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

For subscription details etc. see inside back cover.

Cover design: Tony Hartnett, Shoreline Graphics, Ballyvaughan, Co. Clare
Cover photo: Chemistry and light! Peter Douglas in action at the ISTA conference in the University of Limerick, 21/3/09 (Photo: University of Limerick)

Editorial

Doom and gloom: *annus horribilis*

2009 looks like being a miserable year world-wide as the economic recession bites - budget cutbacks and job losses are hitting every sector of the economy, including education. Many aspects of education have been hit - substitution cover for teachers, the per capita grant for physics and chemistry students introduced in 1999, the introduction of the new LC chemistry syllabus … What a pity that the recommendations of the Task Force on the Physical Sciences were not implemented in 2002, when it was published. The additional investment in schools over the last 5 years or more would have had a significant effect on the science experienced by pupils in Irish schools. I am sure we have wasted more money in the meantime than this would have cost over the intervening years - the money spent on the electronic voting machines would have been very useful in schools! Schools are going to find it more difficult to do their job properly and meet the needs of every child. The job market for new science education graduates is going to be very difficult for several years, and it was already tight!

ChemEd-Ireland returns to UL

2009 will see the return of ChemEd-Ireland to the University of Limerick on Oct. 17th., but under new management. This year it will be organised under the auspices of the National Centre of Excellence in Maths and Science Teaching and Learning. The conference will move between 3rd. level institutions and in 2010 it will be in Dublin Institute of Technology.

End of the Chymists cartoon series

This issue marks the end of the series of chemical caricatures by William Jensen, **Chymists that strange class of mortals.** #34 is Linus Pauling and this series has been running for over 11 years. I am sorry that no more caricatures have been produced in this series since William Jensen first produced them several decades ago. I hope you have enjoyed them. If anyone reading this has talents in this direction, please send me some more chemical caricatures. I am replacing it by a series of Classical Chemical Quotes featuring a picture and quotation from a famous chemist. I started in issue #86 with Kekulé. This series can be carried on until we run out of famous chemists and quotations!

"Academic calls for ban on weaker students"

This was the headline in the *Irish Independent* of 7/2/09 picking up my editorial in issue #86. I don't think that is what I said and certainly not what I meant. I had a number of emails supporting my views and an interview/grilling on Highland Radio in Donegal. Some people said to me: "You really must be retiring!" I am <u>not</u> responsible for how journalists report my views.

The government has announced a wide-ranging review of 3rd. level education, due to report in 2010. It also seems certain that 3rd. level fees will return in some form, due to the current economic climate. Personally I am not in favour as it will discourage many good students from taking up 3rd. level places. A more equitable way would be to increase taxation at the higher rate - most graduates will profit from their degrees over their careers and will pay back their 'fees' in extra tax. However, the main problem is that 3rd. level institutions are not getting enough money per student to the job properly. Fees look like an easy solution to that problem. At the end of the day it all comes from the taxpayer's pocket and the most important thing is to ensure that the burden is distributed fairly. We need to encourage more bright students from disadvantaged backgrounds to go on to 3rd. level and this requires more, not less support.

One of the biggest problems at 3rd. level, and a major cause of poor student performance, is poor attendance at lectures and tutorials. Many factors that affect this: working for money while in college, the demands of a heavy social life, the shock of moving from a tightly-controlled school environment to the freedom of 3rd. level, demoralisation among weak students when they find they find they can't keep up, or switching-off when students discover they have chosen the wrong course. Better and more realistic careers advice in schools is one answer, plus better care in first year and opportunities to change courses or even institutions early on.

Peter E. Childs Hon. Editor

Education News and Views

Science and maths revival in the UK

The Times 22/10/08

In the UK the numbers taking maths, physics and chemistry for A level and at 3rd. level are starting to increase after years of decline. The UK government has pumped in £350 million to revitalize strategic but vulnerable subjects at 3rd level, including £100 million for science provision. In 2007-8 numbers entering university to study maths are up 8.1%, chemistry up 4.4% and physics up 3.3%. £15 million has also been spent on pilot projects to get young people at school interested in maths and the physical sciences. Numbers doing A level subjects also increased from 2005-6 to 2007-8: maths +15.7%, further maths +29.5%, physics +4.4%, chemistry +5.3%.

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STARS go out

Despite the positive remarks about the STARS programme for science teachers run by SFI (see *CinA!* #86, 2008), the programme has been axed as part of the new austerity drive. This is a great shame as this was a very effective programme to link 2nd. level and 4th. level research.

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New Education Officer at Pharmachemical Ireland

Siobhan Murphy has taken over as Education Director from James Ring at Pharmachemical Ireland. She can be contacted at Siobhan.murphy@ibec.ie. Pharmachemical Ireland, with support from several chemical companies, have organised the Science Teacher Awards again in 2009, to recognise excellent young science teachers. The awards were given at the ISTA Annual Conference in Limerick at the Banquet on 21st. March. The winners are given in the item below.

At the conference, Matt Moran, Director of Pharmachemical Ireland, took over from Karla Lawless as President of the ISTA.

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UK Results 2008

Usually the published UK A-level and GCSE Figures show the number of passes, broken down by gender, and the % of students doing each subject BUT the % is of the total number of papers not of the number of students. So as more students do more than 3 A-levels the % of students doing any single subject drops. However, this year I found a reference to the number of candidates doing A-levels and GCSE examinations, so we can calculate the true popularity of subjects as a % of the total student cohort. This allows comparison with Ireland and other countries.

Total GCSE cohort: 653,045

47.6% gained 5 A* to C grades, including English and Maths

53% girls achieved this target compared to 44% of boys.

Only 50% of pupils gained 2 science passes.

A-level cohort: 331,397
Total A level entries: 827,737
(Average 2.50 per student)
LC cohort: 52,144

Subject	No	% all A-levels+	%A-level cohort	%Irish LC cohort*
Biology				
Total	56,010	6.8	16.9	51.0
Male	23,458	6.2		
Female	32,552	7.3		
Ratio M:F 1:1.39				
Chemistry				
Total	41,680	5.0	12.6	13.6
Male	21,366	5.6		
Female	20,314	4.5		
Ratio M:F 1:0.951				
Physics				
Total	28,096	3.4	8.48	13.6
Male	21,941	5.8		
Female	6,155	1.4		
Ratio M:F 1: 0.219				
Maths				
Total	64,593	7.8	19.5	
Male	38,719	10.2		
Female	25,874	5.8		
Ratio: M:F 1:0.668				
Maths(Further)				
Total	9,091	1.1	2.74	
Male	6,325	1.7		
Female	2,766	0.6		
Ratio: M:F 1:0.437				

(+This is the % of the total number of A level entries, usually the figure quoted in results tables.
*Figures for Ireland are total of Higher and Ordinary papers).

Now we have a proper comparison these figures are very interesting. Note the much smaller popularity of Biology in the UK compared to Ireland. The Chemistry figures are not much different but Physics is significantly less popular in the UK. Maths is the 2nd. most popular subject in the UK and the % doing A-level Maths is similar to that doing the higher paper in Ireland. However, in Ireland 96.1% of students do maths of some sort for their LC. Biology is the 3rd. most popular A-level and Chemistry is the 8th. Only Biology gets in the top 10 subjects in Ireland. The other significant difference is the much bigger drop in numbers between the GCSE cohort and the A level cohort, compared to the Junior Certificate and Leaving Certificate in Ireland.

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Not during school hours

One of the consequences of the new rules on substitution and cover in schools is the in-service programme run by SLSS. Courses can no longer be run during the week in school time but must be timetabled in the evenings after school or at weekends. This is a counter-productive move as it will mean only the really committed and enthusiastic teachers will take up offers of in-service courses. They were voluntary anyway but getting time off school to attend was a positive inducement. This turned out to be academic as the SLSS service was also a casualty of the cutbacks (see below).

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New Chemistry syllabus held up

The new LC Chemistry syllabus was supposed to have been published for consultation early in 2009. It is now not likely to be out before September. The cut-backs in the Education budget are going to delay its implementation as the introduction of practical assessment will have significant financial costs.

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3rd. Chemical Demonstration and Magic Show Workshop

The workshop on Chemical Demonstrations will be running again this summer at the University of Limerick. The dates are 22-25th. June and this is a residential 3 ½ day course. The cost to second-level teachers is €100, subject to financial support from last year's sponsors. You can get an application form from peter.childs@ul.ie. (See *CinA!* #85 for a report on last year's course.) The cost is €350 for non-teachers.

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28th. ChemEd-Ireland returns to UL

The 28th. ChemEd-Ireland conference will be held on Saturday October 17th. at the University of Limerick. The conference has returned to its old home this year as part of a circuit of 3rd. level venues. Last year it was held in DCU and in 2010 it is scheduled for DIT. The conference is being organised this year by the new National Centre for Excellence in Maths and Science Teaching and Learning (NCE-MSTL). For more details contact: sarah.hayes@ul.ie An application form is included in this issue.

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SLSS service effectively disbanded

One of the shock items resulting from the budget cutbacks was the effective axing of the SLSS support service in Science and Maths, 'announced' overnight in Febuary. The support staff were cut back from 9 people to 1 to service all the sciences and maths in-service support. This is an impossible task. Tim Regan got the single job and at the end of this school year the other staff will be redeployed (they were on secondment). In my opinion this was the first time that in-service support for teachers was being provided properly and the Brendan Duane, the Chemistry support person, has been doing an excellent job on a relatively small budget. I believe the total budget of SLSS, for all the science subjects, was around €400,000 a year. The Physical Sciences Magazine, now switched to on-line publication only, was an excellent resource for teachers. I hope this will continue in some shape or form.

The article I published in the *Irish Independent* on 25/2/09 under the heading 'Teacher support service cut a disaster' deploring these cutbacks is given on the next page. (This version is slightly longer than the one published, and contains some references.)

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The danger of eating the seed-corn is starvation in the future

On February 12th. I was in a meeting with the science support staff of SLSS to discuss cooperation with the new National Centre of Excellence in Maths and Science Teaching and Learning (NCE-MSTL) at the University of Limerick. This was a profitable meeting where we discussed future cooperation, as SLSS is the largest provider of continuing professional development (CPD) for science teachers. The next day, Friday the 13th, I was shocked to hear that the service was being decimated - one person was now going to be expected to service all the maths and science subjects, at Leaving and Junior Certificate level. The work of the SLSS support staff has been a bright light in the dark wasteland of support for second level science. Their publications, teaching resources and CPD courses have been well received and well supported by teachers - they provided an invaluable service. CPD is not just needed when a new syllabus is introduced, as the DES seems to think, it is needed at regular intervals throughout a teacher's career, as is the case for other professionals. In the UK second -level teachers are entitled to 5 days a year and this is not considered to be enough - it has been proposed to increase it to 20 days. International reports all agree that the quality of teachers is the key factor in the success of an education system and career-long CPD is a vital component of supporting an effective teaching profession. The government's boast of developing a knowledge-based economy is hollow if it does not include adequate support of the grassroots in schools.

More than half of SFI-funded postgraduates come from outside Ireland. I wonder why we don't have enough qualified graduates in science and technology to fill these posts? SFI has cancelled their successful STARS initiative this year, which gave second-level science teachers invaluable experience of research. In the USA the National Science Foundation (NSF), the equivalent of SFI, recognised many years ago that funding science education research and development was a vital part of its brief. They put very significant investment into improving science teaching at 2nd. and 3rd. level. The National Science Board's recommendations to President Obama recognise that *"Dedicated, high quality teachers are central to ensuring high quality STEM education for all students."* If we starve the lower levels of education in primary and second level of necessary investment, much of the investment in fourth level research will be wasted. Unless we support our second level students in science and maths, the intellectual seed corn for future harvests, we risk long-term starvation. The bright vision of a knowledge-based economy will turn out to have been a pipedream. Axing science support staff sends out a clear message to teachers, to academics and to Ireland's competitors, that we are not serious about building a high-tech economy based on high level science and maths skills.

A definite proportion of SFI's still generous funding **must** be earmarked for the support of science and maths education at second level **and** third level - we need to improve undergraduate as well as second level education, something long recognised in the USA. We need investment in school facilities and resources, but more importantly we need investment in people - in life-long CPD for all teachers. John Wilson recommended such a programme as long ago as 1985 but it was never implemented. We need research into effective teaching methods for science and maths at all levels and opportunities within the system to innovate. I have often wished for the chance to pilot an innovative alternative science curriculum in Ireland, similar to the Salters' Courses in the UK.

The McKinsey Report (2007) on successful school systems identified the selection and training of the best people to be teachers, and their lifelong support, and an emphasis on raising the standards of all students, as the key factors in a successful education system. Ireland's science teachers do a great job in under-resourced schools, without any technical support, but how much more could they achieve with better resources, more support and effective life-long CPD? An innovation-led, knowledge-based economy is nurtured in the school classroom by good, well-motivated, well supported teachers. Moves like the axing of the SLSS staff are undermining efforts to change our economy in the long-term in favour of small short-term gains. The SLSS costs ~ €3.5 million a year to run, of which the science component is ~€400,000: small money, compared to the Dail's expenses, for securing Ireland's future!

Sources:
National Science Board letter to President Obama
http://www.nsf.gov/nsb/publications/2009/01_10_stem_rec_obama.pdf

NSF's Education and Human Resources Programme
http://www.nsf.gov/ehr/about.jsp

McKinsey Report on the World's Best Performing School Systems
http://www.mckinsey.com/clientservice/socialsector/resources/pdf/Worlds_School_systems_final.pdf

Peter E. Childs

□

Top LC Chemistry students for 2008

The following 5 students had the joint top marks in the 2008 Honours LC Chemistry examination. They were presented with their medals by President of the Institute of Chemistry of Ireland at the ICI's AGM in DCU on April 23rd.

Rowland Bent
Scoil na mBraithre, Aonach, Co Tipperary
Aaron Donnelly
Davitt College, Springfield, Castlebar, co Mayo
James Alan Donnelly
Christian Brothers College, Sidney Hill, Cork City
Gordon Edward Haire
Community School, Portmarnock, Co Dublin
Craig Mac Liatháin,
Colaiste na Coiribe, Bothar Thuama, Gaillimh

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Newsletter winners 2008-9

In 2008 the annual Schools Chemistry Essay Competition was modified to the Schools Chemistry Newsletter Competition. Students had to work in groups of 2 or 3 to produce a 4 x A4 newsletter on the general theme 'Chemistry in Ireland'. There were 23 entries, with a total of 50 students involved. The newsletters were judged by Dr. Peter Childs (Institute of Chemistry of Ireland), Dr David Birkett (Society for Chemical Industry), Dr Patricia Ennis (Royal Society of Chemistry). All three judges independently came up with the final shortlist of 5 newsletters, which came from just two schools.

First prize:
Anna Lawless, Lorna McSherry, Riona Walsh, Rathdown School, Glenageary, Co. Dublin
Teacher: Ms. Rice
Joint second prize:
Clare Droney and Eimear O'Reilly, Eureka Secondary School, Kells, Co. Meath
Teacher: Ms Mullaghy
Shauna Byrne and Sarah Casey, Eureka Secondary School, Kells, Co. Meath
Teacher: Ms Mullaghy
Commended:
Hannah and Sarah Burmanje, Eureka Secondary School, Kells, Co. Meath
Teacher: Ms Mullaghy
Sophie Heseltine, Megan Fennell and Shana Hall, Rathdown School, Glenageary, Co. Dublin
Teacher: Ms. Rice

□

Pharmachemical Ireland Teacher Awards 2009

Science is fun, and gives an opportunity to be creative in the classroom. This was quite clearly demonstrated by the teachers that received the industry awards for Science Teaching Excellence at the recent ISTA AGM. Each of the winners received a prize worth €2000. These prizes were sponsored by Janssen Pharmaceutical Ltd, Wyeth, Merck Sharp and Dohme, Novartis, Pfizer, ICDA, Schering Plough, TEVA Pharmaceutical, and Genzyme.

This year nine teachers were nominated by their lecturers from the different universities, based on their excellent teaching performance on teaching practice. This was clearly seen on the day as each teacher gave a 15 min presentation to a panel of judges to select the overall winner. The presentation was based on a topic from the Junior Certificate Science syllabus and showed their different teaching techniques, which were vibrant and engaging, from exploding coke bottles to solving crimes scenes. Each of these teachers would certainly motivate any student to study science.

The overall winner, Michelle Kelly from NUI Maynooth, is now teaching physics, mathematics and science in St Finian's college Mullingar. Having already received a €2000 prize sponsored by Genzyme, Michelle also received a further €3000 prize sponsored by PharmaChemical Ireland and she has also been invited to a workshop in Green chemistry in Boston sponsored by Beyond Benign[1].

The awards were established last year by the PharmaChemical industry to acknowledge and applaud young science teachers who demonstrate excellence in their teaching. The industry has long recognised the crucial role that teachers play in the encouragement and development of future scientists. Science is the lifeblood of the Irish economy as a constant supply of high quality graduates are essential to maintain the many industries that are dependant on science, especially in the challenging economic environment ahead.

1 Beyond Benign is a not for profit organisation that promotes science driven by the principles of Green Chemistry in order to create an environmentally, socially and economically prosperous world.

Congratulations left to right to Kerrie Whelan (sponsored by Schering Plough), Niamh McGuinness (sponsored by TEVA Pharmaceutical), Vicki Hennessy (sponsored by Merck Sharp and Dohme), Siobhan Murphy Pharmachemical Ireland, Michelle Kelly overall Winner, Matt Moran, Pharmachemical Ireland, Gareth Belton (sponsored by ICDA), Marie Lawlor (sponsored by Pfizer), Alison Mulcahy (sponsored by Janssen Pharmaceutical Ltd), Mary Manning (sponsored by Novartis), Sharon Boyle (sponsored by Wyeth.)

Siobhan Murphy

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Silver Science Success in Spain

A team of three students who represented Ireland at the 7th European Union Science Olympiad (EUSO 2009) in Murcia, Spain on March 28th – April 5th 2009 won silver medals and the second team was awarded bronze medals. http://www.ucm.es/info/euso09/

The silver medals winning team members were Killian Donovan, Gonzaga College, Ranelagh, Dublin 6: Anna Lawless; Rathdown School, Glenageary, Co. Dublin, and Ramia Jameel, St Andrew's College, Booterstown, Co. Dublin. The bronze medal winning team members were Donnchadh O'Sullivan, Christian Brothers College, Sydney Hill, Cork: Ciarán Deasy; Bruce College, Cork and Paul Stewart, Colaiste Choilm, Ballincollig, Co. Cork. The six students were the individual winners at the Irish national completion (IrEUSO) held in DCU on Saturday 29th November 2008.

The theme of EUSO 2009 was "Fiber". Each team had to work together to solve a set of problems, submit an answer sheet and were given a single grade. The two experiments were developed by the Scientific Committee which included academics and post graduate students from the departments of biology, chemistry and physics at Murcia University. The Director was Professor Juan Antonio Rodríguez Renuncio and the Coordinator was Dr. Jorge Molero Fernández. The Irish delegation was lead by Dr Odilla Finlayson (Country Coordinator and Chemistry Mentor), Dr. Paul van Kampen (Physics Mentor) and Dr. Christine Loscher (Biology Mentor).

Twenty-one EU countries were represented by a total of 40 teams (120 Students). Delegations included one or two teams of three students and a mentor for each discipline. One mentor was the Country Coordinator and Head of the Delegation. Romania and France sent Scientific Observers for the first time and will participate with a full delegation in 2010.

The EUSO 2010 will be held in Gothenburg University, Sweden.

Pictured at the award ceremony from l to r: Dr Paul van Kampen (Physics mentor), Anna Lawless (silver), Donnchadh O'Sullivan (bronze), Paul Stewart (bronze), Killian Donovan (silver), Ramia Jameel (silver), Ciarán Deasy bronze) and Dr Odilla Finlayson (Country Coordinator and Chemistry Mentor.

Michael A. Cotter, EUSO President
michael.cotter@dcu.ie

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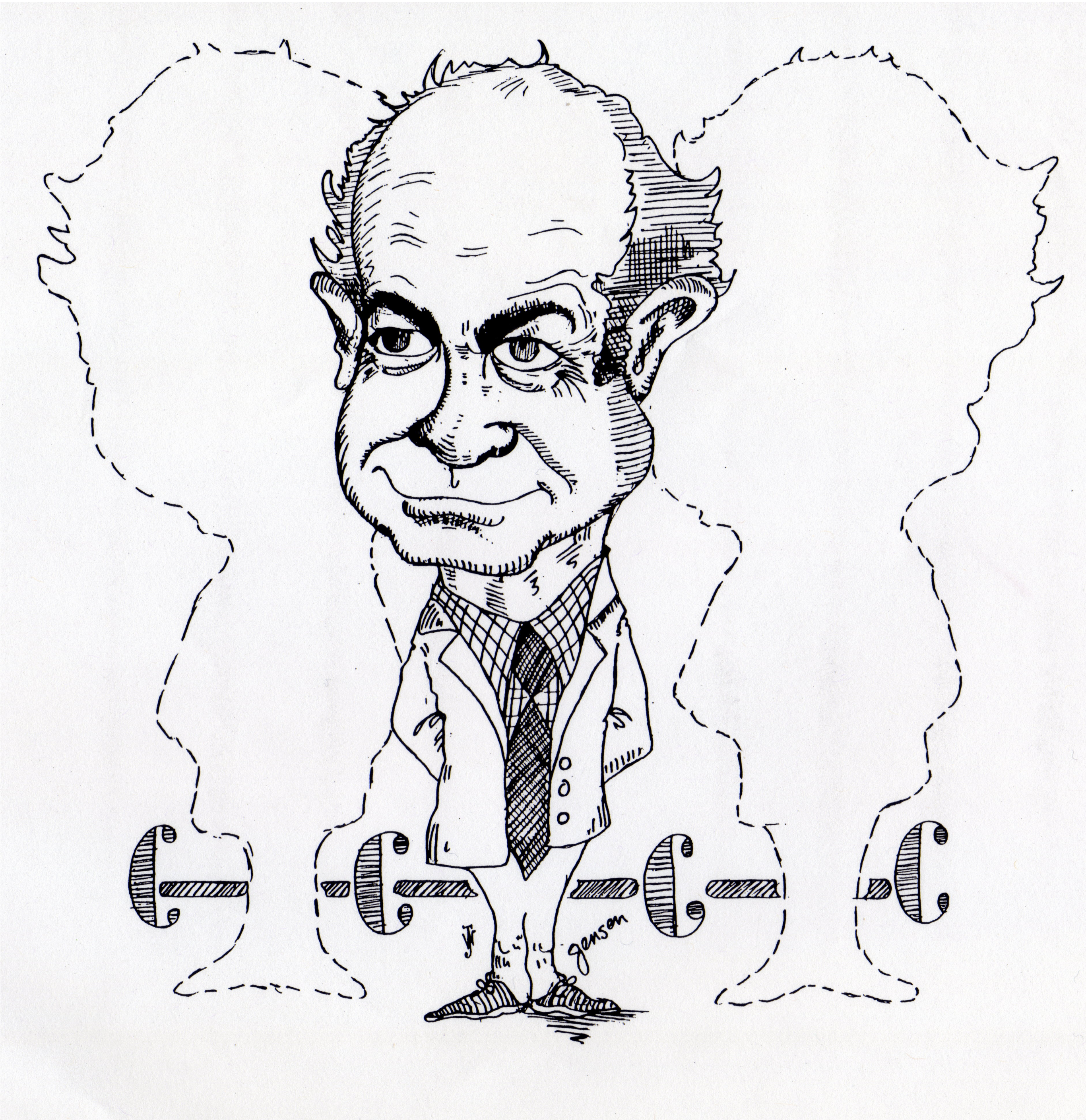
Chymists that strange class of mortals: 34

Linus Pauling: (1901-1994) “Resonance”



Used by permission of Dr William B. Jensen, Oesper Collection, University of Cincinnati

Proceedings 27th. ChemEd-Ireland
DCU 18th.October 2008

This Spring issue of *Chemistry in Action!* contains the papers from last year's ChemEd-Ireland, held at DCU and organised by Dr Odilla Finlayson. It was preceded on the Friday afternnon by a **FREE** hands-on workshop exploring the use of microscale chemistry experiments from 1.00p.m.—4.00p.m., run by Viktor Obendrauf. I believe this was an amazing and profitable experience for those few teachers and the science education students from DCU who attended.

