chem@cam

Chemistry at Cambridge Newsletter

Spring **2006**

The challenge of protein folding

Laser spectroscopy of surfaces

Free radicals in organic synthesis

Energy efficiency and climate change

Peter Spitz has spent his life in the chemical industry. He started out as a chemical engineer, and founded the consultancy Chem Systems, which was acquired by IBM in 1999. He continues to work as an advisor to chemical industry senior management, and spoke to Sarah Houlton about some of the current issues facing the sector

What scope is there with current technology for replacing petrochemicals with natural materials?

There has been a lot of talk about replacing petrochemical hydrocarbons with natural materials, particularly making polymers from starch and intermediates based on ingredients such as corn. Progress is being made, but it's going to be a very long, slow haul.

While a number of companies have said they intend to make more use of natural materials as feedstocks, it's going to take another couple of decades for this to take off. The impetus isn't going to be so much that it can save oil, it's more environmentally based. There will be enough oil for petrochemicals for a long, long time; the big replacement incentive is much more on the fuel side where a great deal of effort is being made with biodiesel and ethanol.

Is it mainly the big companies that are working in the area?

Yes, because it requires huge new investments without achieving breakthrough economics. But many chemical companies have said – and I believe they mean it – that they're in favour of sustainable development. There's a PR aspect. I'm not cynical about their motives, though. I just think companies have to be economically driven, regardless of whether they are altruistically inclined or not.

I think most processes using natural raw materials are more complicated or less direct, for example fermentation. There are a number of products that have been made from natural materials for a long time, such as citric acid and high fructose corn syrup plus, of course, ethanol but, in general, processes are not that economical, and difficult to scale up.

In what other ways can companies address the bad image of the chemical industry?

I don't think there are any easy answers. A lot of money has been spent by industry organisations such as Cefic in Europe and the American Chemistry Council (ACC) in the US to improve the industry's image. I think the problem is that whenever they think they've gained a little PR ground, there's another explosion or revelation of people being adversely affected by some chemical.

It's impossible to avoid this sort of bad PR, and I don't see how companies will ever completely avoid it it – so they just have to live with it. The problem is that when it is translated into proposed action (or overreaction) by government bodies, it creates an enormous problem for the chemical industry. The original proposals of the European chemicals evaluation and testing programme, Reach, would have been extremely costly, almost prohibitively so, and fortunately the proposed testing requirements have been cut back.

The industry associations try to do their best to educate the public with examples, and I think it helps a lot. The American Plastics Council ran a wonderful campaign several years ago on the basis of 'Plastics make it possible', which improved that industry's perception by the public substantially. Industry has to figure out how to best present their positive contribution to society to the public. I think the better a job they do there, the better the image is going to be. They just haven't done the best job so far.

Are they getting better?

The recent campaign started by the ACC, I think, is a lot better than what it has done in the past – it does a good job of presenting to the public how chemicals are necessary to shape their lives, and how people can't do without them. I think the next step will have to be advertising by industry groups to try and get people to buy into the facts.

They have to understand that, like any industry, the chemical sector is subject to certain hazards which are outweighed by the good that they enjoy every day from the products it makes. That's going to be difficult, but we have to continue to try and educate the public.

What will the long term consequences be if they fail?

I think there will be more banning of certain products, some justified but not necessarily a good thing in all cases. There is a lot of evidence to suggest that when DDT was completely phased out, it led to a huge increase in the incidence of malaria in Africa and Asia, and there are now second thoughts about whether it was a good idea, but it was done.

Now Greenpeace and some of the more extreme environmental groups have proposed the elimination of chlorine, which would be disastrous. Chlorine is essential for purifying drinking water. People say it could be replaced with ozone, but that would be tremendously expensive, and ozone only persists for a short time and does not inhibit bacterial growth in the pipes downstream of the treatment plant. When the consequences are properly considered, a ban would make no sense at all.

The chemical industry has changed greatly since you began your career. Why is industrial chemistry still an attractive career option?

When I graduated, industrial chemistry was glamorous. Petrochemicals were growing rapidly, with many new inventions being made. Now the industry is mature, and image problems and a lack of seemingly exciting new developments make industrial chemistry of less interest to graduate students who are more likely to choose areas like pharmaceuticals, biochemistry or nanomaterials.

To me, the exciting part of the chemical industry was taking an invention from the lab to a commercial plant, making the product for a dollar a kilo rather than the thousands of dollars it would cost in a test-tube. That opportunity still exists. It's still thrilling to walk through a large chemical plant and realise a product is being made there on a hundred million pound a year scale. There's an excitement being in a large chemical plant I think can't be matched anywhere else in industry.

CV Peter Spitz

Born: Vienna, Austria

Education: Peter attended schools in Austria and France, high school at Germantown Friends School in Philadelphia, and graduated in chemical engineering from MIT.

Career: After several years at Esso Engineering, he joined Scientific Design Company where he was in charge of designing and starting up new petrochemical plants. He left to found Chem Systems, a management consulting firm that eventually had offices in New York, London, Paris, Tokyo and Bangkok. More recently, Peter founded a strategy boutique in partnership with other consultants, which has among its clients some of the largest multinational chemical firms andmerchant banks.

Interests: Author of two books on the chemical industry. He is a founding member of Chemical Heritage Foundation, which is involved with the history of chemistry from alchemy to the present. Peter is also an avid skier and golfer.

Did you know? Peter and wife Hilda have three sons, all with MBAs from highly-rated universities, who are respectively a chief financial officer of a large firm, a high yield bond analyst and an investment banker. Still, Peter says, it's not yet time to retire.

Dear Editor,
The letter from Antony Barrington Brown (*Chem@Cam* 25) rang a bell with me as I was probably a contemporary of his (I regret to say that I cannot remember him after all these years).

I well remember Dr Saunders' remark [that it's both the malodorous element in human excrement, and the strawberry flavour in strawberry ice-cream],

and I have not forgotten the commercial use of Skatole since then. In fact, I have used the fact several times over the years to shock people who like strawberry ice-cream.

I wonder whether he, or any other undergraduates of that time, remembers another interesting phrase which I think Dr. Moelwyn Hughes used repeatedly in his lectures. Having outlined on the board a particular chemical reaction, he would elaborate by saying that the reaction proceeded 'extraordinarily readily'. One began to wait for the phrase every time, in case a particular reaction was somewhat reluctant!

Yours sincerely,
Keith Parsons
Solihull, West Midlands

Footballs and atoms

Dear Editor,
As chemistry gets more and more specialised I had been considering dropping *Chem@Cam*. Fortunately you have now published some delightful contributions from Vincent Gray and Antony Barrington Brown.

I did not meet Vincent at Emmanuel because I spent several years swanning around the smouldering wreck of the Drittes Reich. We did work together on coal during which he imparted his considerable skills in colloid science. After he left, I did some work on the high temperature flash pyrolysis of coal. I identified a form of carbon which formed deep violet solutions in certain solvents. I called this material 'atypical char'. My boss insisted it should be 'non-typical'. I reminded him of the editor if the Manchester Guardian who, in 1936, pronounced on 'television', 'The word is half Greek and half Latin – no good will come of it.'

Some years later, when I was working for an oil company, a physicist at Sussex university produced this soluble carbon. With the aid of a mass spectrometer and other equipment he showed it was made of two sizes of football molecules. I was glad he won a Nobel prize as no chemist would be fool enough to try dissolving carbon in a solvent.

I do remember Bernard Saunders telling us of his work on nerve gases, and how by 2pm he would have gone temporarily blind and have to go home.

Antony was responsible for the defining moment in my scientific career. B. Lythgoe was delivering a tedious lecture on unlikely organic reactions and had reached the contribution from a Dr. Lössen. Antony brightly called it the Dead Loss Rearrangement. I knew then that I would never be a narrow specialist chemist, but a generalist or even a polymath.

When I discovered it was easier to make money than work I entered on a new profession as a chartered layabout. I decided to endow some scholarships and wrote to *Chem@Cam* asking why scientists did PhDs. Despite reminders, I only received one charming letter from a non-doctorate. I instructed the trustees that awards should not be made to postgraduate students.

My most recent foray into science was when I wrote to David King at the DTI explaining why on thermodynamic grounds atomic power stations should not be built. Only the gullible fall for the CO_2 ploy. Moreover, no responsible industrialist would build and operate a plant producing an untreatable and highly toxic effluent.

I received a reply from a non-scientist DTI bureaucrat telling me King does not read letters (polymaths do) and giving me several dense paragraphs of Blairite spin on the Kyoto agreement.

What is sad is that the biggest sink for CO_2 is marine vegetation. This has a biomass many times greater than that of terrestrial vegetation. I have yet to meet a botanist with a deep understanding of diatoms and marine algae. Of course Nobel understood diatoms, which he used in dynamite and which formed the basis of his prize funds.

Yours sincerely,
John Mainhood
Tonbridge, Kent

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Chemistry at Cambridge Newsletter

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Sally Boss, a postdoc in Brian Johnson's group, at work in the third floor inorganic lab

Photograph:
John Holman and Nathan Pitt

This newsletter is published three times a year by the University of Cambridge Chemistry Department. Opinions are not necessarily those of the editor, the department, or the university.

