus on designing and making. The key skills developed here are exploring, planning, making and evaluating. The scientific and the design and make skills are developed as learners experience the units of work in each of the four strands of the curriculum. There is an increased emphasis on development of the transferible scientific skills of Inquiry-Based Learning (IBL), as opposed to a focus on the scientific content knowledge.

Here are some titles of the projects showcased at the Primary Science fair in MIC, where the primary pupils investigated chemical concepts:

- What are the different methods for keeping foodstuffs fresh?
- How do sunglasses protect our eyes?
- Which type of chocolate melts the fastest and why?
- What household substance makes the best window cleaner?
- How do materials, design and technology contribute in creating effective sports footwear?
- Why do soap bubbles form and what mixture makes the best bubbles?
- How does packaging affect the ripening of fruit?
- The Science of Baking - An investigation of the common ingredients used and their purpose
- How do fizzy drinks affect our teeth?
- Chemicals - Do they damage human hair?
- Biodegradable Plastic: Is it the best option?

Research (The Research Base, 2016) has found the fair to be unique on an international level through its methodology of whole-class, child-led approach to primary school STEM learning.

Pupils being entertained at the Junior Einsteins Science Show, just one of the many events that took place during the RDS Primary Science Fair at MIC.

This study also found that multi-annual participation has lasting impact at student, teacher and school levels; improving students' confidence, social skills, teamwork, and communication, in addition to equipping them with science skills.

The RDS STEM Learning Programme (RDS 2017) is an innovative and interactive professional development programme which underpins the fair. The STEM Learning programme is aimed at developing primary school teachers' pedagogical and conceptual knowledge of science and mathematics to support teachers in engaging their learners in developing their scientific skills. The STEM Learning conference was held in the RDS in November 2016.

In addition to the pupils' project exhibits, there were a range of interactive workshops and shows for pupils, teachers and families running throughout the three-day event. The Primary Science Fair is set to become a fixture in the Limerick calendar.

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Department of Education and Science, (1999b), *Primary School Curriculum - Science; Social, Environmental and Scientific Education,* Dublin: Department of Education and Science.

RDS (2017), RDS STEM Learning, available online: http://www.rds.ie/Ireland-s-Philanthropic-Society/Our-Work/Projects/RDS-STEM-Learning-(1) [accessed Feb 2017].

The Research Base (2016), *Executive Summary- External evaluation of the RDS Primary Science Fair,* RDS, Dublin.

□

Anne O' Dwyer, Maeve Liston, Miriam Hamilton are part of the Science Education Team in Mary Immaculate College, Limerick.

Engaging Children in STEM Education EARLY!

Joshua M. Sneideman
http://naturalstart.org/feature-stories/engaging-children-stem-education-early

But many parents and teachers wonder, at what age is it appropriate to start teaching STEM? And how can we implement these concepts into early childhood education? The answer is: It is never too early to start STEM education, and an ideal way to teach STEM is to go out into nature.

....

The most important thing to remember about teaching STEM to early learners is that they are perfectly adapted to learn STEM concepts, and it is not difficult to teach STEM to young children. The secret is to tap into their natural and innate curiosity about the living world. By simply allowing them to investigate, by encouraging them to ask questions about the real world, you are engaging children in STEM.

....

We need to work together to change the status quo for our nation's children. If the leading thinkers on education believe that our hopes for a vibrant democracy hinge upon a foundation of STEM education, then we need to be encouraging best practices in STEM from the get-go. One of the best practices in teaching and learning is to make learning relevant, and there is nothing more relevant than being outside and exploring the world we live in. Let's not wait another day to take young children outside to start engaging them in STEM education.

□

Chemlingo: Sharp stuff

Peter E. Childs

What do you do if you cut yourself? Most of us would put on a plaster but if you cut yourself shaving you would look for a **styptic** pencil. What is this and how does it work? Styptic comes from the Greek *stypticos* meaning to contract. A styptic pencil contains a chemical that causes blood vessels to contract, thus cutting off the blood flow. The most common ingredient is aluminium sulphate (alum), which is also used in anti-perspirants, where it causes sweat glands to contract and close up, thus stopping sweating. Another name for such chemicals is an **astringent**. An astringent also causes blood vessels to contract and comes from the Latin *astringere* = to close up. In the mouth an astringent substance, such as the tannin in wine, will cause the mouth to pucker. Another name for something that stops bleeding is a **haemostatic** agent, meaning that it causes blood to stop (stasis). An alternative name for a styptic pencil is a haemostatic pencil.

Strict and stringent come from the same root as astringent, meaning to narrow or draw in, which came to mean precise and rigorous. Astringency is closely related to the words bitter and acerbic. Acerbic comes from the Latin *acerbus* = bitter, sharp, deriving from *acer* = sharp, which also gives us acrid = sharp or pungent. Acrid is often used to refer to a small, e.g. burning sulfur. We are more likely today to use acerbic to describe someone's wit. *Acer* is the origin of acid (Latin *acidus* = sour), after the most common feature of acids. Sour comes from Old English *sur* meaning acidic and sours are drinks mixed with acids such as lemon juice.

Bitter originally came from the word biting and changed meaning to bitter = acrid or sharp. Many people still get acid tastes, which are sour, mixed up with bitter tastes – taste the difference between lemon juice and tonic water. Bitters are a powder made from herbs added to cocktails to make them taste bitter, and a pint of bitter needs no explanation, where the bitter taste comes from the hops. Sharp-tasting is usually used for bitter substances which cause the mouth to contract and pucker.

Interesting how many of these words are connected to drinks and to people. We talk about someone being sour-faced who is unpleasant and disagreeable, and they may also be bitter and acerbic. Perhaps due to drinking too much bitter beer and too many whisky sours!

□

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Contributions are always welcome to *Chemistry in Action!* providing the material is of interest to second-level chemistry teachers. Articles, experiments or demonstrations, teaching tips, book and AV reviews etc. are all welcome.

Send one hardcopy + diagrams and a copy on disc (or by email as a Word document) when submitting material.

You can contact the editor by email at: **peter.childs@ul.ie**

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Internet version

Chemistry in Action! is in the process of being put on the Internet at URL:

It is hoped to put back issues will be put on the Internet one year after publication. This is not yet fully operational and only issues 38 - 68 are now available. In time I hope that most back issues will eventually be available, 3 issues after publication.

At the same site you will also find the University of Limerick's science and technology magazine for schools, *ELEMENTS* and also information on SICICI, ChemEd-Ireland and other chemical education activities.

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TY Science Modules

These modules for TY Science are available from the University of Limerick.The titles are:

- **Forensic Science**
- **Cosmetics Science**
- **Science and Sport**
- **Environmental Science**
- **Science of Survival**
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- **Food Science**
- **Science and Medicine**
- **Scientific Heroes**
- **Scientific Mysteries**

Each consists of a student's guide and teacher's guide and covers 8-10 week's work. We have discontinued the hard copies and where available, electronic copies will be available free of charge.
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In the next issue:

Lithium – the light metal powering the future

Consumer chemistry firelighters

Update on the biopharma industry in Ireland