I would like to thank the speakers for preparing their talks for publication, thus reaching a much larger audience. I would also like to thank the sponsors of the 2008 ChemEd-Ireland: The Institute of Chemistry of Ireland; the Royal Society of Chemistry Education Division - Ireland Region; the Second level Support Service; The Society for Chemical Industry, Ireland Section; Dublin City University.

One important feature of the programme was the section allowing postgraduate students to talk about their current research in science education, with relevance to chemistry teaching. I hope this will become a feature of future conferences. I hope you find the articles on their work interesting.

The turn-out wasn't great (~40), but it was a very interesting programme and worth it for Viktor Obendrauf's demonstration lecture alone. Viktor Obendrauf's lecture demonstration cannot be captured in print but he kindly sent copies of the slides used to illustrate the talk and the various experiments. These have been included in black and white, but a colour version is available on request. Unfortunately Brendan Duane's talk was not available for publication.

Programme

9.30-9.45 Welcome & Opening Remarks Odilla Finlayson
9.45-10.30 SCI Lecture: Teaching Chemistry through Contexts,
Ilka Parchmann University of Oldenburg, Germany
10.30-11.00 Tea, Coffee, Bookstall & Exhibitions
11.00-11.45 ICI Lecture: Organic Chemistry Made Easy,
Kieran Nolan Dublin City University, Dublin
11.45-12.05 The Persistence of Students' Difficulties in Chemistry,
Maria Sheehan University of Limerick, Limerick
12.05-12.25 CASE for teaching Chemistry,
Lorraine McCormack Dublin City University, Dublin
12:25-12:45 LC Chemistry – What is really asked on exam papers!
Edelle McCrudden Dublin City University & St. Kevin's College, Dublin
12.45-14.15 LUNCH
14.15-15.15 RSC Lecture: Halogen Reactions on the bench!
Viktor Obendrauf University of Graz, Austria
15.15-15.30 Break
15.30-16.00 LC Chemistry Syllabus Review & Chemistry Support
Brendan Duane Chemistry Education Officer NCCA, Ireland and SLSS
16.00-16.30 Discussion & Wrap-up

Programme and Book of Abstracts:
http://www.castel.ie/pdfs/ChemEd%20Book%20of%20Abstracts2008.pdf

Don't forget that ChemEd-Ireland 2009 will return to the University of Limerick on October 17th., details from sarah.hayes@ul.ie and it will be organised under the auspices of the National Centre of Excellence in Mathematics and Science Teaching and Learning.

Teaching Chemistry through Contexts

Chemie im Kontext – one approach to realise science standards in chemistry classes?

Ilka Parchmann
University of Oldenburg, Germany
Ilka Parchmann and the CHIK-team[1], University of Oldenburg, Faculty of Mathematics and Natural Sciences, Institute of Pure and Applied Chemistry, Department of Chemistry Education, PO Box 2503, 26111 Oldenburg, Germany; Email: ilka.parchmann@uni-oldenburg.de

Summary: *Chemie im Kontext (CHiK) is one approach to realise science standards in chemistry classes in Germany. It was developed and implemented by ´learning communities´ of university researchers in chemistry education and teachers, funded by the German Ministry of Education (BMBF). The implementation process was accompanied by several empirical research studies, e.g. on the perception of CHiK by teachers and students. Next to the research findings, a curriculum framework for all age groups of secondary education and tested teaching and learning material were developed and offered to other teachers.*

Introduction

How can subject matter teaching react to the unsatisfying results of international studies, such as TIMSS (TIMSS, 1996), PISA (OECD, 2007) or ROSE (ROSE, 2008)? This was a leading question for the research and development project *Chemie im Kontext* (CHiK). Regarding the decreasing interest and a rather low motivation for science classes – especially physics and chemistry – and the difficulties that many students show in the application of scientific concepts for the explanation of real-life contexts (e.g. High Level Group, 2004; Gräber, 1995), we were looking for alternative approaches towards the teaching and learning of sciences and chemistry in particular. While the traditional curricula in Germany are often overloaded wth facts and a rather historical view on chemistry and relevant research topics, so called context-based curricula such as *Salters* (Salters, 1994) or *Chemistry in the Community* (ACS, 1993) offer a more authentic insight into the relevance of chemistry in everybody´s daily-life and in our research community. Experiences with the Salters curriculum developers and the teachers using it, as well as a literature research on theories about learning and motivation, finally became the background for the first developments of the CHiK-project in 1997, which were followed by a national approach of implementation in 2002[1]. In 2004, National Standards were additionally implemented into the German school system. This article describes the background, the framework with regards to the National Standards, some exemplary units and some research results of the CHiK-project, looking back at ten years of experience.

National Standards for science education in Germany

In 2004, an important development took part in Germany: National Standards for the science subjects biology, chemistry and physics had been developed and implementated into the school system (Schecker & Parchmann, 2006). This was a huge step for the education system because of two reasons: a) For the first time, unique standards for all 16 German states and all types of secondary schools were mandatory, and b) those standards describe learning outcomes instead of teaching inputs.

The background philosophy of such standards derives from the definition of “scientific literacy” (see Figure 1), leading to four described areas of competence:

(1) development and application of basic concepts as a structure for subject matter knowledge (with four basic concepts in chemistry: matter and particles, structures and properties, chemical reaction and energy),

[1] The CHiK-project was funded by the German Federal Ministry of Education (BMBF), the participating states and the foundation of the German chemical industries (Fonds / VCI). The exchange with the Salters group was supported by the DAAD.

(2) methods of investigation (experiments and models, “Nature of Science”, NoS),

(3) communication in science (daily-life and subject specific languages, symbolic language, graphical representations, research and presentation of information) and

(4) reflection and judgment (application of knowledge and competencies for authentic questions, e.g. for society issues, personal issues or career issues related to chemistry).

"Scientific literacy is the capacity

- **to use scientific knowledge**,
- **to identify questions** and
- **to draw evidence-based conclusions**
- in order **to understand and help make decisions**

about the natural world and the changes made to it through human activity."

(OECD-PISA, 1998)

Figure 1: The educational goal of scientific literacy

As these goals are very similar to the goals of so called context-based approaches, they offered a suitable foundation also for the *Chemie im Kontext* programme. Therefore, the (mandatory) implementation of the National Standards supported the (voluntary) implementation of the CHiK-approach on the one hand. On the other hand, the CHiK project offered exemplary units and material to deal with the demands of the National Standards in school practice. The following paragraphs will therefore describe the framework of CHiK and some teaching and learning units as examples for standard-based teaching and learning.

Chemie im Kontext (CHiK) as one approach of standard-based teaching and learning

Even though CHiK began as an idea for a different way of teaching and learning chemistry, it soon became a huge project with different aspects and goals (see Figure 2).

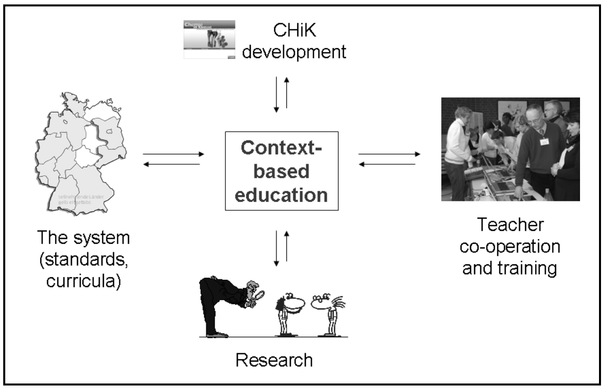
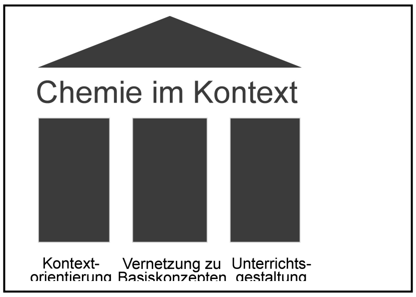


Figure 2 The different goals and aspects of the project *Chemie im Kontext*

By the end of 2008, more than 200 teachers and more than 4000 students participated in the project, though many more probably used the CHiK material, e.g. through the text-books (Demuth et al., 2006 and 2008). As the implementation was also followed by a research programme (Parchmann et al., 2006), an additional international co-operation began (see the special issue on context-based learning in the *International Journal of Science Education*, Gilbert et al., 2006).



The framework of the teaching and learning approach of Chemie im Kontext

The CHiK-framework consists of three columns:

1. **Context-based learning**: Learning environments are considered **“**in context**”**, when learners acquire knowledge and competence on a need-to-know-basis in dealing with a relevant issue, starting with their questions and ideas. Examples are: “Food design - why, how and where?”; “Carbon dioxide and climate change?”; “Materials by design”; “A mouth full of chemistry”.
2. **Development of basic concepts**: To develop a basic knowledge foundation that can be applied to new contexts and situations, the main principles of chemistry must be derived and abstracted from the contexts. These principles are

described as “basic concepts”. They structure and summarise the factual knowledge (see the basic concepts of the National Standards).

3. **Variety of teaching and learning methods**: A variety of teaching and learning methods is one of the key elements for a successful chemistry education, a) because it considers the diversity of interests, pre-knowledge, capabilities and learning styles and b) because it offers the students situations in which they can develop and apply competencies in all areas as demanded by the National Standards.

All teaching and learning units are structured by four phases: **1) phase of contact** (aiming at the students´ motivation and an activation of their pre-knowledge), **2) phase of curiosity and planning** (aiming at the development of the students´ questions and structuring the following learning process), **3) phase of development and presentation** and **4) phase of summary, deepening, exercise and abstraction and transfer**.

A typical unit of CHiK applies the following steps (see Figure 3), of course in different length and depth for different units.

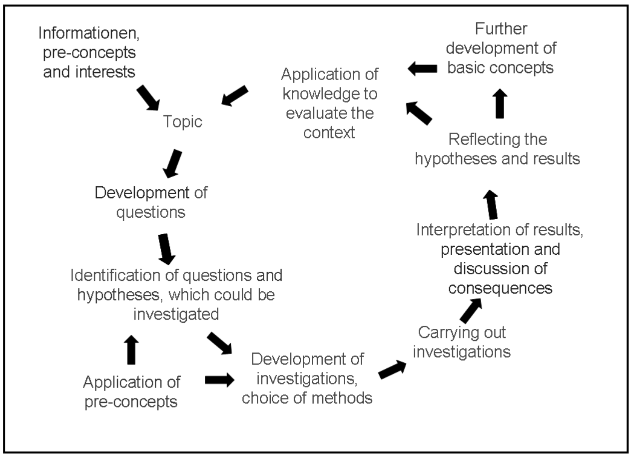


Figure 3 Steps of development in a context-based units of CHiK

The implementation of Chemie im Kontext

CHiK was not developed as a complete curriculum. It was developed as a framework with exemplary units to enable teachers in different states and schools to adopt it to their syllabi and conditions (see also Parchmann et al., 2006 and Nentwig et al., 2007). Hence, the implementation of CHiK was also part of the further developmemt of teaching and learning units and material, based on the idea of “learning communities” (see Figure 4). Such communities enable a close co-operation between teachers in practice and university educators and researchers, which ensured that the CHiK approach considered the demands of research findings and school practice at the same time.

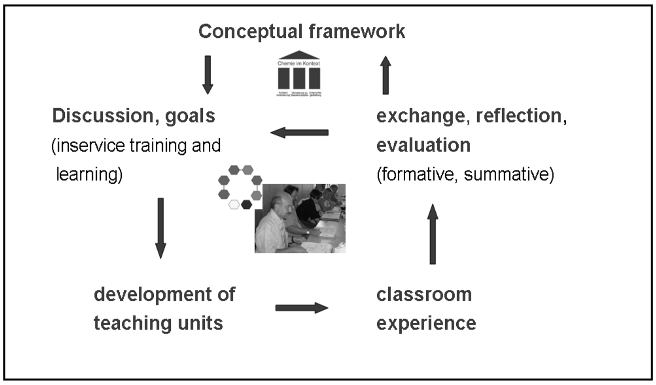


Figure 4: The implementation of *Chemie im Kontext* through learning communities: steps of discussion, development, evaluation and optimisation

Exemplary units

1. The Taster – an introduction into chemistry (see also Nentwig et al., 2007)

In many states, the introductory unit (age group 11-13) was “The taster in danger – chemistry replaced the taster” (Nentwig et al., 2007). The main goals of this unit are the introduction of typical chemical questions and experimental methods, such as the analyis of mixtures or the properties of substances, as well as the introduction of the idea of using models to explain phenomena and ideas.

In the phase of contact, the students were told the story of the former tasters and asked if that was still relevant to them. The unit trials showed that students always found examples in which they could not taste or smell the ingredients of food, or in which they were even cheated, for example about the amount of sugar in Coca Cola.

In the phase of curiosity and planning, the students were asked to develop questions and ideas of their own interest. Here, they often asked about poisoning substances or ingredients (again, for example, of Coca Cola) and they told stories about own experiences with food and drinks

The phase of development was divided into two mayor parts: a) the introduction of experimental methods and b) the introduction of the use of models. Not all teachers decided to do both parts in this units, some introduced models in following units. The first part was sometimes started with the demonstration of a swimming and a sinking can of Coke (Figure 5). Several questions and hypotheses were collected to explain this phenomenon and leading to the investigation of the ingredients of Coke.

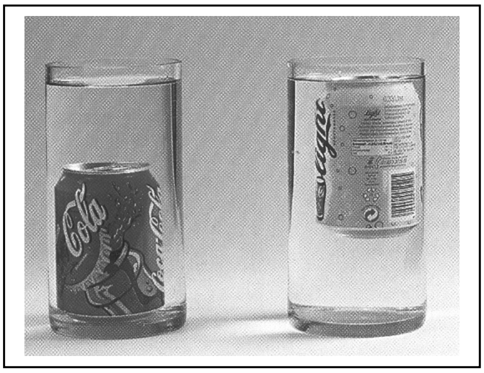


Figure 5 Swimming and sinking cans of (diet) coke

Separation and identification methods for substances were now introduced, for example for sugar, for acids in general and phosphoric acid in particular, for carbon dioxide or for water. Several methods of separation (e.g. filtration, absorption or distillation) were also applied for other mixtures. In summary, the students learned the same methods and terms as in traditional introductory units, but additionally, they saw a good reason and a personal relevance for what they did.

The second part – instroduction of models – started with students´ drawings (see Figure 6) and their own ideas about processes. Such ideas were reflected and the necessity of using models for processes that cannot be observed directly was introduced.

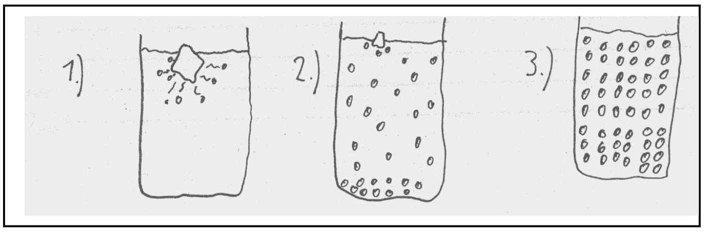


Figure 6 Students' drawings as starting points for the reflection of pre-concepts (here about the idea of sugar particles dissolving in tea)

The phase of abstraction and transfer summarised and pointed out the methods that the student had learned and the idea of a very first particle model, if introduced. Posibilities for application and exercise were different foods (e.g. chocolate) and drinks (e.g. milk) or other mixtures the students know, such as cosmetics or water treatment.

2. The discussion about fuels, climate change and alternatives for the future: CHiK-units for lower and upper seondary education

Processes that enable human beings and societies to consume energy are crucial for our daily-life and business. However, they also cause questions and problems, such as the amount of fossil fuels that is left, problems caused by unwanted products or possible alternatives. The unit "Wanted burnings, unwanted products" confronts the students with the often described pre-concepts that burning processes destroy matter and reports about waste products, such as carbon dioxide. The leading question is why chemists, however good, can never avoid the development of waste products by burning processes?

In this unit, the students work in groups and investigate the origins of different fossil fuels, such as coal, oil or gas. As a result in the discussion, they come up with a cycle (see Figure 7). This cycle leads to the following question: What does actually cycle in a cycles?

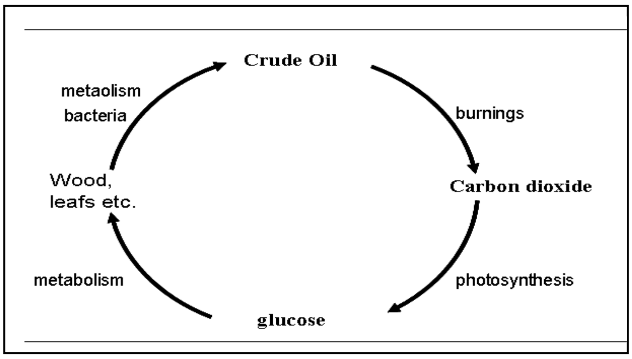


Figure 7 The development of reaction cycles to introduce the idea of the conservation of atoms

To answer this question, the students were now given several ideas of well-known chemists, such as John Dalton, and they were asked to discuss and to apply their ideas to explain the cycling processes.

"We can try to bring a new planet into the solar system or to destroy one, but we cannot produce or destroy an atom. **Changes that we can produce are caused by the separation of atoms that had been connected or by the connection of atoms that had been separate before.**"

John Dalton (Jansen, 1984)

By this, the idea of atoms and the conservation of atoms was introduced in a context-based way that again makes it relevant to the students.

The students then got experiments and phenomena in which they have to apply the idea of atoms, such as the conservation of mass. They finally had to discuss alternative fuels and to predict possible products (e.g. burning hydrogen can never develop CO_2 as there are no carbon atoms in hydrogen).

The unit "The hydrogen car – the car of the future?" picks up this discussion in upper secondary classes and introduces the idea of electric energy and its production by fuel cells. Starting with advertisements (communicating science), the students first developed their own ideas of fuel cells, based onpre-knowledge about batteries (see Figure 8). Afterwards, they learned about fuel cells which are used nowadays and about possibilities of the productio of hydrogen (see Figure 9). In summary, the unit enables them to apply and deepen their understanding of donor-acceptor reactions, about methods of investigating and the functioning of different authentic cells, as well as on reasons and discussions necessary for the evlaution of possible technique for the future (e.g. considering the production of hydrogen, costs etc. next to their chemistry knowledge).

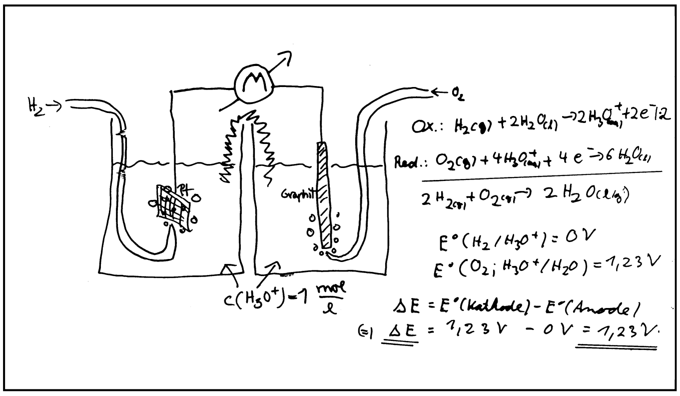


Figure 8 Result of the students´ group work on the design of possible fuel cells

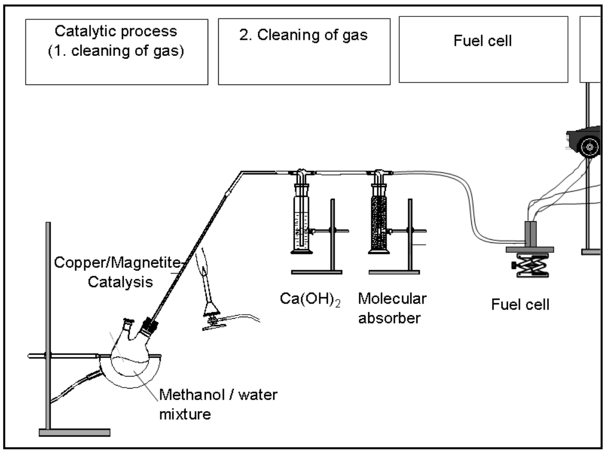


Figure 9 A model experiment to demonstrate the fuel cell car run by methanol

Hence, all areas of science knowledge and competencies were included in this unit and can lead to an understandin of basic concepts when combined with other units (see Figure 10).