Editor-in-Chief: Steve Ley
Editor: Sarah Houlton
Photographers:
John Holman, Nathan Pitt
Editorial Board:
Brian Crysell, Jonathan Goodman, Rosemary Ley, Jeremy Sanders

Address:
Chem@Cam, Department of Chemistry, University of Cambridge, Lensfield Road
Cambridge CB2 1EW
Phone: 01223 763865
Fax: 01223 336362
e-mail: news@ch.cam.ac.uk
website: www.ch.cam.ac.uk

This publication is supported by Cambridge University Press

£6m microdroplet funding boost

A collaboration led by Chris Abell has been awarded around £6 million in research grants to investigate microfluidic microdroplet reactors. Following on from £400k EPSRC Life Science interface platform grant last year, the bulk of the new money comes in the form of a £4.6 million Basic Technology grant from Research Councils UK. It will be backed up by a further 1.6 million NEST grant from the EU.

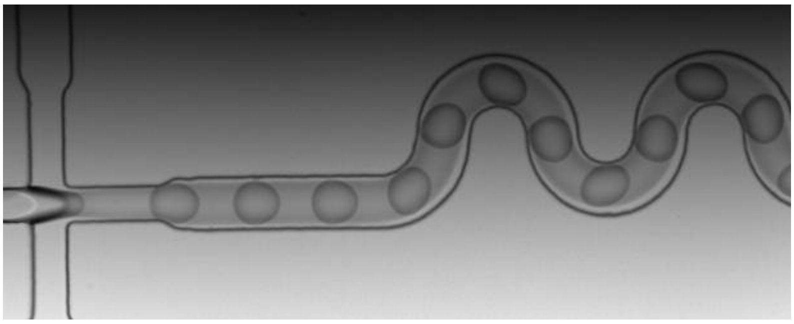
The large RCUK grant has been awarded to Chris, Wilhelm Huck and Carol Robinson here in the chemistry department, plus Florian Hollfelder in biochemistry and Andrew deMello at Imperial College in London.

The project is based on the fact that when water is mixed with oil to make an emulsion, it forms microdroplets of water within the oil. These tiny droplets can be used as miniature reactor cells, with a vast array of potential applications such as drug screening, catalyst development, studying protein–protein interactions and 'genome mining' to find novel enzyme catalysts.

The project is in two parts. First, the aim is to build devices that will enable the team to make the droplets, then manipulate and detect them. It will also fund a large amount of experimentation into carrying out science within the droplets, such as protein evolution. It will allow many experiments at an extremely small scale to be carried out very quickly.

Three PhD students are already working on the project, and 19 postdocs are being recruited, the majority of whom will be based here in Cambridge.

'It's a bit unreal!' says Chris. 'I've spent the past five or six years getting venture capital money to carry out big science. Now the government has given us the chance to do big science with research council money – it will be interesting to see how it goes!'



Microdroplets of water in oil can be used as miniature reactor cells

Library access expanded

Three important electronic resources are now available in the department library for the first time: SciFinder Scholar, and full electronic access to the entire journal archives of both the American Chemical Society and Elsevier journals via Science Direct.

Chemistry has funded university-wide access to SciFinder Scholar, a major resource from Chemical Abstracts that enables chemical data to be searched by structure, substructure and reaction, as well as name. It also allows bibliographic information to be searched. Training sessions are being organised to bring people up to speed with how the database works.

'It's something the department has been wanting for some time, but it's expensive,' says librarian Judith Battison. 'It has relevance to disciplines other than chemistry, however, and we're encouraging other departments to look at it as well, We hope it will be a university resource, not just for chemistry.'

The extension of access to the ACS archives now means the department has full online access to its full journal back files. This is being funded through the university's chemical, biological and medical coordinated journal purchasing scheme. The ScienceDirect access is a university library initiative. Previously, for both of these we only had electronic access to the most recent years; now all the journals are available back to volume 1.

Chris (left) shows off his white tie and fancy hat in Swedish newspaper *V sterbottens Folkblad*

Prizes for Chris

Chris Dobson has been busy picking up awards over the past few months. He recently collected the Royal Society's Davy Medal, and has been elected a Fellow of the Academy of Medical Sciences.

He was also awarded an honorary degree in medicine from the university of Umea in Sweden, and rather than robes, he was required to dress up in white tie, tails and a top hat for the ceremony.

Between all these, he's managed to fit a few lectures in. These include the Sir John Kendrew lecture at the Weizmann Institute in Israel and the William H. Stein memorial lecture at Rockefeller University. He also gave the 50th anniversary lecture of the International Union of Biochemistry and Molecular Biology.

Top download

Chris was one of the authors ofthe most downloaded paper from the *Journal of the American Chemical Society* last year.

The paper involves a combination of NMR experiments, plus theoretical techniques carried out by Michele Vendrusculo.

CRUK to fund medicinal PhDs

Cancer Research UK is putting £10 million into training new medicinal chemists, and about £3 million of that is coming to Cambridge. The rest is going to Oxford, Imperial, Edinburgh and Newcastle.

The plan is to train 60 new medicinal chemists over the next five years, 20 of them in Cambridge. Under principal investigator Shankar Balasubramanian, the students will spend the first year of their four-year programme taking taught courses. The remainder will consist of a research project with two supervisors, one in chemistry and the second in one of the other departments involved in the project – the MRC cancer cell unit, pharmacology, biochemistry and obstetrics & gynaecology.

The first students are being recruited now, to start this October.

More information can be found at www-medchem.ch.ac.uk

RSC landmark plaque unveiled

Photos: John Holman

RSC president Simon Campbell presents the historical plaque to Jeremy Sanders and Sandy Todd

The department is now the proud owner of a Historical Chemical Landmark plaque.

The plaque, on display in the main reception area, was unveiled in December in a ceremony following the Royal Society of Chemistry's nucleotide symposium celebrating the 50th anniversary of the seminal paper published by Michelson and Todd on the first chemical synthesis of a dinucleotide.

This is the 15th such plaque the RSC has awarded in the past five years, and celebrates the work of Lord Todd on dinucleotide synthesis.

The citation reads, 'Research in the department of chemistry at Cambridge over more than 50 years has established the structures and many principles of the synthesis of molecules that control the processes of life. Notably, Lord Alexander Todd FRS and his co-workers invented the chemical synthesis of nucleotides, which led to the elucidation of the chemical structure of DNA.'

The plaque was presented by the RSC's president Simon Campbell to head of department Jeremy Sanders, and Lord Todd's son, Sandy, following a talk on Todd's work by one of his former students, Dan Brown.

Many other luminaries in the DNA field were also present on the day, including Nobel prize winner Sydney Brenner, which gave Jeremy a great opportunity to add to his collection of photos with Nobel laureates!

Jeremy poses with Nobel prizewinner Sydney Brenner

Medal-winning undergrads

Every year, the Chemistry Olympiad is held in a different country, and the UK team meets up in Cambridge for pre-match training before the event. For Chris Kerr of Winchester College, this was a prelude to getting to know the place rather better, as he's now an undergraduate here.

Chris did really well, and won the UK's first gold medal since the Melbourne Olympiad in 1998. He also became the first UK student to take part in the Olympiad twice.

He isn't the only Olympiad alumnus in the first year here – Nicholas Sofroniew represented the US, and won a silver medal.

Teaching fellow Pete Wothers reports that preparations for this year's Olympiad in South Korea are well under way. Pete is involved in setting the examination paper that goes out to schools around the country.

'The photos were interesting to assemble,' he says. 'We had pictures of sherbet lemons and a cutaway catalytic converter thanks to the engineering department. I also headed out to Hangar 9 at Marshalls with photographer Nathan Pitt to take a picture of an oxygen generator that makes the air supply for aeroplanes.'

Finding a picture to illustrate a question about the synthesis of Viagra proved a little more difficult. Manufacturer Pfizer couldn't help because it would break strict rules about promoting licensed medicines. Pete's suggestion (a no left turn sign!) was vetoed in favour of a black blob saying 'Censored'.

■ The 2009 Olympiad is to be held here in Cambridge. It will be the first time it's been held in the UK since the event started in the 1960s.

Patriotic Chris shows off his gold medal

Generous bequest endows Brian's former chair

Thanks to a generous bequest, the chair recently vacated by Brian Johnson now has an endowment. The Moorehouse-Gibson chair is named for Geoffrey Moorehouse-Gibson, who was a student at Trinity College and the department in the late 1930s.

Geoffrey died some years ago, and on the death of his wife last year, the estate left a £2.6 million legacy to Trinity for the support of research in chemistry.

Trinity has donated £2 million of this to the university as part of the 800th anniversary campaign to establish the Geoffrey Moorehouse-Gibson chair in chemistry. It will generate an endowment for the benefit of the holder, and the recruitment process is under way.

■ Another professorial search is also under way – for a new 1920 professor of physical chemistry in succession to Dave King. Much of Dave's time these days is taken up with his work in government as chief science advisor, but he remains actively and enthusiastically engaged in his research.

JP's third edition

A new, completely revised, edition of Jean-Pierre Hansen and Ian McDonald's book, 'Theory of simple liquids', is about to hit the shops. Ian retired from the university in 1999, but popped in to see Jean-Pierre recently and our photographers were on hand to snap the pair of them with an advance copy of the tome.

The first edition came out in 1976 and the second in 1986, and the authors claim they've been working on the third for the best part of the past decade. 'When we wrote the first edition, it was a very new discipline, and few people worked in the field,' Jean-Pierre explains. 'Since then, the amount of work has grown rapidly, for two main reasons. Neutron beam scattering techniques can be used to see fluctuations in liquids at the scale of a few angstroms, and increases in computing power have made large scale simulations a possibility.'

The earlier editions are widely regarded as the standard text in the field of liquid state theory, and have more than 6,000 citations in the literature.

A simple liquid is one that is made up of fairly simple molecules – ironically, water isn't a simple liquid because of its hydrogen bonding. 'The second edition was 50% thicker than the first because interest in the field expanded so much,' Ian adds. 'We have cut it back for the third, and now include the basic concepts plus those recent developments we believe will be important, such as interfaces and supercooled liquids.' The concepts and techniques developed in the study of "simple" liquids are now being widely applied to complex fluids, including colloidal dispersions and polymer solutions.

Jean-Pierre claims that they may contemplate writing another book together, because they get on so well, having collaborated on research since the early 1970s when he was in France and Ian at Cambridge. 'However, it wouldn't be another text book – it would be something more pedagogical,' he says.

Photos: John Holman

Ian and Jean-Pierre: reunited in print

Schlumberger lecturer wows the crowds

This year's Schlumberger lecturer, Teresa Head-Gordon from the University of California at Berkeley, spoke to a packed house in February. The room wasn't just filled with chemists, though – she attracted an audience from all over Cambridge, including physicists, materials scientists and biologists.

She talked about the controversy concerning the structure of water. How many hydrogen bonds does each water molecule form? She has been working on spectroscopic and diffraction methods to find out, as well as theoretical simulations.

Teresa is spending a year in the department, along with her husband Martin, a distinguished quantum chemist who is also a professor at Berkeley.

Photo: Nathan Pitt

From the left: Demos Pafitis, head of research at Schlumberger in Cambridge, Teresa Head-Gordon and Jean-Pierre Hansen

Crystal prize for Graeme

Graeme Day has been chosen as the winner of this year's CCDC Young Scientist award from the British Crystallographic Association.

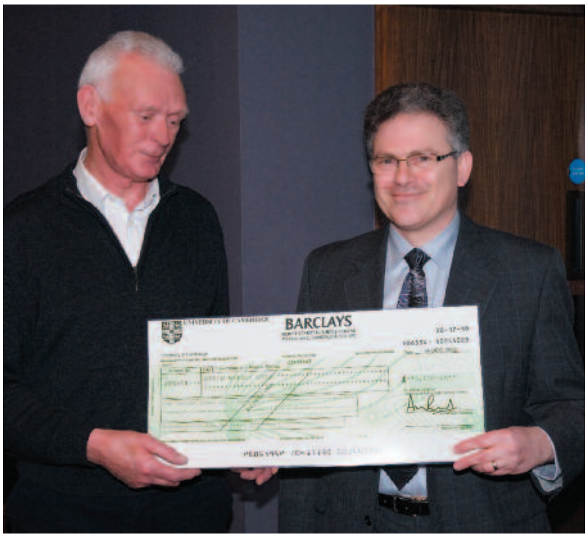
The award has been made in recognition of his 'outstanding work' in the field of crystal structure prediction, notably his recent research on the inclusion of dynamic effects in calculations.

It will be presented at the BCA's spring meeting in April, which is being held in Lancaster, and Graeme will have to give a lecture at the meeting.

'The email telling me about the award came completely out of the blue,' he says. 'It arrived on my birthday, and I didn't realise I was still young!'

Graeme's been a Royal Society research fellow in the department since October, following on from a postdoc with Bill Jones. He's originally from Halifax in Canada, and came to the UK for a PhD with Sally Price at UCL.

Graeme Day: delighted to receive the award



David receives his leaving cheque from head of department Jeremy Sanders, and poses with the 'SAS' who keep him in order – receptionist Sheila Bateman, secretary Anne Railton and technical assistant Sue Johnson

Photos: Nathan Pitt

End of an era as David retires

After an astonishing 47 years of continuous service here in chemistry, David Watson retired at Christmas.

He was initially appointed as a junior technician, and steadily rose through the ranks over the years, ultimately becoming secretary of the department of organic and inorganic chemistry in 1987. He was made the first secretary of the newly merged chemistry department in 1988.

Typically, David didn't want any fuss to mark the retirement, but of course he was never going to get away with that. Paying tribute during his annual pre-Christmas speech to staff, head of department Jeremy Sanders praised David's dedication, humanity and wisdom.

He highlighted David's two major achievements during his time in the department – the successful merging of the two separate chemistry departments, and then the management of more than £50 million of refurbishment work on the department since 1999.

Current and retired members of the department donated a total of more than £5,000 to his retirement present. This magnificent sum indicates the huge affection and respect felt for David by everyone in the department.

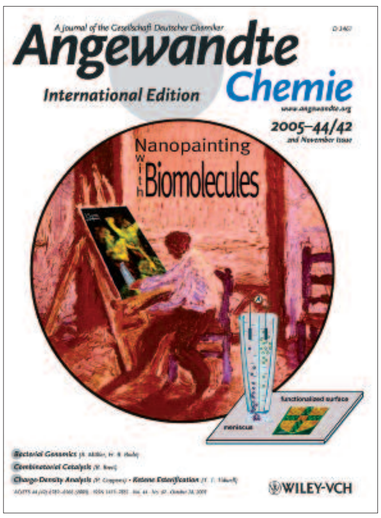
'Successive heads of department have relied for many years on David's intimate knowledge of the building, his appreciation of how chemists use (and abuse) laboratories and his sympathetic yet sometimes hard-nosed understanding of all the staff,' says Jeremy.

'He knows how to deal with requests, large and small, reasonable and unreasonable, in a way which was always friendly but firm. Without him, the department would have been a much less successful place.'

However, we've not seen the last of him just yet. While we recruit a new technical secretary, David has agreed to pop in for a couple of days a week as 'facilities consultant' to ensure the department continues to run smoothly in the interim.

'I thought about spending all my time on the golf course,' David says. 'But Jeremy asked me to come back to help out while the new secretary is recruited. How could I say no?'

Sue Johnson hands over his leaving card

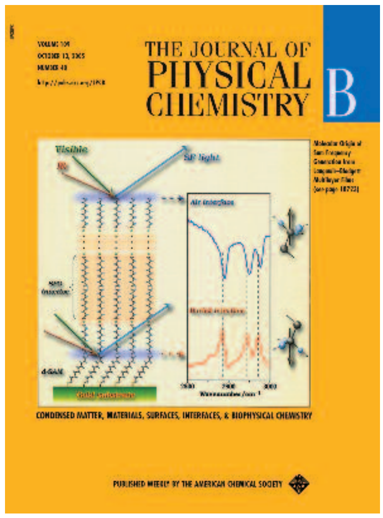


Physical covers

David Klenerman and Paul Davies have both had their work featured on the front covers of respected journals recently.

David's graced the front of *Angewandte Chemie* in November. Along with Kit Rodolfa, Andreas Bruckbauer, Yuri Korchev and Dejian Zhou, he used a double-barreled nanopipette to create the Cambridge University crest, a picture of Sir Isaac Newton and an image of a Degas painting – all a mere 60µm across. The pixels are filled with labelled DNA or rhodamine green to create the microscopic images.

Paul's cover was on the American Chemical Society's *Journal of Physical Chemistry B*. The paper, by Paul and Jasper Holman from Cambridge plus collaborators in Japan and the US, was about sum frequency generation from Langmuir–Blodgett multilayer films on metal and dielectric surfaces. You can read more about Paul's work on SFG spectroscopy on page 12.



Steve celebrates his 60th in style

Steve Ley was 60 in December, and to celebrate, many of the hundreds of students, postdocs and visitors who have worked in his group over the years came to Cambridge for a symposium and dinner.

The speakers were all former Ley group members who had worked with Steve at various points in his career, and who now hold posts in both academia and industry. The day was rounded off by Steve's talk, entitled 'Champagne: an important catalyst for organic synthesis'.

Dinner in the evening was held at St John's college, where he was presented with a magnificent birthday cake decorated with a spiroketal and fireworks.

Clockwise from the left: Steve gets a standing ovation; giving his champagne-inspired talk; the BMS theatre was packed; and that chemical birthday cake

Chemistry pilots computing project

In an attempt to make use of the 'dead' time when computers aren't being used, the university's computing service has been piloting a scheme where idle centrally-managed computers can be put to work.

Over Christmas, James Spencer and Alex Thom from Ali Alavi's group used the system, PWF Condor, to test a new quantum electronic structure method to calculate the optimal geometries of many small molecules. Alex was able to run calculations for 125 geometries of acetone, each taking a day. He would otherwise only have been able to run a fifth as many calculations in that timeframe.

PWF Condor is based on a programme developed at the University of Wisconsin. 'We have made extensive modifications to the original Condor programme over the past year to make it work better in the Cambridge environment,' explains Bruce Beckles, e-science specialist at the computing service.

There are currently around 320 machines in the pool, including 51 within the chemistry department

'At the moment, it's still in the experimental stage, so only PC machines running Linux are being used,' Bruce adds. 'Depending on demand, we plan to roll it out to Macs and Windows machines as well in the future.'