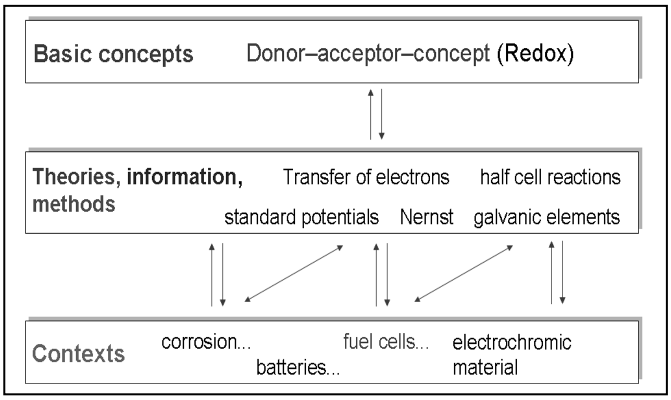


Figure 10 The three levels of *Chemie im Kontext* to develop context-based questions and understandings, factual knowledge and competencies as well as a general understanding of basic concepts

Exemplary research findings

Before and accompanying the CHiK-project, research studies on other context-based approaches had been studied (e.g. Pilling et al., 2001, Bennett et al., 2005, Pilot & Bulte, 2006). For the CHiK-project itself, a variety of research findings were gained, looking at the implementation process and its conditions (Parchmann et al., 2006), the perception of changes by teachers and students or exemplary assessment of learning outcomes (e.g. Eilks et al., 2004, Menthe, 2005, Fach & Parchmann, 2007). This section will point out some of the research results.

The perception of the teachers showed that they had realised two of the three CHiK columns: they enhanced the use of contexts as “backbones” for their teaching units and they also enhanced the variety of teaching methods, without feeling a loss of control (see Figure 11). However, they did not put the same emphasis on the development of basic concepts, which may have lead to rather poor learning results and motivation in some classes (which said they had lost their “guideline” during the unit), while motivation and learning outcomes were very good in other classes.

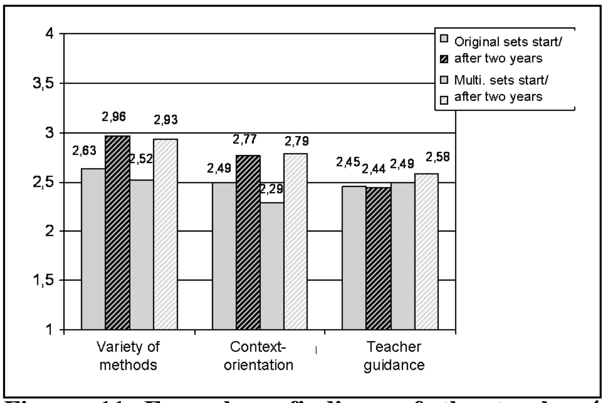


Figure 11 Exemplary findings of the teachers´ perception at the beginning of the project and after two years for the implementation groups and the multiplication groups

A comparison study showed significantly better results for CHiK classes compared to others, regarding the students´ perception (see Figure 12)

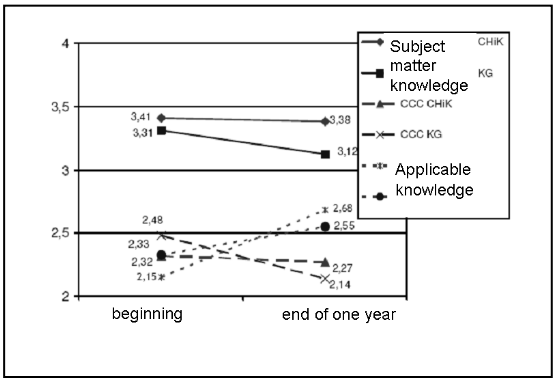


Figure 12: Exemplary findings of the students´ perception at the beginning of the project and at the end of one school year, in comparison between CHiK- and non-CHiK-classes (source of results: CHiK-research report, Fussangel et al., 2007)

On the whole, the implementation process can be regarded as highly successful, while context-based teaching and learning can only be successful when the same emphasis is given to the identification of successful contexts and the structuring of units and learning outcomes, e.g. by basic concepts for the area of subject matter knowledge. The transfer of concepts is one of the most difficult abilities for students and can only be build up by many applications and exercises .

Summary and outlook

As a summary, the CHiK project delivered the following outcomes and findings:

- A pool of **tested modules and materials, including a textbook with CD and teachers guide;**
- **positive results showing that learning communities** support changes and development;
- a positive development of **relevance and motivation in class**, but **depending on the context and the teaching,**
- **diverse learning outcomes**, but as good or better than traditional classes and
- a signal that teachers **focused very much on contexts, students´ activities and an increase in the variety of methods**, but **less emphasis was given to the development of basic concepts, which might lead to learning problems in class.**

Further activities and studies will set a special focus on the necessity of basic concepts and the transfer of knowledge, others on the development of tasks for learning and assessment.

Acknowledgements

Special acknowledgements are due to all colleagues, teachers and students participating in the CHiK-project for their cooperation, creativity and the time spent on the research questionnaires and interviews!

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[1] The CHiK-project was carried out as a cooperation between the IPN in Kiel, the universities of Oldenburg, Dortmund and Wuppertal and 14 participating states with 10-30 teachers and their classes in each state.

□

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Organic Chemistry Made Easy

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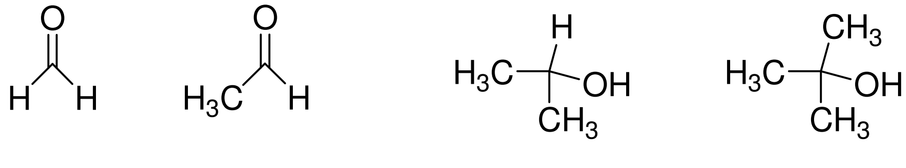
Recently I had the opportunity to teach a fourth year level environmental chemistry course to non-organic chemistry students. My role was to cover both the basic properties and chemical reactivity of organic based chemicals found in the environment. As I walked into the classroom I felt for the first time in my career a sense of fear and loathing amongst the students. As I was about to start to talk one of the students politely interrupted me, on behalf of the class, and shared her feelings toward the topic of organic chemistry, feelings of boredom and abhorrence for the topic! Having lectured advanced organic chemistry to organic chemistry students for the past decade I was very baffled! I asked the students why they felt this way. The responses I received from the students was mind boggling, most of the students thought organic chemistry was some boring and confusing old topic about naming complicated carbon based compounds and memorising a large volume of 'magical' synthetic transformations. I further enquired as to when they arrived at this conclusion? They then answered 'that's what we were taught in Introductory Organic chemistry in secondary school and first year university chemistry'. After the lecture I immediately went back to review a series of secondary level and freshman chemistry textbooks, and after reading the chapter(s) on organic chemistry I understood why the students felt this way!

In my view, the traditional approach of teaching introductory organic chemistry involves a disconnected approach, that is, organic chemistry is treated as a separate topic from the rest of chemistry. I believe it is this approach that alienates students from the topic. The traditional method used in many textbooks introduces organic chemistry as follows:

1) Structure
2) Functional groups
3) Nomenclature (in parallel to 1 and 2).
4) Synthetic transformations (reactions in organic chemistry)

So the question is; why does the above approach 'turn' students off, and what are the alternatives? Let's analyse the traditional approach.

The traditional approach does indeed introduce structure and functional groups, however the introduction of formal IUPAC in parallel to this is not essential at this point. After all, it is the IUPAC nomenclature system that bores the students (and teachers), and as we all know bored pupils do not learn, instead they turn-off! Furthermore, IUPAC nomenclature is becoming less significant for the following reasons – a) electronic chemical structure searches and b) nomenclature software that converts structure into names and vice versa. Additionally, IUPAC is only an effective nomenclature system for molecules that range in between the 'small' to 'large' category. What do I mean by this? Let's look at a few simple examples shown in Figure 1.

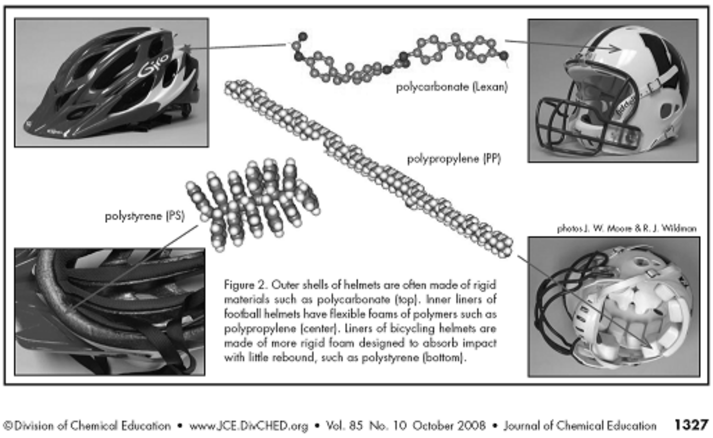


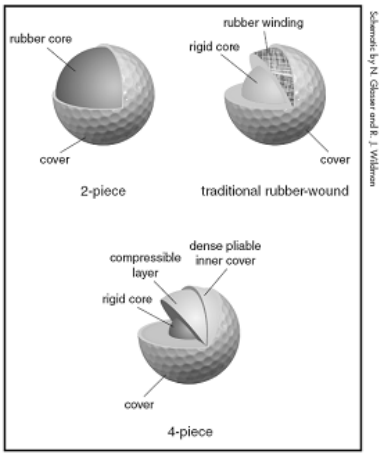
IUPAC:	Methanal	Ethanal	propan-2-ol	2-methylpropan-2-ol
'Kitchen':	Formaldehyde	acetaldehyde	isopropanol	t-butylalcohol

Figure 1

If you were to walk into any organic chemistry laboratory and ask for the compounds shown in Figure 1 using their IUPAC name you would receive some very strange and confused looks (and these are only a few examples). Most ‘small’ molecules are known by their ‘kitchen’ names, names given to these molecules decades before the advent of IUPAC. Thus the introduction of a detailed formal systematic naming system such as IUPAC may not be beneficial for introductory level students. It should also be remembered that IUPAC is about the formal crossing of t’s and dotting of i’s, it has nothing to do with chemistry!!

Perhaps the greatest deficiency with the traditional approach is the lack of connection with the chemistry that the students have already been taught and chemical reactivity of organic compounds. In the texts that I reviewed there is very little explanation given as to why most organic reactions take place, it seems that it is up to the students to memorise these transformations. What’s even worse is that most textbooks first introduce students to organic chemical reactions using radical halogenations of methane (preparation of halogenated solvents), radical reactions are not the norm in organic synthesis so why start here!





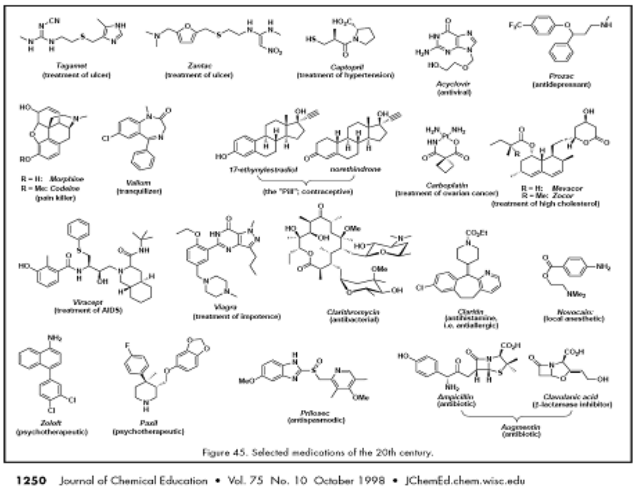


Figure 2

I do believe that there is an alternative approach to introduce organic chemistry to students, an approach that I refer to as the ‘connected approach’. The connected approach is not only designed to simplify organic chemistry for introductory students, but is designed for all students (those who pursue scientific and non-scientific careers) and it involves three stages:

1) Introduction of the topic of organic chemistry.

2) Introduction to structure, functional groups and physiochemical properties of organic molecules

3) The connection of reactivity of organic compounds with periodicity, Lewis dot structures and resonance stabilisation.

In stage 1 it is essential to capture the student's attention to the topic of organic chemistry. The following questions must be answered in proper detail: What is Organic chemistry? What is the difference between organic chemistry and other areas of chemistry? Why is it important? Does it have any impact on my life? Students should be made to realise that organic chemistry makes the modern world go round! I recommend using examples of commercial products that the students are familiar with, ranging from sports equipment, to drugs, to food production, cosmetics, clothing, CDs, plastics etc. A couple of examples are shown in Figure 2.

At the conclusion of stage 1 students should truly appreciate the importance and impact of organic chemistry on the modern world.

Stage 2 will then introduce students to the structure of organic compounds. It is essential at this point to review VSPER rules concerning the structure of sp^3, sp^2 and sp centres. Students must also be aware that organic chemistry deals with a limited number of elements (C, H, N, O, F, Cl, Br, I, S, P, Si) which actually makes the subject less complicated than having to deal with the whole periodic table. I also recommend using stick and ball models to show the three dimensional structures of various chain and ring structures. Once basic structure has been introduced it is then ideal to introduce the concept of functional groups to students. Instead of teaching the nomenclature of functional groups with respect to IUPAC (No formal nomenclature should be discussed during stages 1 and 2.) replace this with a discussion of the physiochemical properties of functionalised organic compounds. Specifically: volatility-odour, water solubility, acidity-basicity, colour and flammability. Also a discussion on the properties of macromolecules specifically functionalised polymers-plastics should be introduced. These concepts are important for all students however, for those students who will not continue on in the sciences this maybe their only opportunity in their education to actually learn something about the properties and uses of everyday organic molecules.

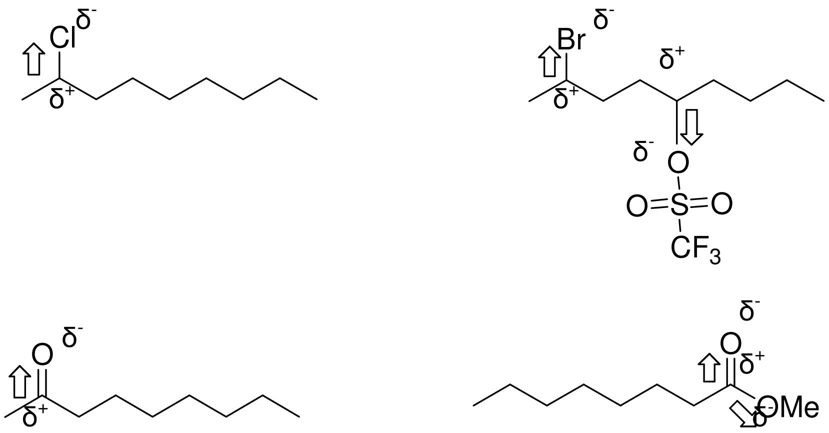
Stage 3 will then deal with the reactivity of functionalised organic molecules. At this point it must be explained to students that the majority of organic molecules that are used in society have to be synthesised. It must be explained to the students that a molecule is like a car or a building: it is assembled from smaller parts. How do you assemble a molecule? Synthesis! What does synthesis involve? Chemical reactions of carbon compounds. The introduction of organic chemical reactions is perhaps the most difficult aspect of teaching organic chemistry. However, I see it as a wonderful opportunity to demonstrate to students the application of periodicity, Lewis dot structures and basic thermodynamics. To achieve this goal I recommend the following approach:

1) Start with nucleophilic displacement reactions, where an electron rich species reacts with an electropositive carbon centre. It is essential to teach students where an electropositive carbon site is located within a molecule and this is where knowledge of the electronegativity of elements is a great tool. (see Figure 3)

2) Once students gain confidence in identifying reactive sites within functionalised molecules then students can move on to the next stage: at what site will a negative charged species attack a functionalised molecule? By simply remembering that opposite charges attract it is quite a trivial operation.

3) Does an actual reaction occur ? – this will depend on thermodynamics (bond forming – bond breaking energies). However, both ionic radii and Lewis dot structures can be used as a simple predictive tool of thermodynamic stability as shown in Figure 4.

Stage 1: Identify electropositive carbon sites



Electronegative elements pull the electrondensity away from the carbon centre making the carbon electropositive

Stage 2: What would happen if a negative charged or electron rich reagent was to approach each of the molecules? Negative is attracted to positive

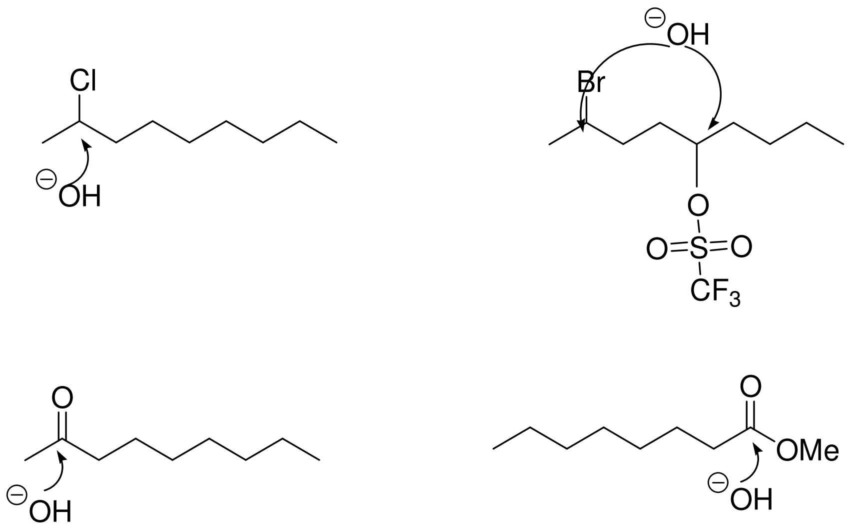


Figure 3

I believe the above described approach of chemical reactivity not only makes logical sense but students will also realise the power of periodicity and Lewis dot structures in predicting reactivity, even in molecules they have never seen before.

I recommend that only a few classes of organic reactions be introduced to students, keep it simple, it is essential that they understand why this chemistry occurs!

After these basic foundations have been laid then feel free to introduce elements of IUPAC nomenclature, but make sure you explain to students what IUPAC is, and stress that it is only a nomenclature system, and not chemistry!

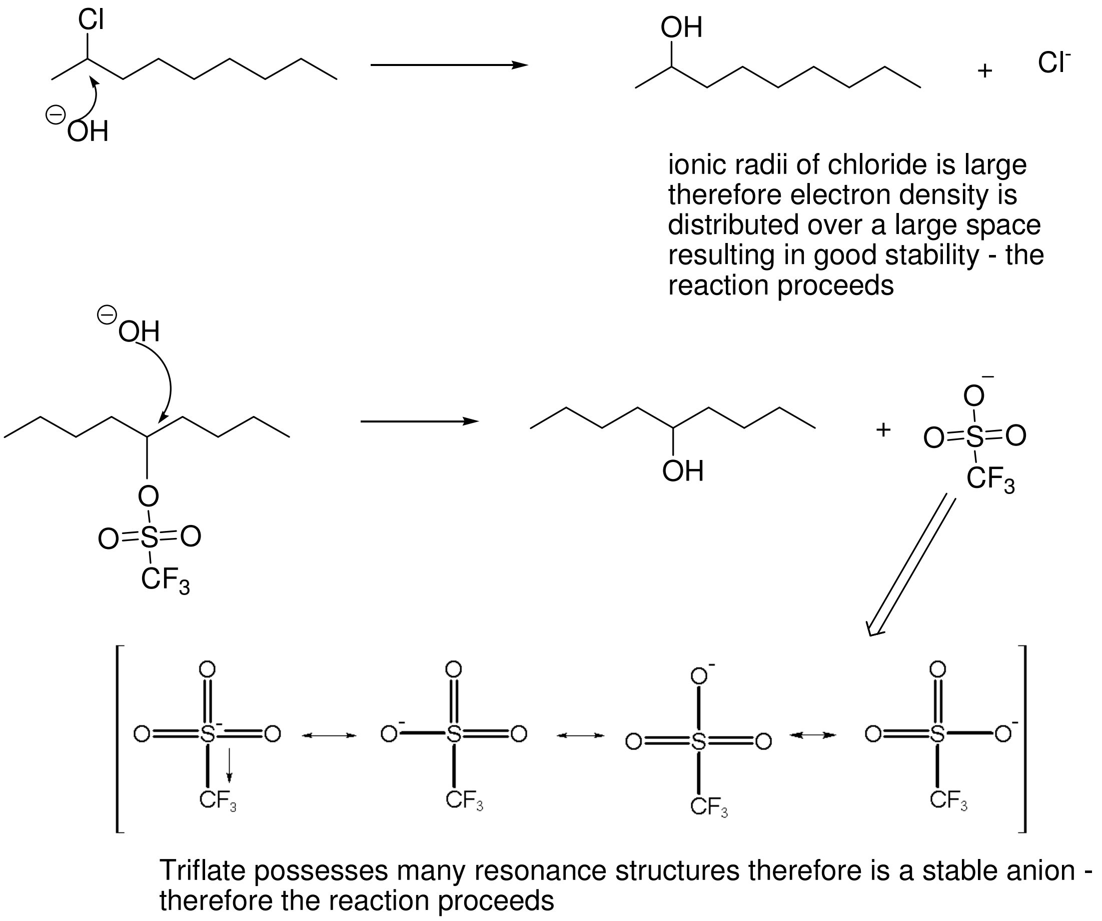


Figure 4

Overall I believe the 'connected approach' offers students the following:

1) An appreciation of the significance and impact of organic chemistry.

2) A good knowledge of the physiochemical properties of organic molecules and materials which will of great value to those students who do not further pursue the sciences.

3) Appreciate that organic chemistry is not separate from the rest of chemistry and that it is actually straight forward and makes sense!

□

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The Persistence of Students' Difficulties in Chemistry

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This paper presents the findings of a semi - longitudinal investigation that identified the Chemistry topics that the majority of Irish Chemistry pupils/students find difficult from Junior Certificate level (age 15/16 years) right the way through to University level (age 18+). The cohort groups included pupils who had completed the three-year Junior Certificate Science course, pupils who had completed the two-year Leaving Certificate Chemistry course, 1st year students who had just finished a first year General Chemistry module at the University of Limerick and a 2nd and 3rd year group of students at the University of Limerick who had completed a number of Chemistry modules.

Pupils/students completed a questionnaire listing the topics covered in the different Chemistry courses, which asked them whether they found each topic difficult or easy. A five point Likert scale was used. The Leaving Certificate pupils and third level students were also asked to identify which five topics they found most difficult, ranked 1 to 5.

This paper highlights the topics that Irish pupils/students find difficult in Chemistry. Topics identified by Irish students are similar to results of studies carried out in the UK by Ratcliffe (2002) and Scotland by Johnstone (2006).

The topics identified most frequently by Junior Certificate pupils as being difficult are topics that relate to the structure of the Atom, Bonding and Chemical Equations and Symbols.

The majority of Leaving Certificate pupils identified Organic Chemistry, Volumetric Calculations and Chemical Equilibria Calculations as being the most difficult topics in the Chemistry course.
At third level, Volumetric Calculations were identified by students as being the most difficult Chemistry topic.

This study also indicates that a number of topics ranked high in terms of perceived difficulty in both the Leaving Certificate Chemistry pupils and University Chemistry students' lists. These topics were Volumetric Calculations, Concentration of Solutions and Redox Reactions. The persistence of these topics being seen as difficult throughout the pupils'/students' experience of Chemistry, indicates that problems associated with these topics have never truly been addressed.

Other findings indicate that the Mathematical ability of the pupils/students has an effect on the topics they chose as difficult or very difficult. Pupils taking ordinary level Maths are more likely to perceive more topics difficult in Chemistry.

A detailed account of the results and findings of this investigation can be found in the July 2009 edition of the free internet journal *Chemistry Education Research and Practice (CERP).*

Subsequent work will look at the misconceptions held by 2nd. and 3rd. level chemistry students, and their cognitive levels, as possible sources of the pupil/student difficulties.

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Johnstone, A. (2006) 'Chemical Education Research in Glasgow in Perspective', *Chemistry Education Research and Practice*, 7(2), 49-63

Awaiting publication:

Childs, P. and Sheehan, M. (2009) 'What's Difficult about Chemistry? An Irish Perspective' , *Chemistry Education Research and Practice*, July 2009

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Teaching Junior Certificate Chemistry and Physics through the Cognitive Acceleration through Science Education methodology

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Background

The CASE programme was developed in the early 1980's and came in response to research that showed that demands of second level science curricula in many nations far exceeded the capabilities of students studying it. Many of the topics on the curricula involve complex scientific concepts and abstract models and require students to use what Piaget called formal operational thinking. Piaget proposed that children pass through distinct stages of cognitive development. The stages of most concern at second level are that of the concrete and formal operational stages. Piaget's general age/ stage picture is presented in Figure 1.

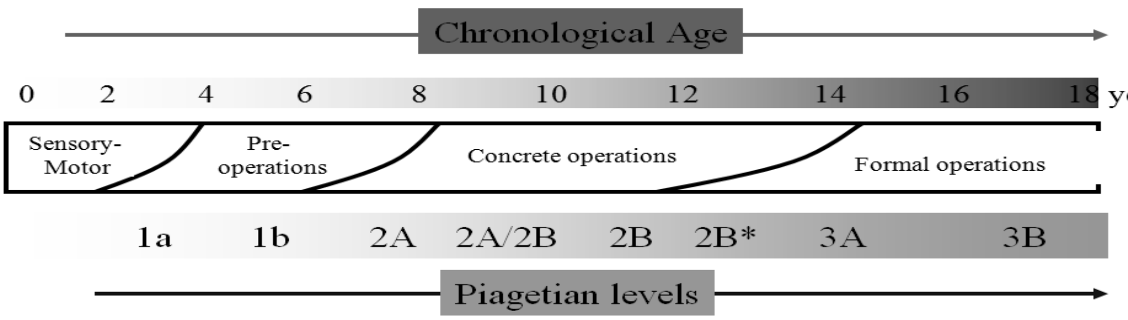

Figure 1 Chart of Piagetian stages of cognitive development and corresponding ages

Formal operational thinking, the stage developed from approximately 12 years of age according to Piaget, is essential for the manipulation of formulae, the design of scientific experiments and making the necessary connections between concrete experimental data and abstract scientific theory. From this perspective, the study of science becomes a challenge to students who have not yet reached this formal operational period. Worldwide studies have implied that fewer students than expected are at this formal operational level. Results from research that we carried out with 1st year second level students (of average age 12 years and 4 months) are shown in *Figure 2*. These results show that less than ten per cent of students are at the early formal operational stage (3A), which implies that the vast majority of 1st year students are not at the cognitive developmental level to engage and have an understanding of many scientific concepts that they are presented with in science lessons.

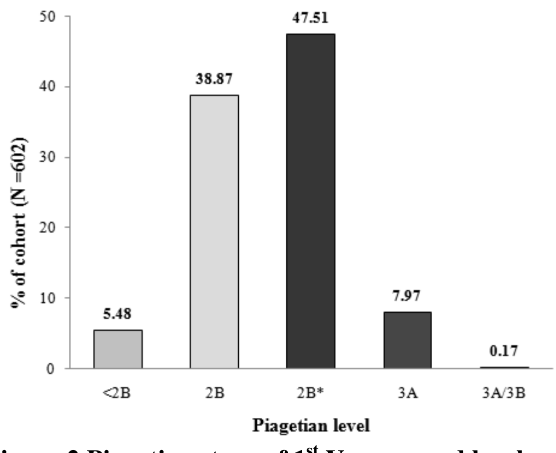

Figure 2 Piagetian stage of 1st Year second level cohort

In response to this mismatch the CASE (Cognitive Acceleration through Science Education) programme was founded by a group - Adey, Shayer & Yates - at King's College London in the early 1980's. The main aim of the programme was to increase the proportion of second level students with formal operational thinking, and hence cater for them to have a more meaningful and solid engagement and understanding of the scientific concepts covered in the National Curriculum. The theoretical foundation of the CASE methodology is partly Piagetian, with an emphasis on providing conflict situations to young adolescents (11-14 years) which encourage equilibration and the construction by students of the reasoning patterns of formal operations. Of equal importance is the Vygotskyan influence, with an emphasis on social construction of reasoning, through metacognitive reflection and carefully managed use of the language of thinking. In particular they were influenced by his proposal of a Zone of Proximal Development (ZPD) which proposes that children not only have a set of developed skills but they have some undeveloped cognitive skills, which they are capable of using successfully. These potential capabilities of the child may develop by chance, because of the effort of the child or due to the mediation of a peer or of an adult.

There are five main pillars that are central to the success of the CASE programme and they are shown in *Figure 3*. Firstly, concrete preparation involves setting the scene or presenting the context of a problem. The idea being that any difficulty encountered in the class is purely intellectual and not due to poor understanding of the task or miss-use of the equipment. Students then begin to work on an activity and this part of the class is known as the construction zone activity. The next pillar, cognitive conflict is central to the methodology. It is the part of the class where the students are faced with a problem that challenges their prior knowledge and personal hypothesis. The teacher plays a vital role by encouraging students to look at the problem from different perspectives and by encouraging dialogue about any difficulties experienced. Leading from this is the social construction part where students work collaboratively in groups of up to four people trying to resolve the cognitive conflict. Metacognition follows where the students are encouraged to reflect on their thinking and explain their thoughts to each other as they solve problems or perform tasks. The teacher plays an important role in this process by asking the students questions that probe their ideas. In essence it is the re-establishing of equilibrium. Finally, bridging is the part of the class where the teacher assists students in applying their new thinking into different

but relevant contexts. Bridging is regarded as a powerful teaching strategy, where students are encouraged to keep practising and challenging the new thinking developed long after the lesson they first learned it in is over.

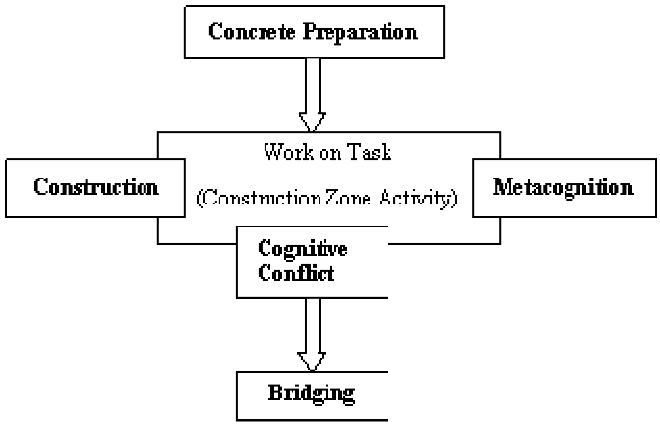

Figure 3 Pillars of CASE methodology

In addition to these underlying principles the authors of the programme regard duration and density as other important features. Feuerstein's work suggests that to have a permanent effect on the way that people think an intervention programme must be allowed to operate over a sufficiently long period of time, to make a permanent difference on student's thinking processes. The original CASE programme had operated over two years on the grounds that previous successful interventions, such as that of Feuerstein's *Instrumental Enrichment*, had shown no effects in less than two years. A supplementary reason was the time required to change the teaching practise of the secondary science teachers.

The original CASE project materials, *Thinking Science*, contained a total of 32 activities, each designed to last approximately 65 minutes. The activities were intended to be an enrichment to the regular science curriculum and for delivery at a rate of about one lesson every 2 weeks over a 2-year period. The materials were designed to address individually each of the schemata of formal operations and incorporate the pillars shown in Figure 3. The success of the programme on students' cognitive development was monitored by using Science Reasoning Tasks as pre-, post- and delayed post-tests with both an experimental group (taught by CASE methodology) and a comparable control group. Results from the original study showed that greater gains were achieved by the experimental group, especially by the male cohort. Since then the CASE programme has been implemented in several countries around the world. Within the Irish context we have adapted the CASE programme and implemented it with 500 6th class and 1st Year students and monitored the effects of the programme on the student's cognitive development. The results were in line with previous findings and show the beneficial effects of the programme.

Development of *Thinking Science through Topics*

Leading on from such promising results it was decided to extend the usability of the CASE materials, *Thinking Science* within the Irish context. Anecdotal evidence showed that teachers who used *Thinking Science* felt the activities were an extra add-on to the already over-loaded curriculum and also not all the CASE activities fitted directly into the Irish Junior Certificate science curriculum. In addition most of the CASE lessons were designed for up to 70 minute classes. In some cases in the Irish schools science is allocated single 40 minute periods and so inclusion of all the key pillars in this time with the existing materials is not possible. There may have been a temptation therefore to avoid using CASE in the classroom for these reasons. As it may have been overly ambitious and unrealistic for us to ask the curriculum to be cut down for certain teachers who choose to use *Thinking Science* it seemed more appropriate and possible to incorporate the CASE methodology into the existing topics on the curriculum. We developed *Thinking Science through Topics,* a programme designed to teach Junior Certificate science topics through the existing CASE methodology. This also would ensure that the methodology was used frequently and also the step-by-step building of the formal schema that is recommended by the original developers, as opposed to just choosing *Thinking Science* activities by random. In addition with the development of topics in the CASE methodology more time could be allocated to activities such as metacognition and bridging, necessary activities for cognitive development.

This intervention was designed for use in the second year of the Junior Certificate Science course, typically with students between 13 and 14 years old. Two topics from chemistry and four topics from physics were selected as the content of the programme. The materials were designed by first initially identifying the aims and objectives of the course in relation to each of the topics. Following this the content in each of the topics was matched with its corresponding Piagetian level using the Curriculum Analysis Taxonomy, an analytical tool developed by Adey and Shayer (1981) intended to gauge the cognitive demands of science syllabi. This provided a useful estimation of the level of thinking demanded by the science curriculum activities. This was necessary to ensure that the lessons were devised in a method of progression, so as to challenge those students at all levels of cognitive development. *Table 1* shows an example of the Curriculum Analysis Taxonomy for Acids and Bases, used in the development of *Thinking Science through Topics*. From there, lessons were compiled, with the CASE methodology central to the lessons. As far as possible each pillar was featured in each lesson, with proportioned time spent on each. In most lessons a scenario which raised a cognitive conflict for the students was included in the lesson. For example in Lesson 2 in the series on 'Acids and Bases' students are asked to carefully consider what will happen to the colour when equal amounts of acid and base (both with universal indicator added) of equal concentration are added together. Students must consider for themselves both physical and chemical changes, and use what they know about solutions and colours. This scenario provides conflict when students contemplate what happens when two solutions which they know about singly, are mixed together.

Table 1 Example of Curriculum Analysis Taxonomy for Acids and Bases

Topic	2A Early concrete	2B Late concrete	3A Early formal	3B Late formal
Acids and Bases	'Acid' as name of substances with certain properties- turns litmus red, attacks metal, sour taste. But only one at a time, the properties are not seen as defining characteristics.	Acids and bases are opposing factions. The pH scale as an interval scale of degrees of acidity. Neutralisation by equal quantities of acid and alkali. If you double quantity of acid, or if you double its concentration you need twice as much alkali.	Reaction of $H^+ + OH^- \rightarrow H_2O$. Limits to change of pH by dilution alone. Acids are solutions, without water they are not acidic. Conservations during neutralization: nothing lost and new product in principle recoverable.	The reaction between an acid and an alkali, understood in terms of disturbance of the equilibrium between H^+ and OH^- ions in water. Use of molar quantities for finding equation of reaction between an acid and an alkali. Can appreciate that there are H^+ ions even in 1.0M NaOH, and hence has rational understanding of pH scale.

Implementation of *Thinking Science through Topics*

The *Thinking Science through Topics* programme was implemented in five Irish schools, both in urban and rural regions, with approximately 130 students. In four of the five experimental classes the programme was delivered by the class teacher, who received specialized CASE training from the authors of this paper. The training consisted of a mixture of theory on the CASE methodology, practical introduction to the lessons and feedback from the teachers on difficulties and successes of the lessons as written. The lessons were adapted accordingly and all materials, including teacher and student workbooks, materials and practical equipment were distributed to each of the schools. In one of the classes the lessons were co-delivered by the first author and the class teacher. The timeline for the implementation and testing of the programme is shown in Figure 4.

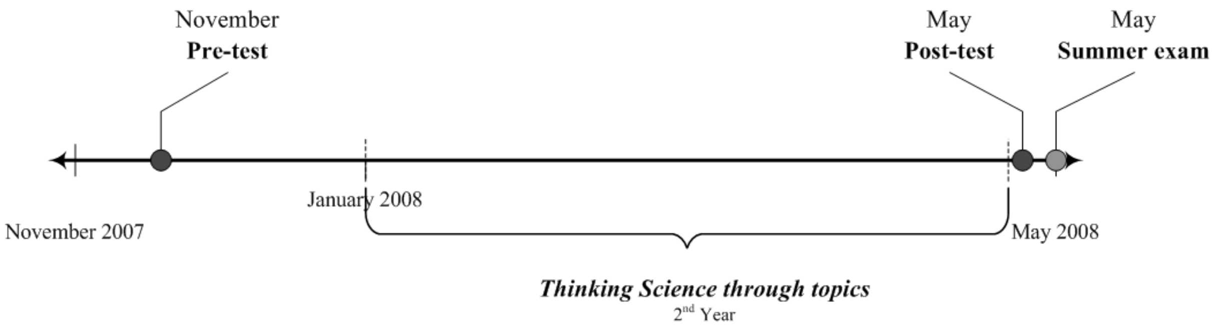

Figure 4 Timeline of implementation and testing of *Thinking Science through Topics* programme

Data Collection

The effectiveness of the lessons on cognitive development was assessed by Science Reasoning Tasks (SRT's) developed by the Concepts in Secondary Mathematics and Science (CSMS) team in the 1970's. These tasks assess the ability of students to use Concrete and Formal reasoning strategies. These tasks were administered by the first author directly before and after the *Thinking Science through Topics* intervention, with both control and experimental groups. The tasks were marked by the first author to ensure consistency and each student was given a score. From this the students were ascribed a level of cognitive development, i.e. 2B, 2B*, 3A, etc., using the Rasch scaling developed for the test instrument. This in turn enabled a total score to be converted to an equal-interval cognitive scale. In addition, students answered a set of 'Thinking questions', upon the completion of the programme that aimed to assess student's understanding of the concepts taught in the period of the intervention. Also student's grades in their end-of-year examination were recorded in order to evaluate the effect of the programme on student's exam performance.

Results

104 students completed both cognitive tasks (pre- and post-tests) and hence their scores were valid for statistical analysis. 60 students were part of the experimental group and the remaining 44 students were part of the control group. The average age of the students was 14.2 years at time of pre-test.

Initial analysis showed that there was no significant difference between the pre-test scores for the experimental and control group, with means of 4.1 and 3.7 respectively. However, the post-test scores for both the experimental and control groups were significantly different (at the 99% confidence level). The mean post-test score for the experimental group was 9.4, while it was 4.3 for the control group. Both groups scored higher in the post-test but the greater gains were made by the experimental group. *Figure 5* shows the degree of change in Piagetian sub-levels for the experimental and control groups. This was done by counting every student's progress/ regress from the pre-test to the post-test, in terms of their Piagetian level of cognitive development, for example if a student had a cognitive level of 2B at the pre-test and 2B* at post-test they would be ascribed an increase of one sub-level (+1). It can be seen that many more of the experimental group made gains in cognitive sub-level when compared with the control group, i.e. more of the experimental group moved up the scale referred to in Figure 1, compared with the control group.

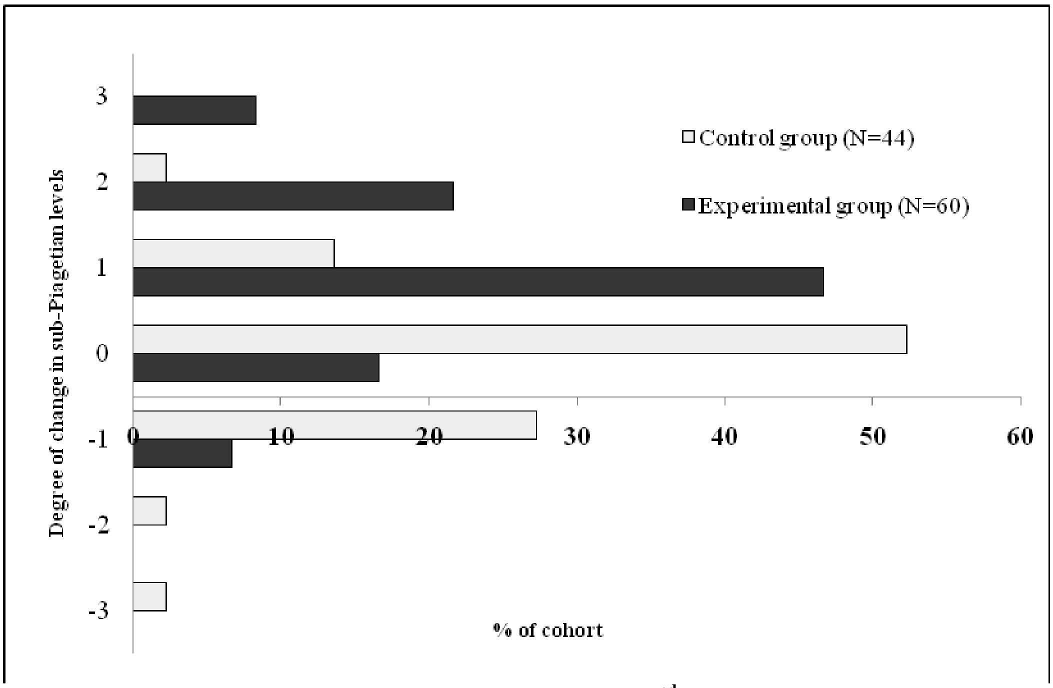

Figure 5. Chart of degree of change in Piagetian sub-levels of 2nd Year control and experimental groups

In order to gain greater insight into the degree of change that the control and experimental groups made, it was necessary to analyse the data further in terms of scores they achieved in the pre- and post- tasks determining Piagetian levels. This was done through Residual Gain Score (RGS) analysis. This technique works by using the pre- test score for each control person as a covariate to his post-test score, and a regression line is computed for the pre- and post- test scatter. The pre- test score for each experimental group student was then entered into the regression equation, and the difference between the predicted and actual post- test score estimates the effect of the intervention in comparison with the control. This method of analysis is valuable in as far as each student's gains are compared with control students of similar pre-test scores.

It can be seen that the residual gain scores for the experimental groups were greater than the comparable control group in all cases. The mean RGS for the entire experimental group was 4.9, while it was 0.002 for the control group. This number shows that the actual score that the experimental group got was greater than that predicted by the results of the control group. The mean RGS value of the control group implies that this group scored as predicted but no greater than expected.

In order to assess the broader effect of the intervention on the student's thinking and exam performance, analysis was also conducted on their end-of-year examination result and a set of 'Thinking questions', based on concepts they covered in the *Thinking Science through Topics* intervention. The end-of-year exam was set by the individual schools and therefore each school group sat a different test. The thinking-type questions were designed by the authors and their aim was to assess if students had a deep understanding of the concepts that were taught during *Thinking Science through Topics* or was it just a surface knowledge. Student's total scores from these questions were converted to a percentage and the mean results of all three assessments are shown in *Table 2* for the experimental and control groups.

Table 2 Mean RGS, Mean end-of-year percent & mean 'Thinking question' percent for experimental & control group

Group	Mean RGS	Mean End-of-year exam %	Mean 'Thinking question' %
Experimental	4.9**	65.1	59.2**
Control	0.0**	58.1	28.4**

**** Significant to the 99% confidence level**

As the information in *Table 2* shows the experimental group performed significantly better than the control group in both the Science Reasoning Tasks and the 'Thinking questions'. The difference in the results for the end-of-year science exam was not significant. However, such a result shows that the *Thinking Science through Topics* intervention programme succeeded in improving students' cognitive skills and conceptual understanding. The end-of-year exam with a majority of recall and knowledge questions was mastered comparably well with both cohorts.