Double Pfizer poster triumph

Stephen Dalby from Ian Paterson's group won the annual Pfizer poster competition in December, with his poster entitled 'Studies towards the stereochemical determination and total synthesis of spirastrellolide'. The molecule is a marine-derived antitumour agent. He spent the cash prize on a new bike.

It turned out to be a good day for Cambridge, as Andy McNally's poster on organocatalytic sigmatropic rearrangements was one of the runners-up. Andy, who works for Matt Gaunt, adds that the work he presented has just been published in *Angewandte Chemie*, and was singled out as a 'hot paper'.

Switch that kettle off – and make more tea

In the autumn, the university held a 'Switch Off' day to try and raise awareness of how much energy is wasted by lights and electrical appliances being left on unnecessarily.

The idea was that if everyone made a concerted effort on one particular day to turn anything off that could be turned off, it would show just what a difference it could make to the amount of electricity we consume.

Here in chemistry, in the week following the switch off day we saved 0.8% of the electricity we had used the week before.

This may not sound like much, but by university energy manager Paul Hasley's calculations, that's enough electricity to make 9,460 cups of tea.

University-wide, around 5% was saved. That's enough electricity to make more than 300,000 cups of tea – enough for 11 cuppas each for every student and member of staff.

Radical thoughts

Jonathan Burton is trying to unlock the potential of free radicals in organic synthesis by finding cleaner ways of making them in reactions

CV Jonathan Burton

Born: Croydon, Surrey.

Status: His partner, Nick Bampos, is also an academic in the department.

Education: School in Surrey was followed by a chemistry degree at New College, Oxford, with a Part 2 research year in George Fleet's group. 'That was the most productive research year I've ever had, even though it was only nine months!' he says. He came to Cambridge for a PhD with Andy Holmes in 1993.

Career: After a postdoc with Alexandre Alexakis at the Université Pierre et Marie Curie in Paris, Jonathan returned to Cambridge, first as a research fellow at Corpus Christi. He's been a Royal Society Research Fellow since 2000.

Interests: Jonathan is a keen squash player, and loves cooking. 'I find it very relaxing after a day's work!' he says. He's also got three godchildren, two of whom (aged 2 and 1) live in Cambridge so he spends a lot of his time at weekends with them.

Did you know? In the 1920s, his grandfather, John Trevan, FRS, introduced the LD50 test that's still essential for drug registrations today. 'He died in 1956, so I never knew him,' Jonathan says. 'But I remember his wife, Margaret Llewellyn Smith, my grandmother, extremely well. She got a first in Chemistry from Bedford College in 1926, followed by a PhD in botany. She was very helpful when I was doing my chemistry A-level!'

Free radicals have great potential in organic synthesis, as their reactivity can be quite different from the more commonly used ionic reactions, but their use is often limited by the way they are generated. While the radical reactions themselves can be clean and specific, the reagents used to make the radicals in the first place frequently make the reactions very messy. The top culprit is also the favourite reagent – tributyltin hydride. It's toxic and smelly, and removing the tin residues from the reaction mixture is rarely straightforward because it loves to stick to other components in the reaction mixture.

Radical chemistry would be much more use in real life industrial processes if a simpler, cleaner way of creating them were available. And this is the focus of much of Jonathan Burton's work. 'I spotted EJ Corey's synthesis of the natural product paeoniflorin, where the first step was a manganese-mediated reaction I'd never seen before,' he says. 'I wondered how it worked, as it seemed incredibly powerful.'

This curiosity led Jonathan to try generating radicals using manganese. 'The best thing about it is that it makes the radical oxidatively, which means that – unlike tin – you keep the functionality.' In tin-mediated radical reactions, you typically start with an iodide group, which ultimately is replaced by a hydrogen atom in a reductive process. The oxidative nature of the manganese reactions means that a useful functional group remains within the molecule.

Jonathan Burton: looking for more predictable free radical reactions

Photo: Nathan Pitt

'The other main benefit is, frankly, that it's not tin,' Jonathan claims. 'The manganese is really easy to get rid of by chromatography.' However, there are drawbacks. It's nowhere near as well understood, and it can result in unwanted side-reactions.

We found from the literature that it's possible to use manganese in the presence of copper salts, such as copper acetate,' he says. 'In these examples, the result is an alkene, so we wondered if, instead of forming an alkene by oxidative elimination, we could make substitution products.'

Rather naïvely, he claims, he got a summer student to try it – and it worked. 'Since then, we've also introduced copper triflate and copper trifluoroacetate as co-oxidants for these reactions,' he says. 'When it works well, it's brilliant. But it's not as predictable as we'd like it to be. We can get some reactions that are essentially quantitative, but there's no guarantee that this will happen. We're trying to work out conditions that will mean we can approach more reactions with more confidence.

For certain substrates, the dream of predictability is close to being realised. 'If we are trying to trap our radical with a carboxylic acid, then we can pretty much say that we're going to get a yield of at least 70%, which is great. But if we trap our radical with an alcohol, we could get 70% – or we could get 20%.'

As a bonus, he discovered by characterising a side product from the reaction that he'd found an easy way of making cyclopentanes. 'This has great potential, as these feature in numerous natural products like prostaglandins,' he says. 'All you have to do is add manganese acetate to your substrate in ethanol, heat it up, and leave it overnight. It gives you a 70–80% yield of the cyclopentane, and it's really easy to isolate.' Jonathan is already applying the technique to natural product synthesis.

He's also trying metals other than manganese to generate radicals, such as lead tetraacetate. 'We could, potentially, make substitution products from those reactions by using co-catalytic copper triflate,' he says. 'And then this leads on to another field that we'd like to investigate – how to get rid of lead tetraacetate. It all melds together beautifully.'

Photos: Nathan Pitt

Jane Clarke: model proteins can predict the effect of mutations in other proteins

Catching up with evolution

Jane Clarke is using chemical tools to find answers to a number of fundamental biological questions

Proteins are long, complex molecules yet, amazingly, nature folds them up with extraordinary precision. How does a linear sequence of amino acids fold to a specific 3D shape? How does it specify that one particular structure, and not one of the myriad other structures it could fold up into – and how does the folding take place in a matter of seconds, rather than the very many years a random search for the best arrangement would take? These are some of the questions that protein folding chemists like Jane Clarke are trying to answer.

'It's a really challenging intellectual problem,' Jane says. 'Evolution has solved it, but even with fast computers we find it extraordinarily difficult to design the simplest structures.' The human genome encodes around 30,000 different proteins, and studying each one of them individually is a rather tall order. Instead, Jane is taking families of structurally related proteins, and trying to work out rules that can be applied to all members of that family.

'We've recently shown that you can use well-characterised model proteins to predict the effect of disease-causing mutations in other members of the same protein family,' she explains. Around 80% of mutations in humans that are known to cause disease affect either protein stability or protein folding.

'The problem with studying these is that proteins of interest are often difficult to express, purify and analyse. But with a well-characterised model protein that's similar to – but easier to work with than – the protein we're interested in, we can make the same mutations and predict exactly what effect that mutation would have on the human protein.'

Jane believes that using model proteins to predict what's going on in proteins is going to be a powerful technique. Her group has been focusing largely on immunoglobulin-like proteins – proteins that include antibodies and proteins that control a variety of processes that take place in the body including development and movement. A number of human diseases are associated with mutations in immunoglobulin-like proteins. If the effects these mutations have on the way proteins act in the body can be predicted, then it is likely to give an insight into the diseases and conditions they cause.

Another aspect of Jane's work is trying to explain the differences between two proteins that, on the face of it, are very similar, but have rather different properties. 'We're using computer simulations alongside our experiments,' she says. 'Our experiments are used to benchmark molecular dynamics simulations. When the these give a good prediction of the experimental results, we can use the computer simulations to look at the atomic detail of what's happening to the protein under experimental conditions.'

An example involves the dynamic behaviour of proteins, and how they differ between the similar structures. 'When you look at a protein's crystal structure it looks very well defined, but in reality we know from NMR studies that the proteins are highly flexible and mobile, and it seems that the dynamics of the protein can be intrinsic to its activity within a cell.

'We've been looking at two cell adhesion proteins involved in cell development and cancer growth whose structures are very similar, but have extraordinarily different dynamic properties. Could our simulations explain all the dynamics, based on the differences in their compositions? Small differences in protein sequence were having a big

CV Jane Clarke

Born: London, to Welsh parents, so if pushed she'd claim to be Welsh. 'Certainly not English – I support Wales at rugby, so I'd fail Norman Tebbit's cricket test!'

Status: Husband Chris is a banker with the Royal Bank of Scotland in London. Their daughter Hannah is a medic, currently working in A&E in Gateshead, and son David is a physiotherapist who's just started a medical degree in Leicester.

Education: She moved to Cambridge when she was 10, and went to the former Cambridge High School for Girls. A degree in York was followed by a PGCE at Cambridge. A masters degree in applied biology from Georgia Tech in the US was led to a PhD with Alan Fersht here in Cambridge.

Career: Her first career was as a schoolteacher. Her second, as an academic, started at Cambridge, first as a postdoc in MRC Centre for Protein Engineering with Mark Bycroft and Alan Fersht in protein NMR. She moved back to chemistry with a Wellcome Trust career development fellowship in 1986, and four years later was made a Wellcome Trust senior research fellow, a position she still holds today.

Interests: Jane loves cooking ('it's just chemistry, really!') and travelling, as well as visiting friends.