Conclusion

This study shows that CASE does increase the cognitive developmental level of Irish students at 2nd level, in both 1st and 2nd year of the Junior Certificate cycle. Also CASE type activities can be developed to incorporate the Irish science curriculum. The programme that we developed, *Thinking Science through Topics* was implemented and results from analysis show that students who were taught science through this programme made significant gains in cognitive development, when compared with a comparable control group. In addition they performed significantly better in questions which demanded conceptual understanding of the topics taught. The approach involved teachers focusing on thinking skills rather than content knowledge and there was a demand for the student to engage and think.

Acknowledgements

I would like to acknowledgement the students and teachers from the five schools involved in this study for their co-operation and also the IRCSET Embark Initiative for the funding. If you would be interested in using the materials of Thinking Science through topics please contact one of the authors above for details.

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LC Chemistry – What is really asked on exam papers!

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Background

Assessment at both second and third level has come under immense scrutiny over the last decade particularly addressing the role which it plays in driving student learning. Good assessment strategy should be performed in such a way that it is justifiable and allows all students to achieve their maximum potential (4). Assessment should also reflect the stated objectives or learning outcomes of a course (5). Distinctions have been made between student evaluation and student assessment in that assessment is understood as the collection of data about a learner's understanding while evaluation is the passing of judgment on the learner's understanding based on the data collected through assessment (6). Evaluation is a necessary part of the educational process but appropriate evaluation requires good assessment strategies and tools. Summative assessment is often used as the final evaluation of student's learning and determines the extent to which a student has achieved curricular objectives (7). The characteristics of summative assessment (8) are that it:

- Takes place at certain intervals when achievement has to be reported;
- Relates to progression in learning against state or national curricula;
- Allows for the results of different pupils to be compared for various purposes because they are based on the same criteria;
- Requires methods which are as reliable as possible without endangering validity;
- Involves some quality assurance procedures;
- Should be made on evidence from the full range of performance relevant to the criteria being used.

The Leaving Certificate Examination in Ireland is the national summative assessment that takes place at the end of the second level education. Each subject follows a national syllabus and culminates in an examination. This study focuses specifically on the Leaving Certificate Honours Chemistry examination and syllabus and determines the level of questioning used in the examination.

The current Leaving Certificate Chemistry Curriculum was implemented in 2000 (first examination in 2002) and incorporates the following components (1):
Science for the enquiring mind, or pure science, to include the principles, procedures and concepts of the subject as well as its cultural and historical aspects (70%);
Science for action, or the applications of science, and its interface with technology (22.5%);
Science which is concerned with issues – political, social and economic – of concern to citizens (7.5%).

There is 30% of this syllabus devoted to social and applied aspects, which is one of the major changes to the revised curriculum combining the two areas 'Science for Action' and 'Science which deals with issues of concern for students'. A study conducted in 2006 examined the extent that the social and applied aspects (or Science, Technology and Society (STS)) of the revised Chemistry curriculum were actually implemented (9) and found that STS was not adequately reflected in either the state examinations or textbooks and was significantly less than the 30% stated in the curriculum.

The aims of the curriculum are stated as (1):

- To stimulate and sustain students' interest in, and enjoyment of, chemistry;
- To provide a relevant course for those students who will complete their study of chemistry at this level;
- To provide a foundation course in chemistry for those students who will continue their studies in chemistry or in related subjects;
- To encourage an appreciation of the scientific, social, economic, environmental and technological aspects of chemistry and an understanding of the historical development of chemistry;

- To illustrate generally how humanity has benefited from the study and practice of chemistry;
- To develop an appreciation of scientific method and rational thought;
- To develop skills in laboratory procedures and techniques, carried out with due regard for safety, together with the ability to assess the uses and limitations of these procedures;
- To develop skills of observation, analysis, evaluation, communication and problem solving.

Clear objectives are laid out in the syllabus covering areas of knowledge, understanding, skills, scientific competencies and attitudes. Many of these objectives are of higher order and are well formulated and stated. The assessment guidelines state that "the curriculum will be assessed in relation to its objectives. All material within the curriculum is examinable. Practical work is an integral part of the study of chemistry; it will initially be assessed through the medium of the written examination paper" (1). To date, the only national assessment of practical work is on the written paper. This method is totally inadequate to assess student's skills and competencies in laboratory procedures and techniques. However, to date all assessment of the students competence in chemistry is carried out by means of the written examination paper. This further emphasizes the importance of the questions set on the paper.

Written assessment may take many formats, however the type of questions asked in an examination will guide the learning by the student. The adage that "assessment drives learning" (10) indicates that the questions asked on examination papers are key to achieving the curriculum aims and objectives as stated above. This study examines the types of questions that are set on the Leaving Certificate Chemistry examination papers (from 2002-2008) with regards to the type of questions asked and the question content, specifically determining the competencies assessed, the range of content knowledge and the weighting allocated to each. The papers from 2000 and 2001 are also compared to determine if the change in syllabus resulted in changes in the question types. This analysis has been done by application of Bloom's Taxonomy.

Bloom's Taxonomy and its use in this study

Bloom's Taxonomy is a schematic which provides a method of classifying the learning objectives and skills (11). Within the cognitive domain, this hierarchical framework consists of six categories indentified below which can be used to identify the level of learning achieved (Figure 1).

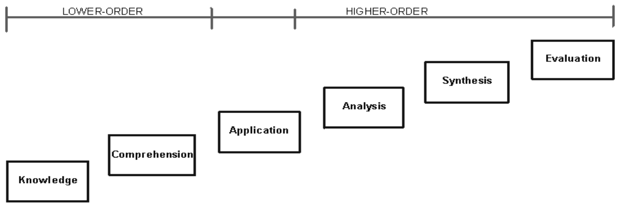

Figure 1 Schematic of Bloom's Taxonomy

The most basic level is knowledge which requires recall or the ability to simply state a fact without any real need to understand what it means e.g. stating definitions. Comprehension requires showing understanding by e.g. describing or comparing. Application is where students use their accumulated knowledge of concepts to solve problems on an analytical basis. These three questioning types are grouped together as lower order questions.

The three types of higher order questions require more critical thinking and skill by the examination setter, student and marker. Analysis requires e.g. breaking down a complex idea into its basic components, evaluate them critically and formulate an answer. Synthesis involves the student making predictions or seeking links between different ideas and concepts. Evaluation is where the students are required to make judgments about the quality of ideas or problem solutions. It often seeks to see if students can give rational opinions or assessments on controversies that can be justified by concrete evidence or factual information they have accumulated.

Bloom's taxonomy has been applied in a number of educational situations (9, 12, 14, 15, 16, 17) particularly in curricula assessment. There are of course other classification systems e.g. those proposed by Rosenshine, Dunkin & Biddle & Taba, Gallagher and Carner (as discussed by Gall (18)) and there are limitations to Bloom's

Taxonomy, such as cross over of questioning terms used to identify the cognitive level. However, despite the limitations, Bloom's Taxonomy was deemed useful in this study as a comparison / diagnostic tool.

The taxonomy was applied to each question on the Leaving Certificate Chemistry honours examination papers by classifying the active verb used in the question and then by comparison to Table 1, determining the learning objective.

Each question and part of question was classified as above and the marks allocated to each question was also noted. This allowed calculation of the % of the overall marks that were allocated to particular types of questions. It must be noted here that there are 11 questions on each paper giving a total of 650 marks. However students need only attempt 8 questions totalling 400 marks. The percentages presented here are based on the 650 marks for comparison purposes. Also as there is a level of subjectivity in application of Bloom's Taxonomy, 3 people rated one particular paper independently. The results indicate a discrepancy of between ± 4% between them in each category.

Results and Discussion

The % of the questions that were asked on each paper that were knowledge (K), comprehension (C), application (Ap), analysis (An), synthesis and evaluation type was determined for each year and compared to the % of marks allocated to these questions. The results for the paper in 2005 are shown in Figure 2.

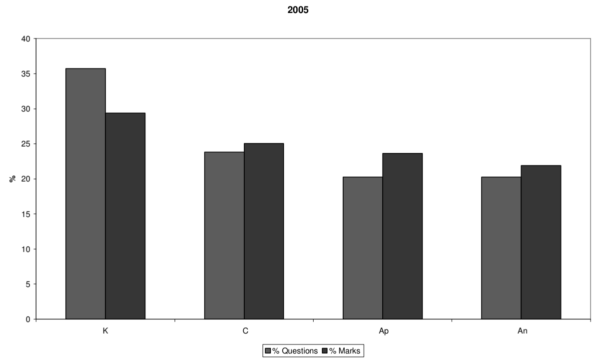

Figure 2 % of each question type and % marks allocated to each question type for the 2005 Honours Chemistry Examination Paper

From Figure 2, it is clear that that there are no synthesis or evaluation questions. This was a feature of all the papers examined. The majority of the questions asked were of the lower order knowledge type – over 35% with approximately 20% analysis type questions. It should be noted here that while the % of marks allocated to each question area was broadly reflective of the question types, more marks were allocated to the comprehension, application and analysis type questions. The 35% of the knowledge questions asked were awarded less than 30% of the marks.

Figure 3 summarises the data obtained for each year from 2000 to 2008, showing the % of each question type for each paper.

Knowledge		Comprehension		Application	
tell list relate define recall	label select locate find state name	explain estimate interpret outline discuss identify	distinguish predict restate translate describe explain draw	solve show use write demonstrate give	illustrate construct complete examine classify
Analysis		**Synthesis**		**Evaluation**	
analyse distinguish compare contrast investigate categorise	separate calculate diagrams differentiate advertise devise	create invent compose plan construct design	imagine propose formulate compile relate summarise	choose decide debate prioritise critique	verify argue recommend assess rate evaluate

Table 1 Application of Bloom's Taxonomy (adapted from 18)

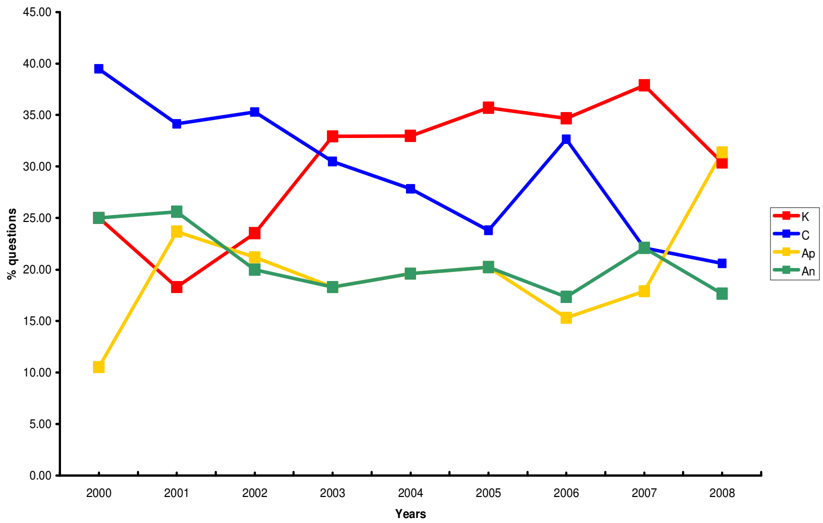

Figure 3 % of each question type for the Honours Chemistry Examination Papers from 2000 to 2008

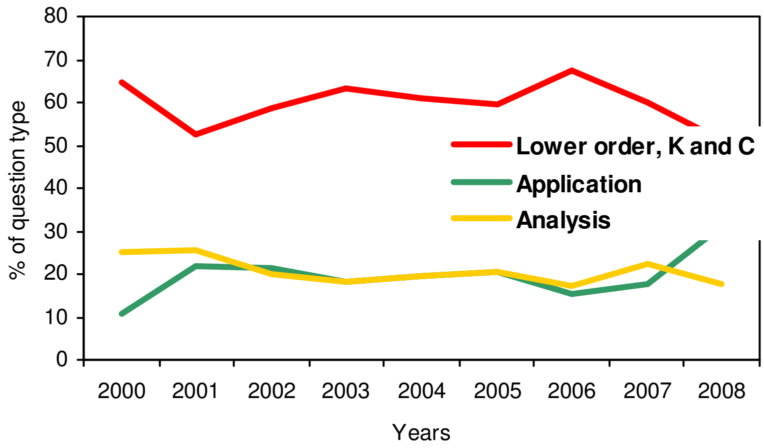

Figure 4 % of lower order questions (knowledge and comprehension), application and analysis question type for the Honours Chemistry Examination Papers from 2000 to 2008

It is clear that the % of knowledge type questions increased sharply after the introduction of the revised syllabus in 2002 and rose to a highest of almost 40% in 2007, from a low of 18% in 2001. This figure reduced to approx 30% in 2008. In marked contrast, the proportion of comprehension type questions has decreased over the same period from a high of 40% for the old syllabus to a low of less than 25% in 2008. Considering the hierarchical framework of Bloom, this trend suggests that there is an increasing focus on the lowest order questions. Figure 4 combines the proportion of lower order questions (i.e. knowledge and comprehension) to application type questions and to the higher order questions (i.e. analysis) for each year. Collectively, the proportion of the lower order questioning varies between 50 – 65% over the 9 years examined.

Of the higher-order question types, analysis was the only type evident and the proportion of analysis type questions has remained more or less steady at approx 20% over these years. Likewise the proportion of application type questions decreased from 2002 to 2006 but have increased in 2007 and in 2008. The 2008 paper showed an increase in the application type question with reduction in lower order questions.

While the variation in question type is interesting over the years, it is necessary to determine if the proportions of the different question types are reflected in the marks allocated for each question. Figure 2 shows the % of the overall marks available for each question type for the 2005 paper. It is clear from Figure 2, that the proportion of marks allocated to e.g. the knowledge questions was less than the proportion of the questions set. The ratio of %marks to

%question in this case is 29/36 = 0.8, indicating that less marks have been allocated than would be expected if marks are allocated equally to each question type.

Figure 5 shows the ratio of % marks to % question for each question type over each of the years. Note that a value of 1 indicates that marks are equally allocated to each question type; a value >1 indicates the availability of more marks while a value <1 indicates fewer marks allocated in proportion to the number of questions.

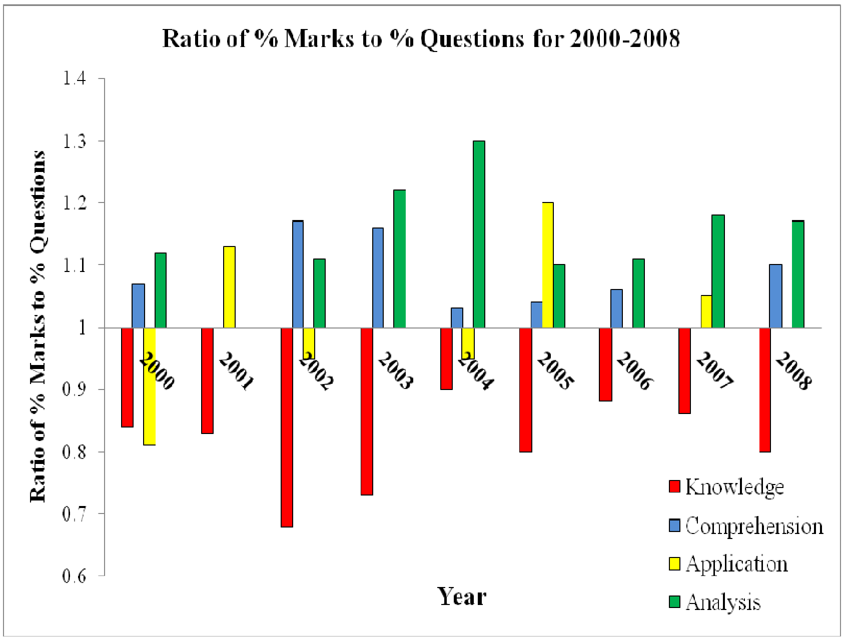

Figure 5 Ratio of %marks to % questions for each question type for each year. Value of 1 indicates equal rating of marks to question, a value >1 indicates greater level of marks allocated while a value <1 indicates less marks allocated.

From Figure 5, it is clear that knowledge type questions are generally allocated fewer marks than expected purely on the basis of the proportion of the questions. On the other hand, the higher order analysis type questions are allocated greater proportion of the marks over what the proportion of the questions would suggest. This suggests that there is a potentially greater 'reward' for the student in answering the analysis questions over the knowledge questions.

Conclusions

The aim of this study was to determine the level of cognitive questioning that was used in Leaving Certificate Chemistry Honours examination papers. It was found that, since the introduction of the new syllabus in 2002, the proportion of knowledge-based questions has increased each year and comprehension type questions have decreased. Taking these two question types together as lower-order questions, they account for approximately 60% of the questions asked on the examination paper. In 2008, this proportion decreased to approx 50%.

Application type questions, which are considered by some authors to be lower-order and by others to be higher-order, remain at approx 20% over the last 7 years but again in 2008, this increased to almost 30%. The only higher-order questioning type on the papers was analysis, with no synthesis or evaluation questions evident. The level of analysis questions are again at approx 20%.

The high proportion of lower order questions is a cause for concern. In this analysis, all questions were considered on the papers and the mark allocation to each question type was a proportion of the full number of marks allocated to the paper (i.e. 650 marks). As a student is asked to answer only 8 full questions, the full marks possible is 400 marks. Now if the proportion of lower-order questions is say 62% on a paper, and if these questions carry 62% of the marks available, then a student can (mathematically at least) achieve 100% by answering lower order questions only. In reality, due to varying types of questions within large questions, the situation as outlined above is not possible.

When the allocation of marks are considered for each question type, in general the knowledge questions are under rewarded while the analysis questions are over-rewarded, based on a notion of equal marks for equal proportion of questions. The fact that the higher order questions are 'over-rewarded' is appropriate as it implies that higher order thinking is rewarded. The question can be asked though if this reward is sufficient. Also, it would be beneficial to see all types of questions appearing on the papers with appropriate mark allocation.

The objectives set out in the syllabus document cover knowledge, understanding, skills, competencies and attitudes. Many of the objectives are higher-order such as interpretation, organisation, proposing, relating, assessing. However, the majority of the examination paper is determining knowledge and comprehension which require lower-order thinking skills. Further work will determine if the proportions of question types as determined for Chemistry is evident in the examination papers for the other science subjects and indeed for other subjects outside of the science area.

Additional work has been carried out as part of this study, examining the topics and sub-topics of the syllabus that have been assessed each year. Also the extent of the assessment of these topics relative to the proportion of marks allocated and also in proportion to the time allocation suggested in the syllabus. This data is published in the M.Sc. thesis by Edelle McCrudden, held in DCU.

Acknowledgements

One of the authors (EMcC) acknowledges the support of Embark Initiative.

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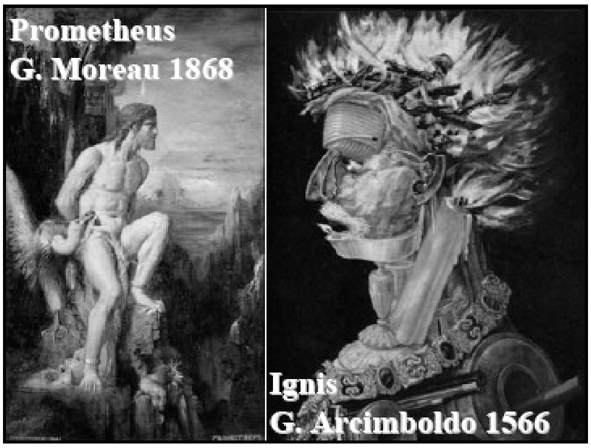
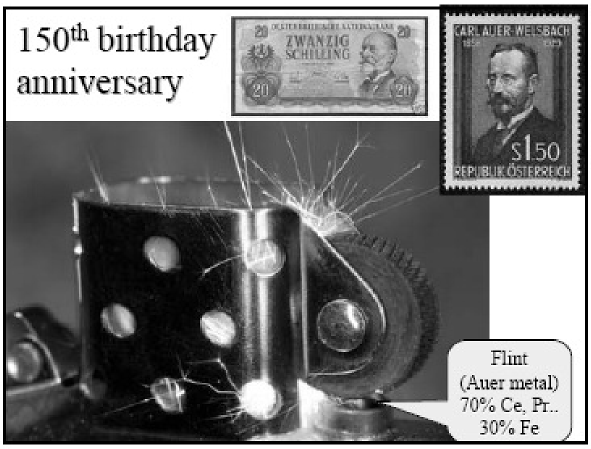
□

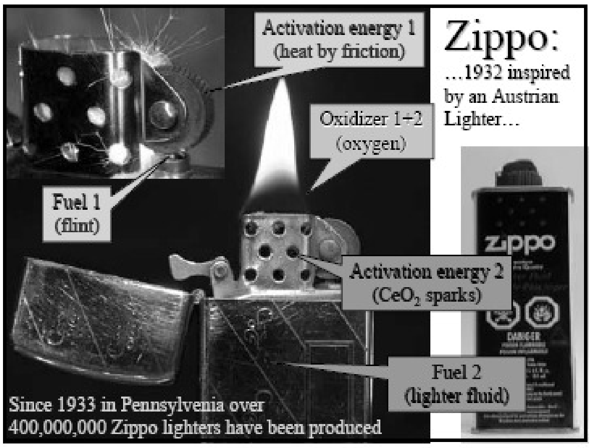
Edelle McCrudden has just completed a Masters based in part on this work under the supervision of Odilla Finlayson at DCU.

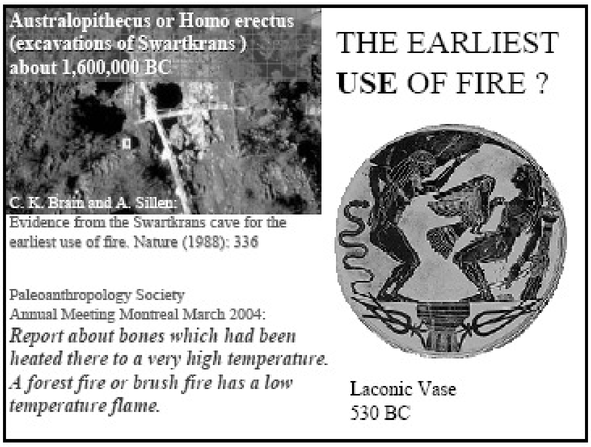
From fire drills to jet flame lighters

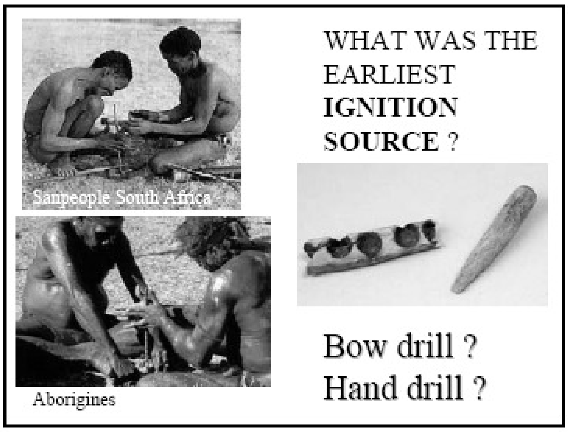
Viktor Obendrauf
University of Graz, Austria

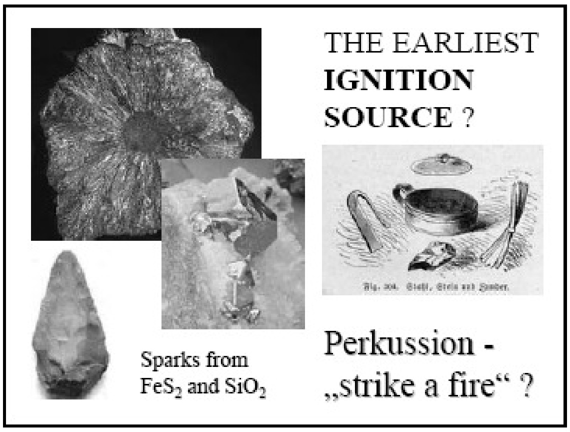


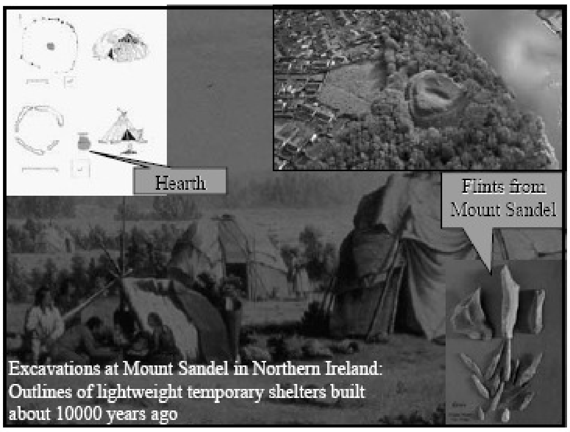


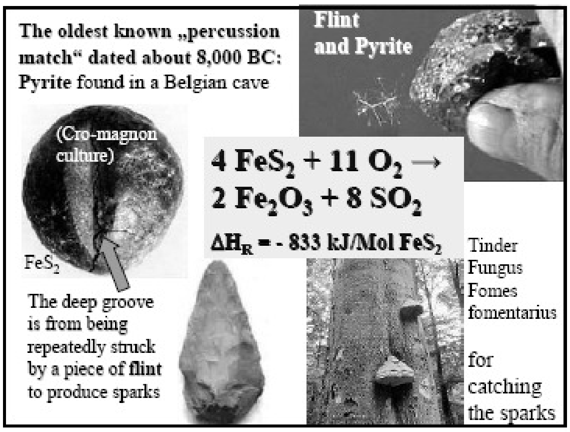


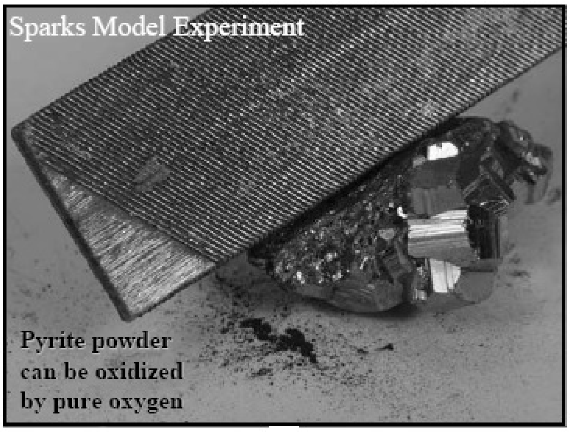


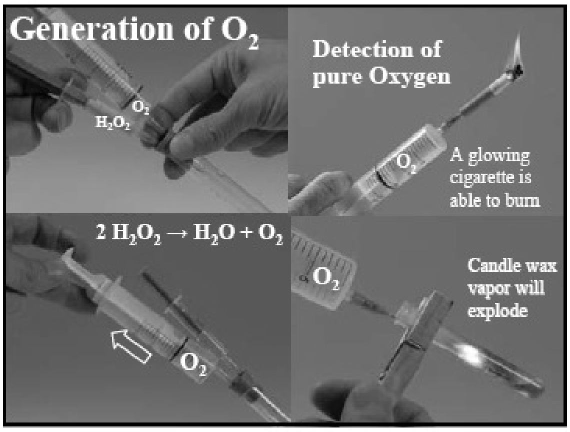

WHAT WAS THE
EARLIEST
IGNITION
SOURCE ?
Sanpeople South Africa
Aborigines
Bow drill ?
Hand drill ?

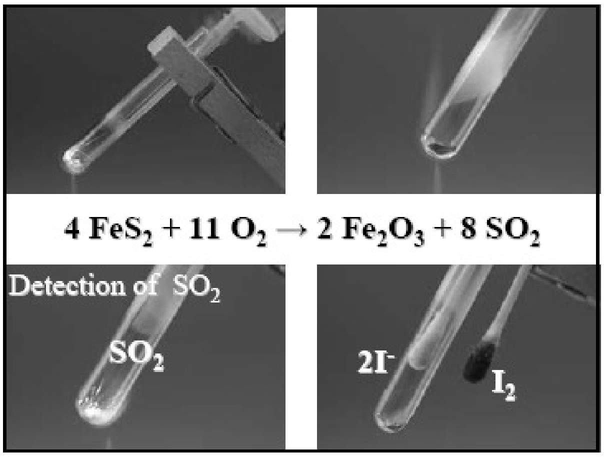

THE EARLIEST
IGNITION
SOURCE ?
Sparks from
FeS2 and SiO2
Perkussion -
„strike a fire“ ?

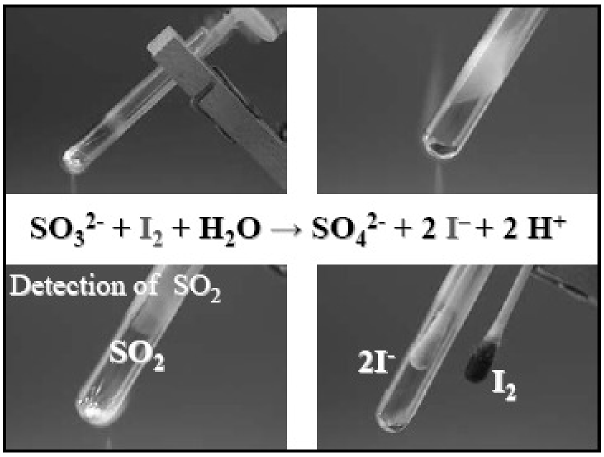

Hearth
Flints from
Mount Sandel
Excavations at Mount Sandel in Northern Ireland:
Outlines of lightweight temporary shelters built
about 10000 years ago

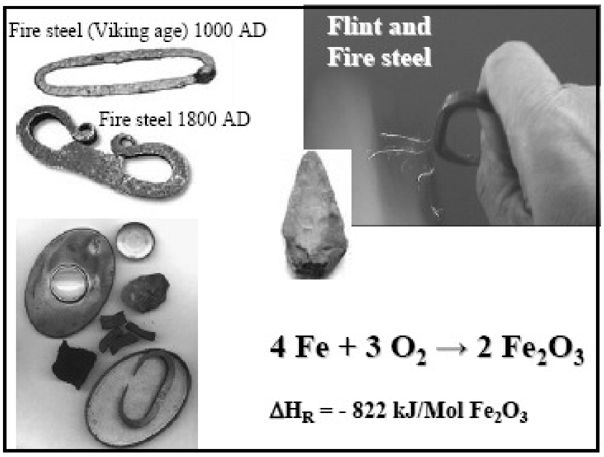

The oldest known „percussion
match“ dated about 8,000 BC:
Pyrite found in a Belgian cave
Flint
and Pyrite
(Cro-magnon
culture)
4 FeS2 + 11 O2 →
2 Fe2O3 + 8 SO2
ΔHR = - 833 kJ/Mol FeS2
FeS2
The deep groove
is from being
repeatedly struck
by a piece of flint
to produce sparks
Tinder
Fungus
Fomes
fomentarius
for
catching
the sparks

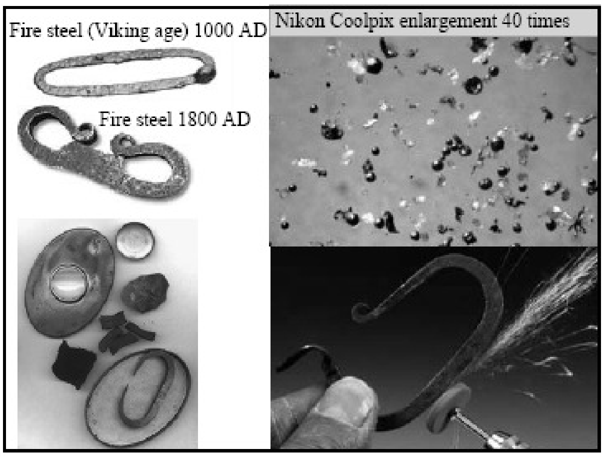

Sparks Model Experiment
Pyrite powder
can be oxidized
by pure oxygen

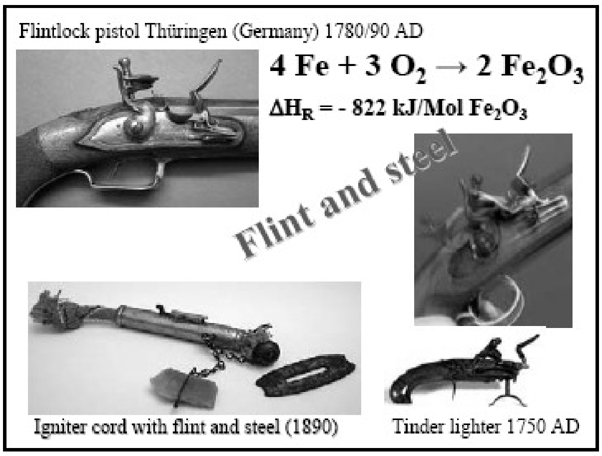

Generation of O2
Detection of
pure Oxygen
H2O2
O2
A glowing
cigarette is
able to burn
2 H2O2 → H2O + O2
O2
Candle wax
vapor will
explode

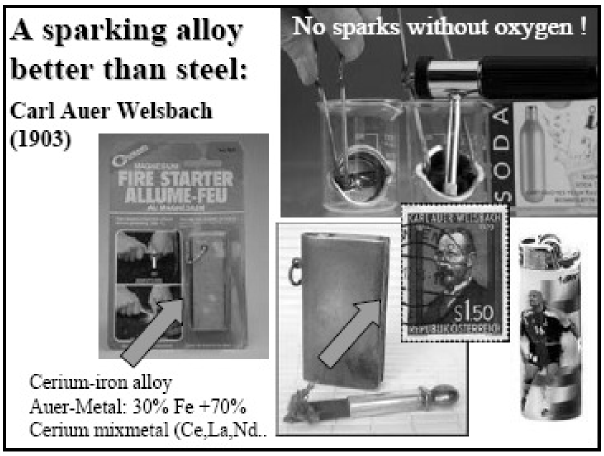

$4 FeS_2 + 11 O_2 \rightarrow 2 Fe_2O_3 + 8 SO_2$
Detection of SO_2
SO_2
$2I^-$
I_2

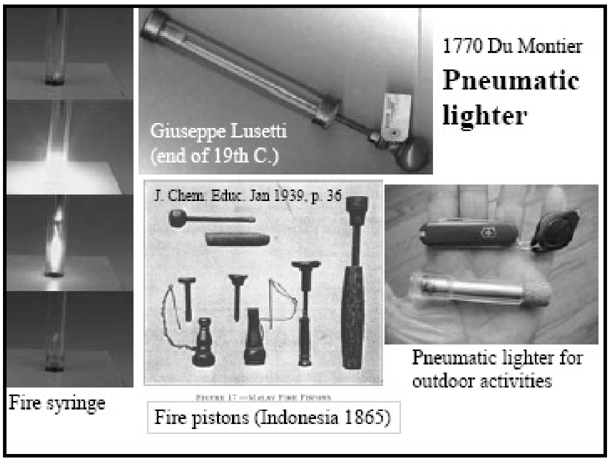

$SO_3^{2-} + I_2 + H_2O \rightarrow SO_4^{2-} + 2 I^- + 2 H^+$
Detection of SO_2
SO_2
$2I^-$
I_2

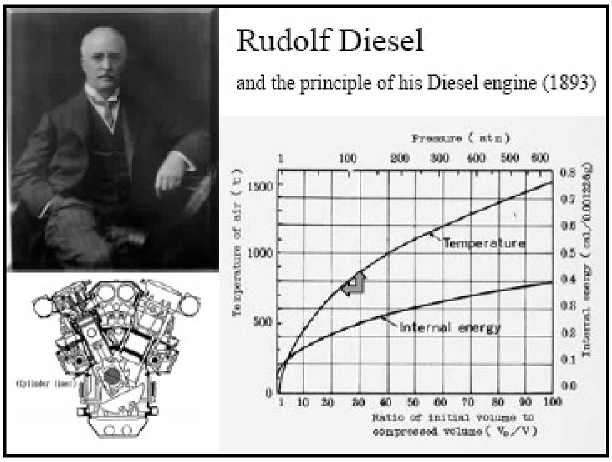

Fire steel (Viking age) 1000 AD
Fire steel 1800 AD
Flint and
Fire steel
$4 Fe + 3 O_2 \rightarrow 2 Fe_2O_3$
ΔH_R = - 822 kJ/Mol Fe_2O_3

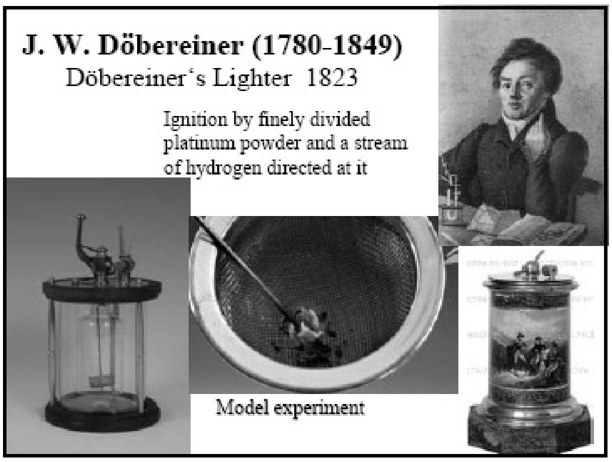

Fire steel (Viking age) 1000 AD
Nikon Coolpix enlargement 40 times
Fire steel 1800 AD

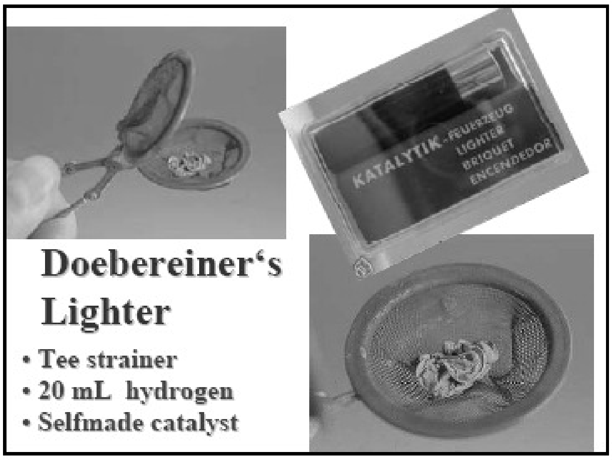

Flintlock pistol Thüringen (Germany) 1780/90 AD
$4 Fe + 3 O_2 \rightarrow 2 Fe_2O_3$
ΔH_R = - 822 kJ/Mol Fe_2O_3
Flint and steel
Igniter cord with flint and steel (1890)
Tinder lighter 1750 AD

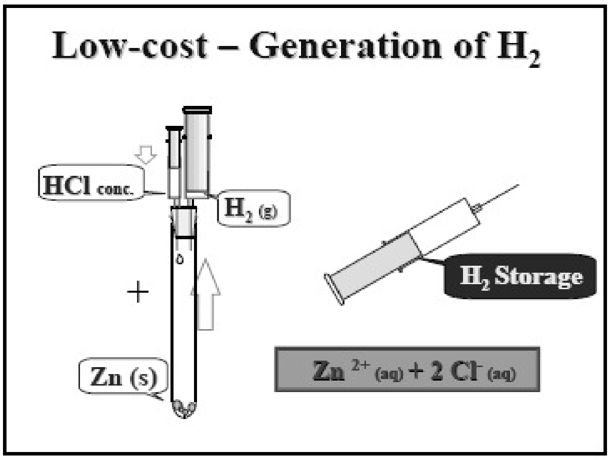

A sparking alloy
better than steel:
Carl Auer Welsbach
(1903)
No sparks without oxygen !
FIRE STARTER
ALLUME-FEU
SODA
Cerium-iron alloy
Auer-Metal: 30% Fe +70%
Cerium mixmetal (Ce,La,Nd..

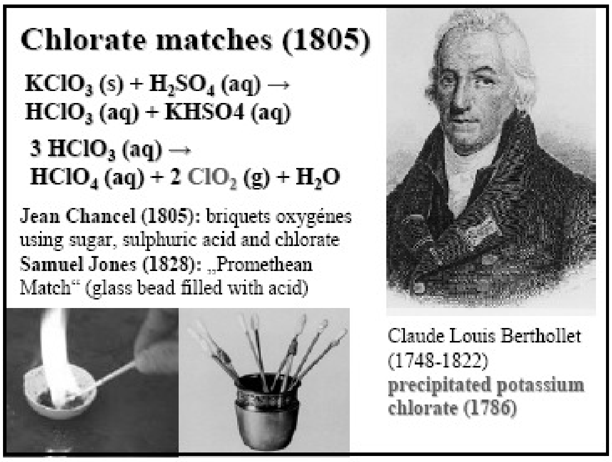

1770 Du Montier
Pneumatic lighter
Giuseppe Lusetti
(end of 19th C.)
J. Chem. Educ. Jan 1939, p. 36
Pneumatic lighter for
outdoor activities
Fire syringe
Fire pistons (Indonesia 1865)


Rudolf Diesel
and the principle of his Diesel engine (1893)
Pressure (atm)
Temperature
Internal energy
Ratio of initial volume to
compressed volume (V₀/V)


J. W. Döbereiner (1780-1849)
Döbereiner's Lighter 1823
Ignition by finely divided
platinum powder and a stream
of hydrogen directed at it
Model experiment


Doebereiner's
Lighter
• Tee strainer
• 20 mL hydrogen
• Selfmade catalyst
KATALYTIK-FEUERZEUG
LIGHTER
BRIQUET
ENCENDEDOR


Low-cost – Generation of H_2
HCl conc.
H_2 (g)
+
Zn (s)
H_2 Storage
Zn^{2+} (aq) + 2 Cl^- (aq)

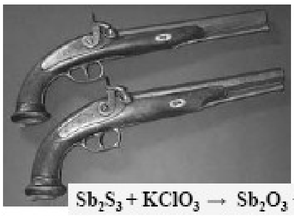

Chlorate matches (1805)
$KClO_3$ (s) + H_2SO_4 (aq) →
$HClO_3$ (aq) + KHSO4 (aq)
3 $HClO_3$ (aq) →
$HClO_4$ (aq) + 2 ClO_2 (g) + H_2O
Jean Chancel (1805): briquets oxygénes
using sugar, sulphuric acid and chlorate
Samuel Jones (1828): „Promethean
Match" (glass bead filled with acid)
Claude Louis Berthollet
(1748-1822)
precipitated potassium
chlorate (1786)

The basis of the Imperial-Royal-Match Industry of Vienna

Stefan Rómer (1788-1842) produced Chlorate matches in:

Vienna 1831

Match head: $KClO_3$: S = 30 : 10
Ignition with Sulphuric Acid (soaked up in Asbestos)



Perkussion Pistols

50:50 mixture of Sb_2S_3 and $KClO_3$ for the percussion caps

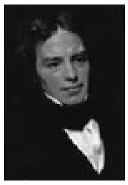
$$Sb_2S_3 + KClO_3 \rightarrow Sb_2O_3 + 3\ KCl + 3\ SO_2$$

John Walker (1781-1857)

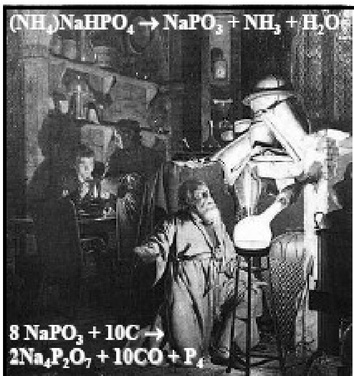
The first friction match (1826)

Sb_2S_3 : $KClO_3$: gum Arabic : Fe_2O_3 = 5:5:3:1

Samuel Jones named them „Lucifers“ (1829)



M. Faraday showed the friction match in his famous lecture 1828



$$(NH_4)NaHPO_4 \rightarrow NaPO_3 + NH_3 + H_2O$$

$$8\ NaPO_3 + 10C \rightarrow 2Na_4P_2O_7 + 10CO + P_4$$

Discovery of white phosphorus
(Henning Brand about 1670)

In 1680: **Robert Boyle** coated a piece of paper with phosphorus and a piece of wood with sulphur. Rubbing the wood across the paper created a fire.