Did you know? There is a collection of holiday souvenirs in her lab, all of them really rather awful. Jane's glorious contributions to the hall of shame include a couple of Christmas tree decorations – one of Elvis, complete with guitar and swinging hips, and one of Santa delivering presents on a military tank.

effect. It turned out that our simulations could predict complex dynamic behaviour of the core of the proteins.'

A third project is looking at the activity and evolution of multidomain proteins. 'Around 80% of the proteins in the human genome have more than one independently folding subunit or domain,' Jane explains. 'Evolution has mixed and matched different proteins to build activity, putting different domains together. Protein folding scientists tend to focus on small proteins, because they're easier to understand.

'We've started to look at multidomain proteins, where two or more are together in the same molecule. Can we take what we know about the domains and say, therefore, that we know about the whole protein? Or do the two have some form of synergistic effect and affect each other?'

Her group has been able to show that in some cases the domains may be essentially independent, but in other cases the opposite is true, and one protein domain can have a significant effect on its neighbours. 'You get cooperativity between the domains, and I'd suggest that in evolutionary terms this could be highly advantageous. Some of these multidomain proteins are huge, and if they go wrong when they're being synthesised in the body, it's very biologically costly.

'With some multidomain proteins, when one domain is made and folded, it speeds up the folding of the next. As the protein is in much more danger of being degraded by enzymes or aggregating with other proteins before it has folded, the faster it can be made and folded, the less likely something is to go wrong.'

Elastic proteins are another field of interest. 'Many of the proteins in the body are elastic,' she says. 'When you stretch out a muscle, for example, it will spring back into place when it relaxes, just like an elastic band. That wouldn't work if the muscle proteins unfolded when you pulled on them. How have proteins evolved to withstand the forces that are put on them?'

Jane's group have been studying two such proteins – the muscle protein titin, and spectrin (which ensures that red blood cells spring back into shape once they've squeezed through tiny capillaries). 'We've been using single molecule atomic force microscopy to study the unfolding of these proteins. If we lower a tiny microscopic tip repeatedly into a mixture of the protein in water, we can pick up a single protein on the tip. We get a trace with a number of peaks, each of which is the signature of the unfolding of a single protein molecule.' By making mutations to the protein and repeating the exercise, it helps pinpoint which regions of the protein are important for maintaining mechanical stability.'

While Jane is keen to point out that she's not claiming her group's research will directly lead to a cure for cancer or any other known disease, it is providing important information that may be of help in the discovery of those cures.

'We're developing tools that will allow us to study biomedical proteins,' she says. 'These are all tools based on physical organic chemistry, along with analytical methods. We're just developing the basic understanding of how some proteins fold, which will enable us to go on to understand how they all work – and what's going on when they don't.

'If I were to tell someone at a dinner party that I work on protein folding, their eyes would glaze over and they'd reach for another drink. But if I tell them that diseases of protein folding are very common – Alzheimer's, Parkinson's, cystic fibrosis, CJD, the list goes on – I might just manage to keep them interested for a little bit longer!

'These diseases can only ever be understood if we can work out precisely what's going on in the protein. We are never going to be able to discover what's going on in the disease state without doing the sort of academic fundamental basic research my group is carrying out.'

A career less ordinary…

Jane has taken a career path that's a little different from the normal academic route. After she graduated in biochemistry at York in 1972, she trained as a teacher. She spent 13 years as a biology and chemistry teacher in secondary schools, ultimately becoming head of science at a school in London, having two children and going part-time along the way.

Her husband is a banker, and in 1986 his job took them to Atlanta in the US. 'I couldn't teach there because I didn't "have" Georgia history and college English,' Jane says. 'But I'm not a stay-at-home sort of person, so I went to Georgia Tech and did a masters degree in applied biology. And I suddenly realised that, however much I'd loved teaching, I should be doing research instead – and working on proteins.'

By the time the family returned to Cambridgeshire four years later, Jane had decided that she wanted to do a PhD. 'I visited the biochemistry department, and they essentially told me that I was 40, with two children and a really old degree, so they weren't interested,' she recalls. 'But a mentor from Georgia Tech had given me a letter to Alan Fersht, so I figured I might as well get turned down by the best! I cold-called on him, and he said, "OK, start in October." I owe him an awful lot because of that chance he took on a middle-aged mother!'

Jane's group, from the left: Matt Kitching, Sarah Batey, Sean Ng, Adrian Nickson, Julia Forman, Annette Steward, Jane, Ilkka Lappalainen, Lucy Randles, Ross Rounsevell, Beth Wensley, Kate Billings, Martina Gärtner and Mike Hurley. 'Working with such a fantastic group of people is the best part of the job,' Jane says

Studying surfaces

What's going on at the interface between a biocompatible polymer and the water that surrounds it? Research being carried out by Paul Davies means it's possible to look at the interactions between the two more closely

After starting out as a kineticist, Paul Davies has spent most of his career as a spectroscopist. Back in the mid 1970s, not long after returning from a postdoc at Harvard, Paul was involved in the first successful laser magnetic resonance (LMR) experiments in the UK.

Microwave spectroscopy is the highest resolution technique there is, but at that time it could not be used to detect a variety of important free radicals because they were outside the range of microwaves. Spectroscopists were desperately searching for new light sources that could bring these free radicals into range. 'Then Ken Evenson, a gifted experimentalist in the US, hit on the idea of using far infrared lasers and tuning the transitions into range with a magnetic field, and LMR was born.'

Since then, LMR has been superseded by tunable far infrared frequency sources, like the one that resides in Paul's basement labs here in the department. His old LMR magnet has found its way into the lab of a former student in China.

PULSED LASERS

Paul took another major change of direction back in 1990. He had been looking at short-lived molecules in the gas phase using lead salt diode lasers, but following a chat with scientists at Unilever, he started to investigate the possibilities of non-linear laser spectroscopy. This is based on the fact that a powerful pulsed laser can produce effects that normal light cannot, and Unilever thought it might have potential for looking at surfactants under ambient conditions.

This was a major undertaking as no-one in his group had any experience of the technique but, spurred on by substantial funding from Unilever, they began to look at molecules at wet surfaces, with the help of Colin Bain, a Royal Society research fellow newly arrived at Cambridge from George Whitesides' group at Harvard, and now a prof at Durham. The outcome was the UK's first sum frequency generation (SFG) spectrometer.

'Ron Shen at Berkeley had shown a few years earlier that if two laser beams with different frequencies were shone at a surface, then light was generated with a wavelength that was the sum of those of the two beams,' Paul explains. 'This light only comes from the surface itself – there is no interaction with the bulk material above or beneath the surface.'

The new technique made it possible to investigate a multitude of surfaces and interfaces. 'One of the great things about SFG is that it can provide industrially useful answers to companies such as Procter and Gamble, Castrol and Kodak, all of whom have provided us with research grants,' he explains. 'It's proved to be a very exciting method – not least because it's now being used in quite different ways from those we'd first envisaged.'

SFG is now commonly used to look at polymer surfaces, and also to probe the structure of water in the vicinity of biosurfaces. 'We've been looking at such fascinating questions as how biocompatible polymers affect the structure of the water films that surround them,' Paul says. 'This is particularly important for the development of artificial organs. The great advantage of SFG is that it can probe the interface between the polymer and the water at a molecular level, without any interference from the bulk water above the polymer.'

Photo: John Holman

Paul Davies: the technique can even be used to look at how the surfactants in shampoo behave on the hair

POLYMER LAYERS

Further projects are emerging, such as using SFG to study polymer layers on bone and teeth. Hydroxyapatite provides a laboratory mimic of these surfaces which has led Paul's group towards collaborations with materials scientists, and the technique has enormous potential for investigating biological membranes. It could, for example, be used to help understand the dynamic behaviour of lung surfactant, which operates with the aid of four different proteins that enable the surfactant to fold and unfold as we breathe.

'This could be done by recording SFG of a lipid monolayer on a Langmuir trough with moving end barriers,' Paul believes. 'Applying SFG to biological membranes like these is one of the most exciting ideas for our future research.'

CV Paul Davies

Born: Rhondda, Wales

Education: Paul attended Cowbridge Grammar School, now defunct in the age of comprehensive education. A degree in chemistry at Liverpool was followed by a move to Cambridge for a PhD with Brian Thrush

Career: Paul remained at Cambridge, first with an SRC Fellowship and then a Research Fellowship at Corpus Christi, interrupted by a very exciting year at Harvard with Bill Klemperer.

Status: Wife Liz is a research immunologist, running the equine orthopaedic research group, and her collaborations include one with Melinda Duer here in the department. Their son Matthew studied quantity surveying at APU, and is now a project manager.

Interests: Paul's a keen skier, so don't look for him on Friday at the end of the Lent Term! He'll have sloped off to the slopes. He's also started to play golf, and is already being challenged by Richard Lambert, who claimshe is also a novice.

Did you know? Paul claims that Liverpool was an exciting place to be a student in the early 1960s, not least because it was just before the Beatles achieved fame. 'They used to play regularly at the Student Union dances,' Paul recalls. 'We used to say, "Oh no, not them again!"'

The 1960s revisited

On the weekend of 1 and 2 October last year, 17 of those who obtained PhDs from the Department of Physical Chemistry in the 1960s were reunited in Cambridge.