In 1830: **Ch. Sauria** created the first friction match using white phosphorus

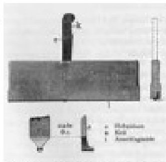
These strike everywhere matches were very famous up to 1900, but they were very dangerous…

In 1906: match heads containing phosphorous were forbidden in most countries

---

White Phosphorous and the Imperial-Royal Match Industry in Vienna and Bohemia

In1836 **János Irinyi** had the idea to use lead dioxide instead of potassium chlorate in the phosphorous matches. He sold the idea to S. Rómer



Match plane from Vienna

1834 S. Rómer and J. Siegel: first match factory in Vienna
1839 Vojtech Scheinost: first factory in Susiče (later *Solo*)
1851 3000 workers in 32 factories in Vienna and Bohemia manufactured **18,000 kg White Phosphorous**
840,000 kg Sulphur and 70,000 kg Potassium nitrate....

1877

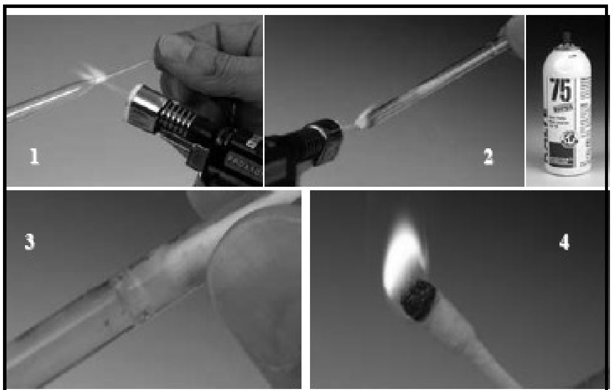
1880

1896

1901

Match box
Pollak, Vienna 1850

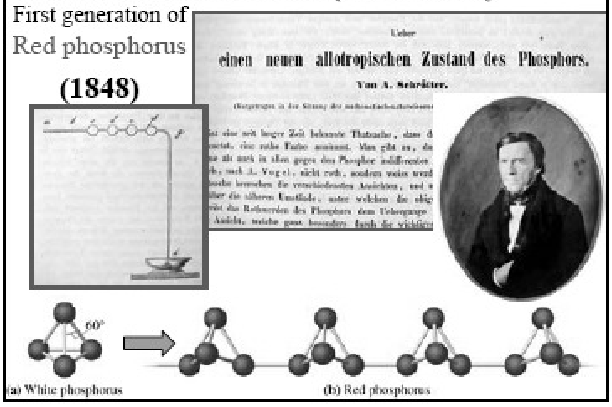
cigar igniter
„Goldteuferl“ Pollak, Vienna 1845



Model experiment: self ignition of white phosphorus in the air
microscale generation of white phosphorus by heating red phosphorus

Anton von Schrötter (1802-1875)

First generation of Red phosphorus (1848)



Safety matches

In 1844: **Gustav Erik Pasch** created his first safety matches (A mixture of chlorate and antimony sulphide can be only ignited by rubbing it on a surface containing red phosphorus)

In 1855: **Johan E. Lundström** (Sweden) produced the first successful safety matches

1) **Red phosphorus** combined with potassium chlorate gives P_4O_{10} (ΔH_f = — 2.984 kJ/Mol)

2) $KClO_3 + 3\ S \rightarrow 2\ KCl + 3\ SO_2$

3) $4\ MnO_2 + S \rightarrow 2\ Mn_2O_3 + SO_2$

4) $K_2Cr_2O_7 + 3\ S \rightarrow 4\ K_2CrO_4 + 2\ Cr_2O_3 + 3\ SO_2$

5) Catalyst MnO_2: $2\ KClO_3 \rightarrow 2\ KCl + 3O_2$

compound (% mass)	Colour of the match head		
	black	brown	other
$KClO_3$	52	52	53,5
sulphur	4,0	4,0	5,0
$K_2Cr_2O_7$	1,0	1,0	1,0
gelatine	10,0	10,0	10,0
ZnO	4,5	4,5	6,0
Fe_2O_3	4,0	5,0	-
MnO_2	4,0	4,0	-
glass pow.	16,7	15,8	20,3
$SiO_2 \cdot x\ H_2O$	3,5	3,5	3,5
carbon	0,1		

$ClO_3^- + 6H^+ + 5e^- \rightarrow 0{,}5\ Cl_2 + 3\ H_20$

$Cl^- \rightarrow 0{,}5\ Cl_2 + e^-$ /x 5

$$ClO_3^- + 5\ Cl^- + 6\ H^+ \rightarrow 3\ Cl_2 + 3\ H_2O$$

$KClO_3$: 122.63g/mol

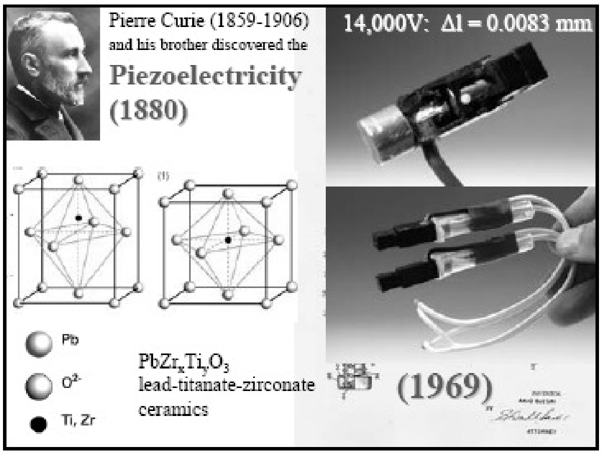
1 mol $KClO_3$ …….. 3 mol Cl_2 (3x 22.4 L)

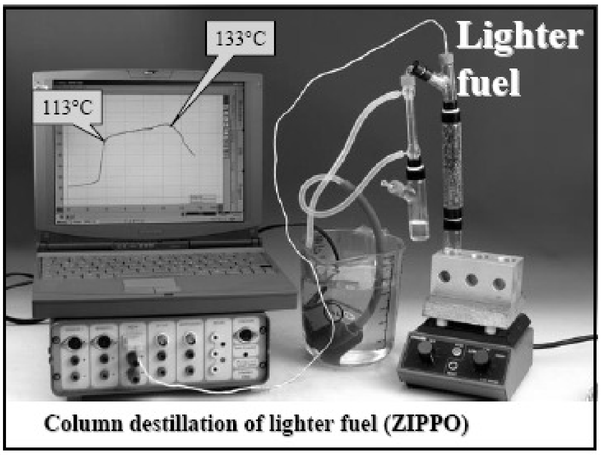
122.63 g …….. 67.2 L Cl_2

12.6 mg $KClO_3$ …….. 6.7 mL Cl_2

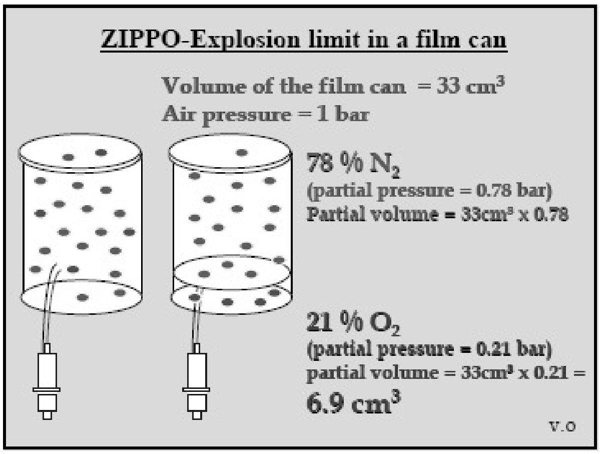
1 Match head mixture ~10 mg (50% $KClO_3$)……. ~ 3 mL Cl_2

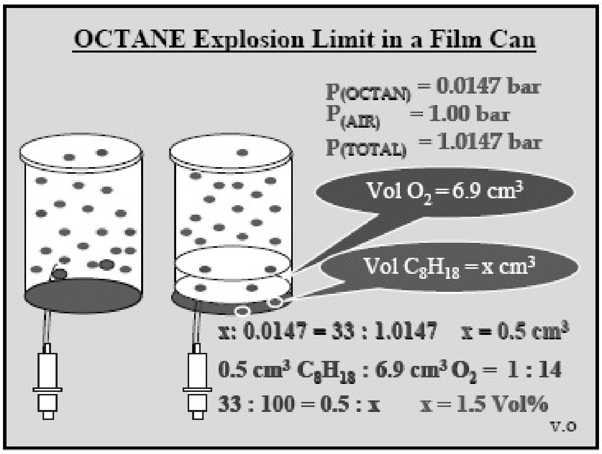

0.00010 mol KClO3 = 12.26 mg
0.00012 Mol P = 3.72 mg
Excess KClO3 (about 40 mg) prevent burning phosphorus on the skin.
10KClO3 + 12 P → 3 P4O10 + 10 KCl

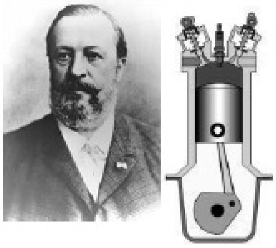

Pierre Curie (1859-1906) and his brother discovered the
Piezoelectricity (1880)
14,000V: Δl = 0.0083 mm
Pb
O2-
Ti, Zr
PbZrxTiyO3 lead-titanate-zirconate ceramics
(1969)


133°C
113°C
Lighter fuel
Column destillation of lighter fuel (ZIPPO)

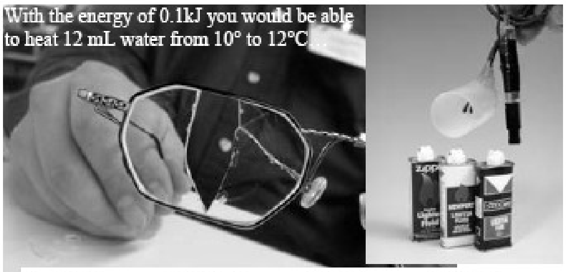

Lighter fuel in a Fuji film can
CHEMIE &Schule
1 film can (Fuji-RD-colour slides), 1 piezoelectric ignition device, electricity wire, hot glue gun, Zippo
ZIPPO boiling range: 113-133 °C (mainly octane)
octane: LEL: 0.8 %vol, HEL: 6.5 %vol
Vapour pressure of octane: 0.0147 bar
1 C8H18 + 12,5 O2 → 8 CO2 + 9 H2O
FEUERZEUGBENZIN IM ARBEITSTAKT
LEHRAMTSSTUDIUM CHEMIE
WÄRMEENERGIE DURCH ADSORPTION
V.O.


ZIPPO-Explosion limit in a film can
Volume of the film can = 33 cm3
Air pressure = 1 bar
78 % N2
(partial pressure = 0.78 bar)
Partial volume = 33cm3 x 0.78
21 % O2
(partial pressure = 0.21 bar)
partial volume = 33cm3 x 0.21 = 6.9 cm3
V.O


OCTANE Explosion Limit in a Film Can
P(OCTAN) = 0.0147 bar
P(AIR) = 1.00 bar
P(TOTAL) = 1.0147 bar
Vol O2 = 6.9 cm3
Vol C8H18 = x cm3
x: 0.0147 = 33 : 1.0147 x = 0.5 cm3
0.5 cm3 C8H18 : 6.9 cm3 O2 = 1 : 14
33 : 100 = 0.5 : x x = 1.5 Vol%
V.O



Nikolaus August Otto (1832-1891)
Otto´s 4 stroke engine
Patent 1877



$$1\ C_8H_{18} + 12{,}5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$$

$0{,}5\ cm^3\ C_8H_{18} : 6{,}9\ cm^3\ O_2 = 1 : 14$

$\Delta H_R = \Sigma\ \Delta H_f$ (products) - $\Sigma\ \Delta H_f$ (reactants)

$\Delta H_R = [8\cdot(-393kJ) + 9\cdot(-242kJ)] - [(-250\ kJ)] = -5072$ kJ/Mol

$0.5cm^3\ C_8H_{18} = 0.2\cdot10^{-5}$ Mol which gives: $\Delta H_R = -\ 0.1$ kJ

Tab. 1

sample		air %	ethane %	propan %	isobutan %	butane %	isopentan %	pentan %	Total pressures (bar)	
									calcu-lation	determi-nation
1	Sarome	5,8	2,6	27,2	19,9	33,6	9,1	1,7	5,36	5,3
2	Clipper	2,5	2,0	27,7	25,2	41,3	1,2	-	4,87	4,7
3	Esso	4,6	2,5	25,7	34,4	32,8	-	-	5,17	5,1
4	StarDust	4,0	2,3	25,3	24,8	39,5	0,9	3,2	4,76	4,6
5	Golf	2,6		8,4	29.3	53.5	6,2	-	3,59	3,5
6	Flame	9,0		26,9	23,6	33,4	6,2	0,8	-	5,9
7	Hadson	7,4	2,3	18,1	30,8	36,8	4,8	-	4,31	4,3

Tab. 2

sample		density of the sample at 26°C (g/100ml)	
		calculation	determination
1	Sarome	0,216	0,20
2	Clipper	0,212	0,22
3	Esso	0,213	0,22
4	StarDust	0,216	0,22
5	Golf	0,231	0,23
6	Flame	0,214	0,21
7	Hadson	0,242	0,23

Lighter gas

Boiling temperature of isobutane

LIKE DISSOLVES LIKE – the butane fountain

The Element Makers: 6

Carl Gustav Mosander 10th September 1797 – 15th October 1858

Adrian Ryder tutorajr@gmail.com

Born in the sea-coast town of Kalmar, about 370 km south of Stockholm, on the tenth of September 1797, Mosander is credited with the discovery of Lanthanum (1839), (Atomic number = 57), Erbium (1843), (Atomic number = 68) and Terbium (1843), (Atomic number = 65). He died at Lovö, Stockholm County on the 15th of October 1858. His father Isak Mosander was a merchant sea-captain, who "volunteered" to serve as a navy captain during Sweden's war with Russia and who appears to have died in service in 1808 or early 1809. Isak had previously married Christina Maria Törnqvist and appears to have had but one child, Carl Gustav, the subject of this article.

Carl Gustav Mosander
http://de.wikipedia.org/wiki/Carl_Gustav_Mosander

Carl Gustav was educated in the early years by tutors and then in the local elementary school, but following Isak Mosander's death his mother moved to Stockholm in 1809, when Carl was twelve years of age. After three years of schooling there, in 1812, he became an apprentice at the Ugglan Pharmacy. Here Carl remained, taking his pharmacy examination in 1817, until 1820, when his desire to become more than a pharmacist saw him matriculate and enter the Korolinska Institute in Stockholm, opened in 1810, to study medicine. He graduated in 1825 with the degree of Master of Surgery but inspired by his chemistry professor, Berzelius, (see previous article in this series), remained at the Institute as assistant to Berzelius and as assistant in the mineralogical collection of the Swedish Museum of Natural History.

Sweden, at the time of Mosander's medical studies, had compulsory national military service, and Mosander used the time he had to serve in the army, in gaining practical surgical and medical experience as an army and navy doctor. The summer of 1820 he spent as a junior doctor aboard the 40 gun, 154-foot frigate Fröja. The following summer of 1821 saw him spend five months as an army doctor with the Ålem garrison, 24 km north of his birth town of Kalmar, a position he returned to from January to May 1822.

Mosander's time as an army/naval doctor put him off following medicine as a life career and he found himself more drawn to the world of chemistry. In 1826, when put in charge of the chemical laboratory of the Institute, Mosander finally turned his back on medicine and embraced the world of chemistry. Mosander's appointment freed Berzelius from many of the routine matters of the Institute, and in giving lectures, when Berzelius was engaged elsewhere. It gained Mosander much practical experience and the life-long friendship of the great man. In 1828 Mosander was appointed Curator of the mineralogical collection of the Swedish Museum of Natural History, a post which allowed him to continue as chemistry assistant in the Institute. In 1829 the position of assistant in pharmacy was added to his duties. From this time Mosander began taking over virtually all the chemical classes of Berzelius and when, in 1832, Berzelius gave up his position at the Institute to concentrate on his work at the Academy of Sciences, where he was the permanent Secretary, Berzelius's esteem of Mosander's scientific technique was such that he made sure that the vacant Professorial position in the Institute was placed in Mosander's hands, temporarily at first but as full Professor in 1836.

On the 20th of December 1832 Mosander married Helda Philippina Forsström, with the union producing four children, two sets of twins, Carl Jacob (16th October 1833 – 3rd March 1852), Gustav Adolf (16th October 1833 – 29th November 1833) and Edgar (16th April 1836 – 19th Sept 1839), Hulda Elisabeth Constance (16th April 1836 -). Hulda was to marry Richard Pegott Beamish, a captain in the Irish Artillery and was his only child to survive Mosander.

From his first days at the Institute Mosander fell under the influence of Berzelius and this blossomed into a strong life-long friendship. This was to be reinforced by the pair living for years in the same house belonging to the Academy at Drottninggation, in the centre of Stockholm, where they had daily contact with each other. Later on, after his marriage, Mosander moved to an apartment beside the geological collection that he tended. Whereas Berzelius was outgoing and published widely, Mosander was cautious and published little, and only five major papers are recorded, and these only after pressure was exerted by Berzelius. Berzelius and their mutual German friend Friedrich Wöhler (1800-1882) used to tease Mosander about his caution, calling him "Father Moses" and much of Mosander's findings were only promulgated when Berzelius took over and saw to their publication. Friedrich Wöhler is the chemist whose synthesis of urea in 1828 changed the direction of organic chemistry, by showing that a 'vital force' was not necessary for these compounds. Wöhler's friendship with Berzelius and Mosander stemmed from his studies under them as a student.

Berzelius had discovered the element Cerium (Atomic number = 58) in 1804 in the mineral cerite and in 1825, shortly after Mosander had joined him, asked the latter to undergo another study of the mineral from which the original discovery was made. This Mosander did and in 1827 he isolated an impure powdered form of the element, by reduction of the cerium oxide with potassium and hydrogen. During the course of the work Mosander began to think that something else, as yet undiscovered, remained in the residues from the extraction of the cerium oxide and began a long, laborious set of extractions by fractional crystallation, to try and bring to light the suspected hidden elements.

The years passed with no notable success apart from Mosander's skills in extraction improving, but finally, in January 1839 he discovered a second element in the impure cerium oxide, by heating with hot dilute nitric acid and crystallising the product. Berzelius suggested the name lanthanum (Greek, *Lanthano* = to hide or escape notice), for the element since it had escaped notice for 36 years and Mosander accepted the name. The pure form of the element was not isolated until 1923. In this same year, 1839, one of Mosander's students, Axel Erdmann, discovered a previously unknown mineral in Norway, which he named mosandrite in honour of his illustrious teacher.

Still Mosander was not satisfied that all the elements had been found in the ore and he continued the search. His work on this subject was hindered by the time he had to invest in a mineral water business that he had undertaken. Drinking the waters at mineral spas was all the rage in the nineteenth century in many countries. Often the spa would be a considerable distance from where people lived and also winter weather greatly hindered travel. Various chemists produced artificial mineral waters and sold these in flasks or barrels for the use of people at home. Mosander's mineral water plant was one of these and since each batch had to be analysed for purity, his time for research was limited. The employment of students for this task eased his involvement and gave the students pocket money and valuable work and laboratory experience. Indeed one of his students, Victor Hartwell, was recommended by Berzelius to spend a spa season in Odessa, where he was to train people in the production of the artificial waters. In spite of these work 'asides', Mosander was not idle in the search for a new element. In 1842 he was able to announce the new element that he called Didymium, from the Greek *didumos*, a twin. His choice of name led to his being teased by Wöhler and Berzelius, with the pair gently teasing him of trying to immortalise his own twins, one of each pair having died by then. Whether or not Mosander was thinking of his dead children was not to matter and the name stuck. It turned out later, in 1885, that this 'element' was separated into two elements by the Austrian Chemist Carl Auer von Welsbach (1858-1929), which were called praseodymium (green twin) and neodymium (new twin). The element did indeed turn out to be a 'twin'!

In the autumn of the year Mosander turned to an element discovered by the Finnish chemist Johan Gadolin (1760 - 1852) in 1794. The element had been found in a mineral called ytterbite, later renamed gadolinite to honour Gadolin. Mosander suspected that the mineral might yield more elements. Again by fractional crystallisation he seperated three oxides from the ore. The first, a colourless oxide contained Gadolin's element yttrium; the second, a yellow compound he found to contain a new element which he called erbium; and the third a rosy compound, which contained another new element, which he called terbium. Mosander decided on the names by splitting the name Ytterby, the area where the ore was originally found in 1787, in three, Ytt, Terb and Erb giving the little town of Ytterby its own place in the history of science.

Later investigations into the new elements in 1860 resulted in the names of erbium and terbium being switched, however the existence of the elements were confirmed. Thus Mosander discovered three elements and narrowly missed two others. Mosander died the year before Robert Bunsen (No. 5 of this series) produced the first spectroscope, which was to be a deciding factor in the discovery of new elements. Had Mosander had this instrument at his disposal he would not have missed the two didymium elements.

Berzelius announced the discoveries in his Annual Report for 1842, which was published in April 1843, and the discoveries were announced to the English-speaking countries at the annual meeting in Cork, Ireland, of the British Association in August 1843, where Mosander's brother in law read the paper.

Mosander did not publish any lengthy papers, and those papers he did publish were usually just two pages in length, with some few running to seven pages. His first paper concerned the coating found on iron when heated. Between 1825 and 1826 he had six publications on this subject, where he showed that the coating was not a single compound, but rather was a mix of various iron oxides. Overall he published some 135 'notes', many on mineralogical results but some 50 were on pharmaceutical topics including the use of opium, creosote, atropine and aldehydes. In Chemistry he published notes on his discovery of the three elements and among other chemical notes was one on "a simple mode of preparing anhydrous sulphuric acid". In 1849 on the death of Berzelius he wrote the Obituary for his long-term friend.

Mosander was a painstaking analytical chemist and not an instrument of change or indeed a person who advanced the theory of chemistry. Sweden had an immense richness of mines and the mine owners sought those capable of analyzing the ores extracted form the mines, looking for quality control and the identification of the new materials being discovered. Tedious repetition was the forté of the Swedish chemist ,with time-honoured methodology being prized and the invention of new processes being shunned. Mosander's discovery of the elements was due to years of tedious analysis and his strength was the ability to differentiate between very similar compounds. However, he lacked the genius of his mentor Berzelius and, apart from his elemental discoveries, added virtually nothing to the advancement of chemistry. Some will argue that the demise of Sweden as a world power in chemistry coincided with the life of Mosander.

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□

Conference and Course Reports

ISTA Conference, Limerick 20-22 March 2009 - a photo report

The main entrance at UL and the ISTA banner

This year's ISTA conference was held at the University of Limerick and the Strand Hotel. Due to the closure of the Castletroy Park Hotel a few weeks before the conference, the committee had to find a new venue in a hurry. They found an excellent hotel in the centre of town, with the bonus of having the banquet in Thomond Park, looking out over the hallowed turf, on the night of the Grand Slam victory! Despite the tight economic situation there was still a good turnout with over 200 teachers attending and a total attendance of ~300. The University venue was excellent as most things were on the same floor and the exhibition was right in the centre of the conference activities. The Friday night lecture by Bob O'Brien on Forensic Science was excellent, as was the meal that followed and the free bar thanks to Shaw Scientific, who were celebrating their 40th. anniversary.

Steve Spangler and sons in action with the Mentos and diet coke demonstration

There was a full programme of lectures, often with 4 parallel sessions. There was one plenary lecture on the Large Hadron Collider by Ronan McNulty from UCD, and the two demonstration lectures by Peter Douglas (on chemistry and light, see front cover) and Steve Spangler were excellent, and were both run twice.

Rockets are go at the rocket making workshop

On Saturday afternoon there were a series of workshops, several run by a large team from Beyond Benign, sponsored by Pfizer, on green chemistry and forensic science. There was also a workshop on technical tips for teachers and one on making rockets. A SLSS biology session was running in parallel with the workshops and, as they were giving out free materials, this drew a large audience and unfortunately sucked people away from the workshops.

Part of the exhibition area at UL

The local organising committee was chaired by Diane Condon (Ard Scoil Ris), with a mix of local teachers and people from UL and LIT. There were also a good number of young teachers on the committee, which bodes well for the future. Limerick County Council provided free 'green' canvas bags for all the goodies.

Snap! The chemical twins at the Strand Hotel (aka Declan Kennedy and Peter Childs)

The conference was only possible with the generous sponsorship of many organisations, and sadly the 2010 conference in Sligo is going to find things much tougher as many bodies have withdrawn their sponsorship. Discover Science Engineering has withdrawn all sponsorship from April 2009.

The view from the banquet suite at Thomond Park - a night to remember

At the banquet on Saturday night in Thomond Park there were many presentations. Matt Moran of Pharmachemical Ireland took over from Karla Lawless (BASF) as President. Oliver Ryan was on fine form as he presented Mary Lee (SLSS) with the Science Teacher of the Year award. The Pharmachemical Ireland awards to New Science Teachers were presented to 9 teachers (see p.6). Peter Childs was given lifetime membership of the ISTA and a glass bowl for his contributions over many years, and he and his family were guests of honour at the banquet.

Diane Condon (Chair, organising committee), John Lucey (Chair, ISTA) and Karal Lawless (outgoing President) sort out a tricky point

The exhibition went very well on Saturday with a lot of exhibitors in the canteen area.

Helen Fitzgerald on the NCE-MSTL stand

The photochemistry lecture by Peter Douglas was spectacular!

Chemical and mining news

Compiled by Marie Walsh, Limerick Institute of Technology

GSK and Pfizer pool resources for new strategy on HIV drugs

Financial Times **17/04/09**

In a move that has been labelled as "industry-shifting", the pharmaceutical companies GlaxoSmithKline (GSK) and Pfizer are set to create a new company to jointly market and develop their HIV drugs. The formation of the new company will lead to annual cost savings of £60 million, command existing annual sales of £1.6 billion, and allow the pooling of scientific efforts. The development of six new drugs is already planned.

*****

Drug patent pools start to take shape

Nature **02/04/09**

In an effort to enhance research into neglected diseases, the pharmaceutical company GlaxoSmithKline (GSK) has announced that it is to put 500 of its existing patents, along with 300 pending applications, into a 'patent pool' for other companies to access and exploit. There have been calls for the rest of the pharmaceutical industry to follow this lead and submit their own patents into the GSK pool, or another one established by UNITAID for AIDS drugs.

*****

Merck strengthens drug pipeline in rival takeover

The Economist 14/03/09

In the latest of a series of such deals in the pharmaceutical industry, Merck is to enhance its drug-development pipeline with the acquisition of rival company Schering-Plough in a $41 billion takeover.

*****

Pfizer sale may lead to 150 job losses

Irish Times **12/12/08**

As many as 150 jobs could be lost following the sale by Pfizer of its Loughbeg site in Cork to a Portuguese pharmaceutical company. The deal is due to be completed by early April and will see 70-80 of the existing 232 staff transfer to the new owners, Hovione. Pfizer, which employs 2,300 people in Ireland, announced in February 2007 that it was closing its Ringaskiddy plant and putting its Little Island and Loughbeg plants up for sale following a global review of its operations. Hovione, which specializes in the manufacture of active pharmaceutical ingredients (API), were to acquire the Loughbeg facility in April 2009. The announcement follows an extensive sales effort over the past 20 months which included numerous site visits.

*****

New vaccine to be manufactured at *Wyeth plant in Dublin*

Irish Times **12/12/08**

Wyeth Ireland announced that it is to manufacture a new vaccine at its Grange Castle plant for worldwide distribution. The vaccine has been developed for protection of children against life-threatening diseases including pneumococcal meningitis, septicaemia and pneumonia.

*****

Jobs lost as workers face cuts in pay

Irish Times **01/04/09**

Drug manufacturer Schering Plough announced the loss of 240 jobs with the closure of its animal health products plant in Bray, Co Wicklow, by 2011. General manager Pat Kerr said the company regretted the impact the decision would have on workers and their families. "We will do everything we can to support people, with career advice and personal counselling. The planned closure date is by mid-2011 and we do not anticipate redundancies in the coming 12 months or so," he said. "The decision announced today is a direct result of global over-capacity and is no reflection on the employees here in Bray." Schering-Plough is currently in the process of being taken over by rival Merck.

*****

Up to 6,000 jobs set for Science Park

Irish Times **13/02/09**

Up to 6,000 high-end jobs could be created by an ambitious Silicon Valley-style innovation and research campus to be built in Cork. Details of Ireland's first 'science park', to be built on the outskirts of the city, which has been announced by the county manager, Martin Riordan. Based on the concept behind California's Silicon Valley, the Cork Science and Innovation Park is designed to attract world class researchers, entrepreneurs, innovators and investors, and is being backed by the county council, UCC, CIT, Enterprise Ireland and the IDA.

*****

150 jobs to go at Clare industrial diamonds plant

Irish Times **03/12/08**

Element Six (formerly De Beers Industrial Diamonds), the Shannon-based company, confirmed that it is to cut its workforce by a quarter by making 150 staff redundant before the end of the year in its second "group-wide cost-saving

programme" in just two years. The company manufactures and distributes industrial diamonds and super-hard materials and it products are mainly used in the manufacture of tools for such applications as drilling, sawing, cutting, grinding and polishing of different materials.
Company general manager at Shannon, Ken Sullivan said: "Our major customers include those in construction, automotive, general engineering and the drilling for oil and gas. All of these are caught up in the downturn in global business. In some sectors, sales are running as low as 50 per cent of what we would have expected a few weeks ago." Element 6, which was established in the Shannon Free Zone in 1960 as De Beers, employs 620 people including about 120 part-time staff. The company is co-owned by South African diamond giant De Beers and Belgian company Umicore.

*****

Trade surplus up 14%

***Irish Times* 28/03/09**

Ireland's trade surplus rose 14 per cent in 2008 to a four-year high of €29.2 billion, largely due to a decline in the value of imports, according to Central Statistics Office (CSO) data. For the year, imports were 10 per cent down at €56.9 billion compared with 2007. On the export side the annual decline was 3 per cent to €86.2 billion.
The chemicals sector, which includes the pharmaceutical and fine chemicals industry, accounted for almost half of all merchandise exports last year. Foreign-owned high technology sectors were the dominant sources of merchandise export activity during 2008. Most notable of such sectors was the performance of the broad chemicals industry.

*****

Kilkenny mines made €22m profit in 2007

***Irish Times Business* 20/02/09**

Galmoy Mines Ltd., the Kilkenny-based mining company that has made 221 workers redundant with the closure of Galmoy mines recorded pretax profits of €22.2 million to the end of 2007. According to accounts recently returned to the Companies Office, Galmoy Mines Ltd recorded almost half of the pretax profits of €43 million recorded in 2006. The workers at Galmoy – 105 of whom work in the mines – were told in January that the operations at the zinc mines are to cease completely this May. Originally management at the plant announced last September that the mine would be wound down on a phased basis by July 2011.
The viability of the Galmoy mines – which are owned by the Canadian-based Lundin Mining Corporation – is directly related to the price of zinc. In November 2006, the market peaked and a tonne of zinc was selling for $4,580. However, in recent weeks, the price has fallen to less than one-third of this figure – $1,300.

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Environment, Food, Health & Energy News

Compiled by Marie Walsh, Limerick Institute of technology

Energy research centre gets €5m

***Irish Times* 03/01/09**

A new energy research centre at NUI Galway has secured €5 million in initial funding for its work. Up to 20 posts will be filled this year at the centre, which aims to become a hub for energy research and development in the State. It also aims to become an international centre for excellence, NUI Galway (NUIG) says.
Researchers from Teagasc, the Marine Institute, partner universities and other international bodies will collaborate with the centre, directed by Prof Vincent O'Flaherty. It is based in the university's Environmental Change Institute, to which more than 100 researchers in college are affiliated.
The initiative will build on NUIG's reputation in bio-energy, energy efficient technologies, renewable resources and energy policy. Potential for new approaches extends from electricity-producing micro-organisms to smarter wind power, Prof O'Flaherty says.
Last year, Minister for Energy Eamon Ryan initiated a €26 million ocean energy programme, but the outgoing US ambassador to Ireland, Thomas C Foley, was among those critical of the slow pace of development. He said the west coast could be the location for a technological cluster which would attract investment. Ireland's natural advantage, due to latitude, weather, Atlantic location and current sources of fossil-fuel-based electrical power, gave it a distinct economic fillip, Mr Foley said.
Late last year, a new Oireachtas sub-committee was established to create jobs through the use of renewable energy resources. Its remit is to focus on opportunities for renewable energy projects in rural and undeveloped areas of the State. Dundalk Institute of Technology's Centre for Renewable Energy was one of the first groups to address the new sub-committee.

*****

57 MW wind farm in Macroom

Irish Times 10/12/08

Ulster Bank is leading a €100 million fundraising drive for a wind farm that the developers say will provide electricity for up to 30,000 homes. Green Energy Company Ltd is developing a 57 megawatt (MW) wind farm close to Macroom, Co Cork. The project has a licence from national electricity grid operator Eirgrid and is scheduled to begin generating electricity in 2012.

The cost of such projects runs at roughly €2 million a megawatt. Green Energy Company is seeking to raise €100 million to fund the development. Green Energy has already ordered 19 wind turbines from Danish manufacturer Vestas, which will have the capacity to generate 3MW of electricity each.

The Green Energy Company is one of a large number that have had projects in the pipeline for the last three years. The Irish national grid now supports wind farms with the capacity to generate more than 1,000MW of electricity. Ultimately, the Commission for Energy Regulation intends licensing farms with the capacity to generate close to 6,000MW by 2020. It is about to embark on a new licensing round, known as gate three, which will open the system up to a further 3,900MW.

Two previous rounds gave permits to close to 2,000mw worth of projects. The Republic is committed to generating one-third of its electricity needs from renewable sources by 2020. The State set the target to meet obligations to the EU and under international treaties.

*****

EPA grants licence for *€250m incinerator*

Irish Times 03/12/09

After more than 10 years €250 million Poolbeg incinerator has been granted an operating licence by the Environmental Protection Agency (EPA). The plant, which is set to be one of the largest municipal waste incinerators in Europe, has been granted a licence to burn 600,000 tonnes of waste annually by Dublin City Council. This includes up to 80,000 tonnes of sewage sludge not sanctioned for processing at the plant by An Bord Pleanála. The licence also frees the council from having to pre-sort the waste using mechanical biological treatment (MBT), a waste management process favoured by Minister for the Environment John Gormley.

The EPA decision is subject to more than 216 conditions relating to the environmental management, operation, control and monitoring of the facility. But it is understood that, despite the list of conditions - a number of which are likely to result in considerable extra cost - the council will be able to go ahead with the plant and expects construction to begin in the second half of 2009. The council was granted planning permission by An Bord Pleanála in November 2008. It was at the time one of the most controversial proposals to come before the board, attracting more than 2,500 objections.

Within days the EPA announced its intention to grant a licence to the council to operate the facility. Following objections the agency held a public hearing on its decision last April.

While the EPA has now confirmed its decision to grant a licence, it said that it had "strengthened" the approval with additional conditions which it said "take account of the concerns expressed at the oral hearing". The majority of these conditions relate to monitoring and testing of the environmental impact of the plant, rather than specific restrictions on the plant's activities. The EPA has put particular emphasis on the testing of the undiluted final effluent of the plant to ensure it is not harmful to fish.

One condition, which may have significant financial implications for the council, relates to the facility manager of the plant. The council had requested that this individual be a person with 10 years' experience in running power stations, but the agency has directed that the facility manager must have 10 years' experience in incinerator operation, leaving a smaller pool of experts from which to draw. The council has also been directed to assess the feasibility of transporting the bottom ash - residue left over after incineration - from the facility to Dublin Port for export using an enclosed continuous conveyor-belt system, rather than trucks. A report on this must be submitted to the EPA before the plant begins operating.

In what will be a particular blow to locals opposed to the plant, permission has been granted to burn sludge from the adjacent municipal sewage treatment plant. This has initially been set at a limit of 10,000 tonnes annually but may be increased to 80,000 on application to the EPA. The absence of MBT, which had been a condition in the draft licence, has been dropped from the final licence. This form of treatment was seen by objectors to the plant as a method of reducing waste, making a 600,000 tonne facility redundant.

Timeline

1997 : Dublin Regional Waste Management Plan identifies the need for a municipal waste incinerator for the greater Dublin area.

1998 : Dublin Regional Waste Management Plan sets out a target of 59 per cent recycling, 25 per cent thermal treatment and 16 per cent landfill.

1999 : Feasibility and siting studies begin.

2000 : The Poolbeg peninsula is identified as the best location for the incinerator.

2002 : Expressions of interest are sought to design, build and operate the incinerator.

2003 : Bids are submitted from a shortlist of five companies.

2005 : The contract is awarded to the Danish waste management company Elsam.

2006 : Elsam is taken over by Danish Oil and Natural Gas (Dong).

2007 : In February Dong and its American partner Coventa seek changes to the contract with Dublin City Council which almost causes the agreement to collapse.

The difficulties are later resolved and a new contract is signed in September. In November An Bord Pleanála grants planning permission.

2008 : In December Environmental Protection Agency grants a waste licence,

2009 : Work scheduled to begin in late autumn,

2012 : Incinerator scheduled for completion.

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Watery asteroids may explain why life is left-handed

***New Scientist* 16/03/09**

Soggy rocks hurtling through the solar system gave life on Earth an addiction to left-handed proteins, according to a new study. The research suggests that water on asteroids amplified left-handed amino acid molecules, making them dominate over their right-handed mirror images. Almost every living organism on Earth uses left-handed amino acids instead of their right-handed counterparts. In the 1990s, scientists found that meteorites contain up to 15% more of the left version too. That suggests space rocks bombarding the early Earth biased its chemistry so that life used left-handed amino acids instead of right.

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Energy network to heat 60,000 homes

***Irish Times* 27/11/08**

Geothermal Energy (GT Energy), a spin-off of civil engineering firm Liffey Developments, is spending €100 million on building a system that will use geothermal energy to provide heating and hot water to 60,000 homes. The company announced that it intends developing a district heating network on Dublin's south side in the first project of its kind in Ireland or Britain.

District heating is a system that distributes heat generated at a central location to homes and businesses in a particular area. GT Energy intends using geothermal energy, that is, heat which is naturally generated between 2,500m and 6,000m under the earth's surface, to power the system. Countries such as the US, Germany, France and Iceland are already successfully exploiting this. The company will invest €100 million in the project. The plans include building plants at Grangecastle, Newcastle and Tallaght, with work on the latter due to begin in 2009.

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Power plant poses no health risk, says firm

***Irish Times* 30/03/09**

Joe Hodgins, former manager of ESB's Moneypoint coal-fired power station, and currently the developer of a 200 megawatt (MW) gas turbine power station proposed for east Galway says the project will not pose a health risk to local residents and will be environmentally sustainable. He was responding to fears voiced by over 200 schoolchildren, teachers and parents at a protest outside Galway County Council offices this week.

The "peaking" power plant is designed to work with wind energy in providing back-up supply when wind power is intermittent. Residents say the proposed plant poses a "risk to health, the environment, safety" and will cause "visual obtrusiveness, noise pollution, contamination of the ground and water supply". The residents' group, "People before Profit", argue that the proposed location for the plant is in a heavily-populated rural area, with 500 to 1,000 households and four primary schools in a three-mile radius. "The proposed site is to be located on agricultural land which has not been zoned for any type of development," the group said.

Mr Hodgins claimed the fears were groundless, and a voluntary public consultation had taken place last week in co-operation with the local development committee. "This is a new and more efficient design of plant, run on natural gas, which will not run when wind energy is being fed into the grid," he said. "In this way, it will actually contribute to a reduction in emissions nationally." The company's plans were in the early stages, he said, as an integrated pollution prevention control would have to be applied for from the EPA if planning permission was granted. A grid connection had been applied for, he said. "We would be very happy to work with the local community on this project," he added.

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IFA says 8,000 'green collar' jobs possible

***Irish Times* 21/01/09**

The Irish Farmers' Association (IFA) has claimed that 8,000 "green collar" jobs could be created by developing the renewable energy sector in wind power and biomass. The IFA told an Oireachtas subcommittee meeting that it had identified 6,000 locations where farmers could establish micro-wind turbines that would generate enough electricity to power 32,000 households.

Seán O'Leary, who leads the association's project team on climate change, told the subcommittee the sites would not be visually intrusive and would reduce imported fuel costs on farms. "These turbines have the capacity to drive down on-farm fossil fuel use and to deliver

enough electricity to meet the demands of 32,000 households each year," he said.
"They would also reduce greenhouse gas emissions by over 2 million tonnes of CO_2 equivalent, over the expected service life of the wind turbines," he told the subcommittee which is part of the Committee on Enterprise, Trade and Employment. "This micro-energy strategy provides a significant opportunity for farmers to consider renewable electric farm machinery into the future which could create up to 3,000 jobs." He called for a stimulus package to maximise the opportunities in the renewable sector. These would include changes in planning regulations and an increase in what farmers would be paid for the electricity generated.

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Ban on use of sunbeds for children closer

***Irish Times* 13/10/09**

A ban on the use of sunbeds by under 18-year-olds has moved a step closer with the Department of Health planning to meet interested parties in the coming weeks before it finalises legislation providing for the ban.
In recent months the department received 18 submissions in a public consultation on proposed legislation to regulate the use of the artificial tanning machines. The majority of submissions sought a ban on the use of sunbeds by under 18-year-olds.
Submissions also addressed areas such as restrictions on the sale and rental of sunbeds and the need for supervision in places where tanning services were offered. Warning labels on sunbeds and in places offering tanning services were also called for. The Environmental Health Officers Association has previously expressed concern at the increase in the number of tanning outlets in places such as video stores and health centres. The new regulations will also address the need for exemptions for medical use. The medically-supervised use of sun lamps is sometimes used for certain skin conditions such as dermatitis and psoriasis.
There is growing evidence that the ultra-violet (UV) radiation emitted by sunbed bulbs may damage the skin and increase the risk of developing skin cancer. One in every three cancers diagnosed worldwide is a skin cancer and most of them are attributed to over-exposure to natural UV radiation.
An International Agency for Research into Cancer report published last year found that people who started using sunbeds under the age of 35 increased their risk of malignant melanoma by 75 per cent. The sunbed consultation was introduced by Minister for Health Mary Harney in May after she expressed concern about the dangers of exposing children to ultra-violet rays from sunbeds. She said she had come across young children who were using sunbeds to get a tan for their First Communion. One survey by the Irish Cancer Society found that 6 per cent of under-15year-olds had used sunbeds.
The World Health Organisation (WHO) has encouraged governments to introduce legislation governing their use.
The WHO has also highlighted the need to restrict their use by under 18-year-olds and to ban unsupervised trained personnel.

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Making homes energy efficient could create 7,000 jobs

***Irish Times* 13/02/09**

Meeting modern energy-efficiency standards in Irish homes could generate €600 million a year and create 7,000 sustainable jobs, according to new research from DKM Economic Consultants.
The research, which was compiled for Engineers Ireland, found that meeting requirements of the 2007 building energy efficiency regulations would help the construction industry move to the "green economy", while at the same time providing a significant uplift for the industry in a time of need. Energy Minister, John Gormley said the recently announced incentives for insulation alone could save about €700 per annum for the average household in heating bill reductions and it was now clear that the green economy was part of the "smart economy".
From this year, new houses that come on the market require a building energy rating, and each second-hand house coming on the market will require a rating from 2010. The rating is estimated to cost on average €300 per existing dwelling and approximately €200 per new dwelling.
The research estimated that enabling new housing to meet the regulation will cost approximately €8,000 per dwelling, which will be built into the construction price.
Research has found that 68 per cent of engineers feel energy will be a key issue in the coming years, with a similar number saying the Government's green agenda would be very important to the industry.

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Lithium in water 'curbs' suicide

***BBC News* 01/05/09**

A Japanese study suggests that drinking water which contains the element lithium may reduce the risk of suicide. Researchers examined levels of lithium in drinking water and suicide rates in the prefecture of Oita, which has a population of more than one million. The suicide rate was significantly lower in those areas with the highest levels of the element, they wrote in the British Journal of Psychiatry. High doses of lithium are already used to treat serious mood disorders.

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