The weekend was organised, through the wonderful medium of email, by John Connor, who obtained his PhD with Tony Callear, and Zig Hathorn, who was supervised by David Husain.

Fifteen others showed up, several with partners or wives (physical chemistry was almost exclusively a male pastime in those far-off days!) Several attendees travelled from North America to be present. The company included several Professors, a number of distinguished professional scientists, past and present captains of industry, and one minister of the church.

The participants gathered at the department at noon on the Saturday, and were shown some of the developments in the Department in the intervening 40 years by Ian Smith and Paul Davies. Much fun was had trying to locate where individuals' experimental benches had once stood before the extensive redevelopments on the second floor of the North Wing.

The photo, taken outide the department, shows the following (with PhD supervisors' initials in brackets (ABC – Tony Callear; BAT – Brian Thrush; DH – David Husain; IWMS – Ian Smith): Ian Smith (ABC), Sue Smith, Rick Oldman (ABC), Diana, Ross Dickson (ABC), Gordon Williams (ABC), Adrian Tuck (BAT), Gus Hancock (IWMS), Ross Norstrom (ABC), Mike Pilling (ABC), Tom Banfield (DH), Robert Donovan (DH), Les Kirsch (DH), John Connor (ABC), Zig Hathorn (DH), and John Billingsley (ABC). Others who attended but are not in the photograph were: Revd Tom Broadbent (ABC), Elaine Connor, Paul Davies (BAT), Marian Donovan, Rosie Hancock, Jan Hathorn, Margot Kirsch, Chris Morley (IWMS), Christine Morley, Margaret Oldman and Gwen Pilling

After a pause for photographs outside the department and an unscheduled visit from the newly anointed Senior Proctor (Nick Pyper), the party moved to the Panton Arms for lengthy and unashamed reminiscences.

The main event of the weekend was the dinner held in Churchill College on the Saturday evening which was attended by a total of 26 guests. The food and wine were excellent and the atmosphere convivial in the extreme.

On the Sunday morning those with sufficient stamina (most of the company) met at Ian and Sue Smith's house in Grantchester Road. Happily, they were joined there by Anne Callear who was delighted to see so many ex-members of Tony's research group – all of them scarcely changed despite the passage of the years!

The company dispersed with many promises of repeating the re-union, but agreed that they should not wait so long next time.

Ian Smith

Fifties style

Dear Editor

Thank you for sending the Lensfield Lab magazine. Here are some stories and pensées from 1955-61, illustrating technique, knowledge, and I'm not sure about the others.

Professor H.J. Emeléus stayed in his office on the top floor doing administration most of the time. He would sometimes appear with a delegation of industrial chemists, having first passed word around not to tell them anything.

One of his grad students was once set to making nitrogen sulfide. It's a difficult prep involving ammonia, chlorine and sulphur, and stirred flasks of solvents held at low temperature. The poor student tried and failed over and over again. I was scared. The hood with these goings-on was right at the foot of my bench. If you mix things wrong, the dangerously explosive nitrogen trichloride is possible. After several days of this, Emy came down to help. I didn't watch closely, though I wish I had. He effortlessly had everything working right first shot, and got a huge yield of the desired orange crystals. Emy was the best preparative chemist I ever met. However, were he to be told of this, he would probably deny it in favour of W.G. Palmer.

One day in Cambridge, we were greeted by a horrible smell, spread all over town. It was persistent and intimately organic, a cross between garlic and faeces. It got worse as you approached the Physical Chemistry department, then in Pembroke Street; and it got worse every time you washed. It lasted a day or two and then dissipated. We learned that a student had broken a small tube of dimethyl telluride, maybe 20 grams.

Many years later, I was back visiting with my bride, and introduced her to Emy, urbane and charming, as he always was. With old-fashioned gallantry and chauvinism, he had her pour the tea, 'for the practice'. In the course of conversation, I recalled the dimethyl telluride incident, and the smell on the soap when washing. 'Oh yes,' he said. 'What you have to do is drink lots of orange juice.' Now how did he know that?

The next story involves two demonstrators. I had the dubious honour to be observer. We were in the overnight room. One of them presented us with a small ampoule, sealed under vacuum, now half full of a water-white liquid. He announced phosphine. The other promptly ducked under the nearest table. 'Oh, it's quite safe,' said the first. If there's a moral to this story, I don't know what it is. Nor can I guess who knew more chemistry. The pressure in the ampoule was at least 30 atmospheres.

It might be instructive to ask readers what was the worst chemical they ever tasted (accidentally or on purpose); and what was the worst accident that ever happened to them. The worst I ever tasted was decinormal iodine in carbon tetrachloride (my tongue is probably still violet). And my worst accident? In 1960, wearing goggles was encouraged, but not obligatory. Somewhere I still treasure a pair covered with a brown stain. This was caused by conc. sulphuric acid, when a tube got pinched in a gas drying train. Yes, I was wearing them at the time.

My dear friend, the late Professor J.J. Zuckerman, used to tell his students that he worked with Emy, and Emy worked with Stock, and Stock worked with Moisson, and Moisson worked with Frémy, and Frémy worked with Gay-Lussac.

Sincerely, John A. White
Rochester, NY, US.

Creating a low carbon economy

Carbon emissions reduction can save companies money in the long run. The Carbon Trust was set up to encourage them to invest in energy efficiency projects, and Cambridge chemistry graduate Rosemary Boot is part of its senior management team

The UK government's energy white paper, published in 2003, set the aim for the UK to reduce its carbon emissions by 60%, and create a low carbon economy by 2050. One of the ways government is hoping to enable this to happen is by funding the Carbon Trust, an independent company set up to help businesses and the public sector within the UK reduce their carbon emissions.

Its finance director, Rosemary Boot, is a Cambridge chemist who, after 16 years working in the City, joined the company in its formative stages in 2001. 'The grand ambition when we were set up was to take the lead in developing a UK low carbon technology industry,' Rosemary says. 'Part of the deal when the climate change levy was introduced was that some of the money should go back to organisations to help them reduce their carbon emissions, and invest in early-stage technology that would help them reduce the amount of levy they would have to pay.'

CARBON TRUST
Making business sense of climate change

Defra – the government's department for environment, food and rural affairs – funds the company from the climate change levy to the tune of £50 million a year, with additional money now coming from the landfill tax. In future, it will also receive funds from the department of trade and industry. Further money is to come for public sector efficiency work, as announced in the recent pre-budget review.

The Carbon Trust essentially operates in three areas, Rosemary explains. 'We work with organisations to help them reduce their carbon emissions today, and to fund the development of new low carbon technology for the future,' she says.

Another important part of its work is to raise awareness of the issues, both in government and within business. 'We give companies and organisations pretty hands-on advice to help them reduce their carbon emissions, with the help of our own account managers and external consultants. We provide advice to companies of all sizes – we also offer small and medium-sized companies interest free loans and undertake public sector energy efficiency activities.'

Providing help to small companies and local authorities is one thing. But why should government money be helping big multinational corporations to help them reduce their costs? Rosemary claims that if it were left to the private sector alone, very little would happen except in the most energy intensive sectors – and it's essential that time and effort are put into reducing carbon emissions.

'Our help is needed to catalyse action,' she says. 'We are helping them do things they wouldn't otherwise have done, perhaps because they didn't think it was a priority, or because it may involve some capital expenditure that would require making a business case. But it's important that we prod them into action, for example by co-funding some consultancy to identify emission reduction opportunities that can also deliver bottom line savings. We use a co-funding model for our larger customers because there's pretty good evidence that if people have to put their hands in their pockets themselves, they will value it more.'

While there is a whole raft of things that can be done to reduce emissions that don't cost money, where investment is needed most energy efficiency measures have very short payback times, she claims. And this is where the consultancy that the Carbon Trust funds comes in.

'It's not that the financial case for making changes can't be made, but if a business has a choice between putting investment into something that will cut costs or something that will increase its sales, then it's likely to go for the sales growth option.'

Rosemary Boot: providing support for projects that reduce carbon emissions

The money spent on advertising is important here, too. 'We need to get people, particularly senior decision-makers, to realise that climate change mitigation is something they need to be thinking about,' Rosemary says. 'It's a business issue – not necessarily a key business issue, because it's unlikely to be the sort of thing that keeps a chief executive awake at night – but it might make them realise that there are things they can do, which are actually opportunities for them, and perhaps that they should be employing someone who does stay awake at night thinking about it!'

The Carbon Trust provides grant funding for r&d projects but, Rosemary says, it tries to fund only those projects that have potential commercial applications. 'That's really quite important to us – not only do they have to be innovative low carbon technologies, but they must also offer real practical benefits,' she says.

Incubation support services are also provided for companies that have been spun out of universities, to help them move on from business case development through helping the management team to develop properly so they are in a position to go out and raise funding of their own from venture capitalists and other investors. 'It's important that we help them get through to this commercial funding stage, not relying on grant support.'

The company also has a venture capital arm of its own, investing in equity in early stage companies.

On a wider scale, money is also put into technology acceleration projects that cover an entire sector such as, for example, marine energy, where electricity is generated from wave and tidal streams.

'The aim here is to pro-

From chemistry to the City

Rosemary came to Cambridge as an undergraduate in 1981 to study natural sciences. 'I chose chemistry because it was a subject I liked, and I particularly enjoyed the practical,' she recalls. 'But I never had any intention of staying in chemistry after my degree, and when I left Cambridge in 1984 I went to work for the merchant bank SG Warburg in the City.'

She started off on the banking side, with a year of investment management, before moving into corporate finance. 'That was really interesting,' she says. 'I was working on mergers & acquisitions, takeovers and disposals, and all the time I was there, I don't think I directly used my chemistry once! But I do think that an analytical degree, such as chemistry, is a fantastic starting point.'

In 2000, a change of career beckoned after 16 years in the highly stressful and pressured banking world. 'It's not a job that gives you much of a life – it's very demanding, with truly terrible hours. When you find yourself in Tesco with two small children in your trolley and you're trying to have a conversation on your mobile about bid defence tactics with the chief executive of a large corporation at the same time, you know that something's gone wrong somewhere! I'd had enough of being called at all times of the day and night.'

She knew she wanted to something that built on her skills, but she wasn't sure what. 'I did a bit of consulting so I wasn't in a rush as I had some money coming in,' she says. 'And then I spotted an advertisement for finance director at the Carbon Trust in the Sunday Times, which sounded perfect.' She'd done the chemistry of the atmosphere course in her Part II year, and although that was back in the days before climate change was a known issue, it was enough to pique her interest in the job.

'It seemed to me to be something where I could bring my skills to bear and have an impact, as I could use the skills I'd built up in my years in the City, talking to investors and senior figures in big corporations. I've also had to dust off my chemistry as I'm part of the investment committee that decides on whether r&d projects should be approved. So yes, I suppose I am here because I did a chemistry degree, because otherwise I wouldn't have thought to apply. Although things have changed a lot, I'd been interested in chemistry when I was at school, and that interest in the subject has never really left me.'

vide material help with our money,' she says. 'Obviously, marine energy research is far too big a field for us to fund alone but it potentially offers a significant commercial opportunity for the UK, so we've focused our limited resources on the main barrier to progress – the cost of electricity generation.

'We've provided engineering support to a whole raft of companies in the marine energy sector, with the objective of establishing how and when these technologies can be cost-effective relative to existing technologies.'

A small commercialisation unit has recently been set up to help get co-investors into developing companies that are finding ways to use existing low carbon technologies. While these might not be particularly innovative in themselves, they represent niches in the market that aren't currently being exploited. 'We're trying to say that we think this has potential, we'll put some money in, and we'll try and get other organisations to put money into the project, too,' she says.

It can be difficult to quantify the success of the company's work. Some things are simple to measure, such as the reduction of carbon emissions by a large corporation. 'We track the carbon that has been saved, and can look at that relative to the money we put into it,' Rosemary claims. 'That saved carbon is, effectively, our profit.' When it comes to the development of new technology, it's much more difficult because the carbon savings will come at some point in the future. 'We try to assess it using a model, but it's somewhat challenging to try and work out how we can track the potential effectiveness of that five to 45 years ahead!'

The company has around 135 direct employees, with 100 or so based in its offices by the London School of Economics in central London. It also has staff based in its small outposts in Scotland, Wales, Northern Ireland and the English regions.

'We've grown quite fast, and I like to think we're really making a difference,' Rosemary says. 'The challenge for us is to ensure we put sufficient support into the development of low carbon technologies. It would be very easy to spend all our money on helping organisations to save carbon today, but that would be at the expense of saving carbon tomorrow.

'While some projects may look expensive in the short term, if you look 10 or 20 years down the line, the savings could be enormous. We need to make sure the technologies are developed that will provide the really big carbon savings that will be needed in the future.'

Obituary: Dennis Jacklin

Dennis Jacklin, who was at one time chief maintenance engineer here at Lensfield Road, has died of a heart attack, aged 70.

He was born at Denny Abbey, just outside Cambridge but grew up and went to school in Harston. On leaving school he became an apprentice electrician before being called up for National Service in the RAF.

After basic training in Yorkshire he served his two years at RAF Marham in Norfolk until 1958 when he was demobbed and got married.

Dennis returned to his old trade in Newmarket before moving to the department of physiology here in Cambridge in the early 1960s.

He moved to chemistry in the 1970s, and was responsible for overseeing many internal building modifications, especially the conversion of the physical chemistry teaching laboratory to research labs and helping re-design the old fourth floor tearooms. He left chemistry to become clerk of works & chief maintenance engineer at Churchill College where he stayed until he retired.

Outside of work, Dennis was particularly well known in football circles. He began refereeing locally in the 1960s and then in the old Southern League, before eventually officiating at two events at Wembley.

He later became a referee's assessor and was a leading light in the Cambridge FA right until to his death.

He leaves a widow, two children and two grandchildren. *Brian Crysell*

Cricket spotting

Dear Editor
Dr Geoff Liptrot (Selwyn) is the 10th standing player from the right in the photograph in *Chem@Cam* 24 [reproduced on the left].

He had a distinguished schoolmater's career at Eton, and now lives in retirement in Cambridge.

Yours sincerely
David Harrison
Cambridge

Does anyone have any further suggestions to add to the identities we already have? The photo was taken in 1955, and is of the teams for the Cambridge v Oxford chemistry labs cricket match.

The other names we know are Les Johnson (seated, extreme left); Andy Holmes-Siedle (seated, third left); Peter Sykes (standing, eighth from right); and Jeff Watkins, who sent the photo in, is sitting in the centre.

Let us know if you recognise anyone else in the picture!

Back on the beer

Dear Editor
Antony Barrington Brown was quite right about his 'fragrant memories' (*Chem@Cam* 24) – but I remember that it was F.G. Mann who gave the lecture in 1958/59, and I must admit that I thought it was 2-methyl indole! But I'm not sure.

The information put me off strawberry ice-cream for a long time afterwards – and on the odd occasion that I have something 'strawberry flavoured' now I remember the lecture too.

Incidentally, in Pat Lamont Smith's letter there must either be a misprint or 'elastic sided' 200ml flasks – but I've long since lost my copy of Vogel and I wouldn't know where to start now with trying to decide what was being analysed – something nitrogen containing I suspect.

I look forward to the Spring issue, perhaps someone will have the solution. Incidentally, it's almost exactly 50 years ago that I came up to Trinity for the Schol. Exams – a week of exams and interviews – and it was bitterly cold.

Yours sincerely, Bill Collier
Seaton, Devon

We had no brilliant suggestions about the product that was the complex analysis detailed by Pat in the letters page last time. So it's back to Pat for the (rather surprising) answer…

The product was beer. The idea was to determine the 'Lundin fractions'; in other words, an indication of the proportions of different proteins present. The tannic acid precipitates some of the proteins, and the sodium molybdate another part of the proteins. Boiling with conc. sulphuric acid oxidises the organic matter and converts the nitrogen to ammonium salts. The titration and subsequent calculations lead to figures for the Lundin fractions.

As I recall, these figures were of interest because they relate to the head-retention properties of the beer.

We also analysed for dextrin, tannin, amino-nitrogen, esters, sulphate, chloride, phosphate, copper, iron, calcium, magnesium, lead and arsenic. The last was also a long and interesting procedure, possibly a little out-of-date.

In case you are wondering, there was the possibility of arsenic only because of the spray that might have been used on the hops.

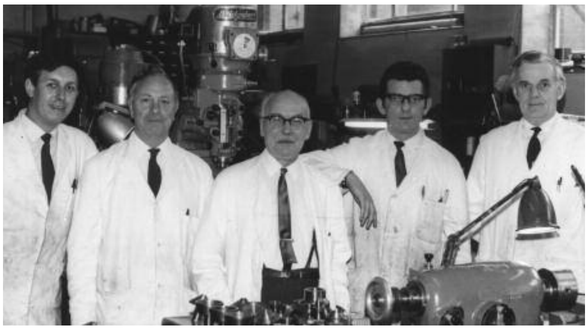
A peek into the past

Brian Crysell's extensive photo collection has yielded these gems. Names for the unidentified faces and reminiscences would be welcome – write to us at the address on page 3.

Left: Brian Crysell, Lesley Coad, Paul Skelton and Mykola Karabyn at a party in G19. Any suggestions who the faces in the background are?

We're pretty sure this shot was taken in the late 1930s on a teaching class technicians' day out, probably to the seaside at Great Yarmouth. From the left: Wally Miller, Jack Fenning, Fred Munns, John Woodcock, Ernie Elborne, Harold Munns, a face we can't put a name to, Les Hunt and (we think) Reg Gilbert

Right: A youthful Brian Crysell poses on the lawn with Stephanie Ginn (now Thoseby). They're surrounded by a selection of items bought by photographer John Constable, who was stocking up on Old Spice, razors and Colgate toothpaste for a trip to the Eastern Bloc!



A photo in the workshop. From the left: Mike Ladds, George Watson, Ezra Chapman, Tim Meehan and Maurice Wilkin

Photo: Nathan Pitt

Faces past and present: Don Flory, Jim Watson, Brian Crysell, John Bullman, Melvyn Orriss and Pat Chapman, with Miss Cooper (front) and her old tea cosy, brush and sugar tin

Miss Cooper pops in for a quick cuppa

Until she retired 34 years ago, Miss Cooper worked in the lecture rooms, first in the old Pembroke Street labs and then here in Lensfield Road. No-one had heard from her for years, but then former technician Jim Watson told our NMR expert Brian Crysell that he'd seen her in the village where he lived.

Brian thought it would be lovely to see her again – and for her to see how different the labs are looking these days. So he brought her in to the department for a wander around and, of course, some tea and biscuits.

'She's 94 now, and looking remarkable for her age,' says Brian. 'Pat Chapman had found her old tea cosy and sugar tin, so we had to get them out for the occasion.'

Also lurking in the cupboard was the old brush she used to use in the lecture theatres. Not for the floor – these were the days before overhead projectors and PowerPoint slides, and lectures were chalk-and-talk on the blackboard. Miss Cooper used the brush to ensure that the lecturers didn't end up leaving the theatres coated in chalk dust.

Two for the price of one

Lisa and Hannah: double the 'aaaaah' factor

It only seems like five minutes ago that we reported the birth of Pete Clapham's first daughter, Zoe. The smelly nappies and lack of sleep can't have put him off too much as he's had not one but two more. Well, wife Jenny did all the hard work, anyway!

Identical twins Lisa Isobel and Hannah Maria made their appearance on 13 December, weighing in at 2lb 13oz and 3lb 3oz respectively.

As they were so small, they stayed in hospital until the end of January. And that's when the fun really began for Pete and Jenny.

'It feels like we're spinning plates all the time!' Pete says of the new-style domestic bliss in the Clapham household. Big sis Zoe was 2 just after the babies were born and, as Pete puts it, is greatly enjoying Helping Out with her new sisters. 'They're about the same size as her dollies,' Pete claims, ominously.

Comings & goings

Leavers:

Sarah Brown
Sarah Njage
Helen Rayner

Joiners:

Keith Jenkins
Caroline Hancox

Photo: John Holman

One evening in January, Cambridge was treated to a particularly dramatic sunset, and photographer John Holman couldn't resist preserving the view from the studio for posterity

Photo: Nathan Pitt

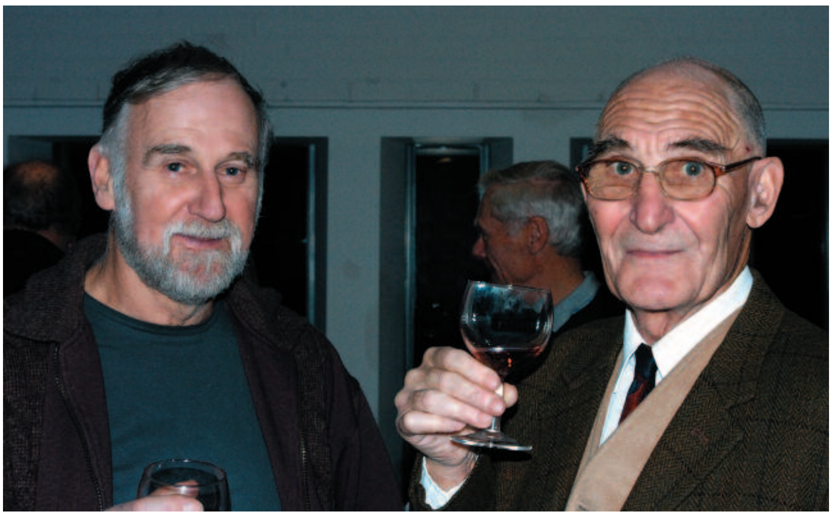
Sarah Brown, who worked with Mykola Karabyn in the lecture theatres, left us in the autumn to head to the US with her boyfriend, who had got a job there. She's pictured receiving her leaving presents from technical secretary David Watson

A drop of Christmas spirit

The annual staff Christmas party is always a good excuse to catch up with a few faces from the past. John Holman was on hand with his camera

Left: Don Flory and Chris Sporikou

Left: Susan Begg and Julie Lee; above: David Watson and Liz Alan; below: Derek Edwards and Cyril Smith



From the top: Brian Crysell and Tiger Coxall; Mike Todd-Jones and Jaci Agarwala; Paul Davies and Sue Johnson; and Tim Layt with a drink, just for a change!

Last issue's winners

Chemdoku

We're onto a winner with this Chemdoku lark – once again the *Chem@Cam* postbag and inbox were positively bulging with correct solutions.

The metaphorical hat this time was another of *Chem@Cam*'s fine collection of Sheffield Wednesday coffee mugs, this one featuring John Sheridan scoring the winner against Manchester United in the League Cup Final at Wembley in 1991 – the only time in her lifetime they've won a proper trophy (last season's League One play-off win was really a prize for coming fifth, however good the day out in Cardiff might have been).

Anyway, the first name to escape from the safekeeping of Mr Sheridan and his dodgy knees was Hugh Aldred from Chester, who was at Downing in 1938. £20 is on its way.

Other correct solutions came from Alice Bull, Robin Pope (who expressed his disappointment that none of the rows and columns were in correct atomic number order!), Mike Sleep, Paul Williams, Mark Booth, A.J. Wilkinson, Donald Bush, Keith Parsons, Tony Pike, F.W. Bennett (who says he's probably best remembered for a failed attempt to demolish the Downing Street labs in the interests of fluorine chemistry – fancy telling us more?!), Jim Dunn, Ian Fletcher, John Salthouse, P.T. Keefe, Helen Stokes, Peter Grice, Paul Cheshire, Roger Duffett, Mike Flower, Andrew Barling, Richard Brown, Peter Rose, John Malone, Peter Ham, Eric Walther, Pete Kennewell, Neil McKelvie, Hilary Ayshford, Annette Quartly, Steve Blasdale, John Carpenter, Howard Clase and Derek Thornton. Phew!

Worthy of a special mention are the entries we also received from King Edward VI school in Stratford-upon Avon. Chemistry teacher Rachel Biggs picked up a copy when she was visiting the department, and thought it would make a good end-of-term activity for her pupils. 'They thoroughly enjoyed it!' she says.

We were so impressed that we decided to award an extra £20 prize to one of the students; Shezza was pressed into action again and this time Mark Brown's entry came out first.

Entries were also submitted by Rachel herself, and students James Frazier, Fred Gravestock, David Massey, James Haseler, Ben Hansen, Hamish Jackson, Dominic Grellier, Alex Mann, Seb Wassell, Nathan Holdbrook, David Eminton, Tristan Gretton, Roger Kingston, Alex Hatcher, James Butt and Tom Hunt.

There was also one final entry from someone who may possibly be called Tom Wadell but has rather indecipherable handwriting.

Just an average

Those dreaded gremelins have struck again. As several readers pointed out, this puzzle was impossible. Setter Keith Parsons had already spotted the error, but somehow his correction got separated from the original problem in Chem@Cam's normally impeccable archaeological filing system.

Here it is again, with the correct total this time...

Last season's batting averages (all less than 100) for the regular players in the village cricket team at Much Stumping were somewhat unusual. One player's average was zero for the third consecutive season (in fairness, he is a demon bowler!) and the other 10 players' averages were all whole numbers, totalling 479, including one prime number.

Each of the top five averages was a (different) multiple of one of the bottom averages. Moreover, when the averages and their multipliers were written down, as shown below, it became apparent that eight of the digits from 1–9 appeared three times each.

Complete the table.

A x B = C
D x E = F
G x H = I
J x K = L
M x N = P

Each of the letters A to P may represent either a one or a two digit number.

£20 prizes are on offer for all three puzzles. Send entries by email to news@ch.cam.ac.uk or by snail mail to *Chem@Cam*, Department of Chemistry, University of Cambridge, Lensfield Road, Cambridge CB2 1EW

This issue's puzzles

Elementary fun

This puzzle comes from regular *Chem@Cam* reader Annette Quartly.

Having randomly assigned the numbers 1 to 26 to the letters of the alphabet, I noticed that by adding together the values of the letters in the names of certain elements, listed below, their atomic numbers were obtained.

Technetium = 43
Ruthenium = 44
Tellurium = 52
Caesium = 55
Barium = 56
Lanthanum = 57
Ytterbium = 70
Iridium = 77
Protactinium = 91
Californium = 98
Rutherfordium = 104

If I were subsequently to discover a new element, and name it Chemistryfunium in accordance with the above system, what would its atomic number be?

Chemdoku

						O		
		Cl			H			
Ne		F		Ar		N	Kr	
	O		H		He			
		Kr		N		H		
			Ar		F		He	
	H	N		Cl		Ar		O
			Ne			F		
		He						

Imitation is the best form of flattery, they say. So *Chem@Cam* had to profess herself flattered when she spotted the latest addition to the range of books sold by the Royal Society of Chemistry – a whole book of chemical sudoku.

In the face of such competition, it would have been rude not to supply *Chem@Cam*'s loyal readers with another puzzle to test their brains. This time, we've come over all gaseous, and the grid needs to be filled with the first nine gases in the periodic table.

In the unlikely event that you've never seen a sudoku puzzle before (and if not, where have you been?) the idea is to arrange the nine symbols in the grid in such a way that each row, column and 3x3 square contains the nine elements just once.

The usual £20 prize goes to the first correct solution out of whatever receptacle is lurking in the *Chem@Cam* office when we do the draw.

Chemdoku – the original and best!

We thought he'd retired, but no! David Watson is back to save us!

UNIVERSITY OF CAMBRIDGE

Chem@Cam is written, edited and produced by Sarah Houlton

Printed by Cambridge Printing, the printing business of Cambridge University Press