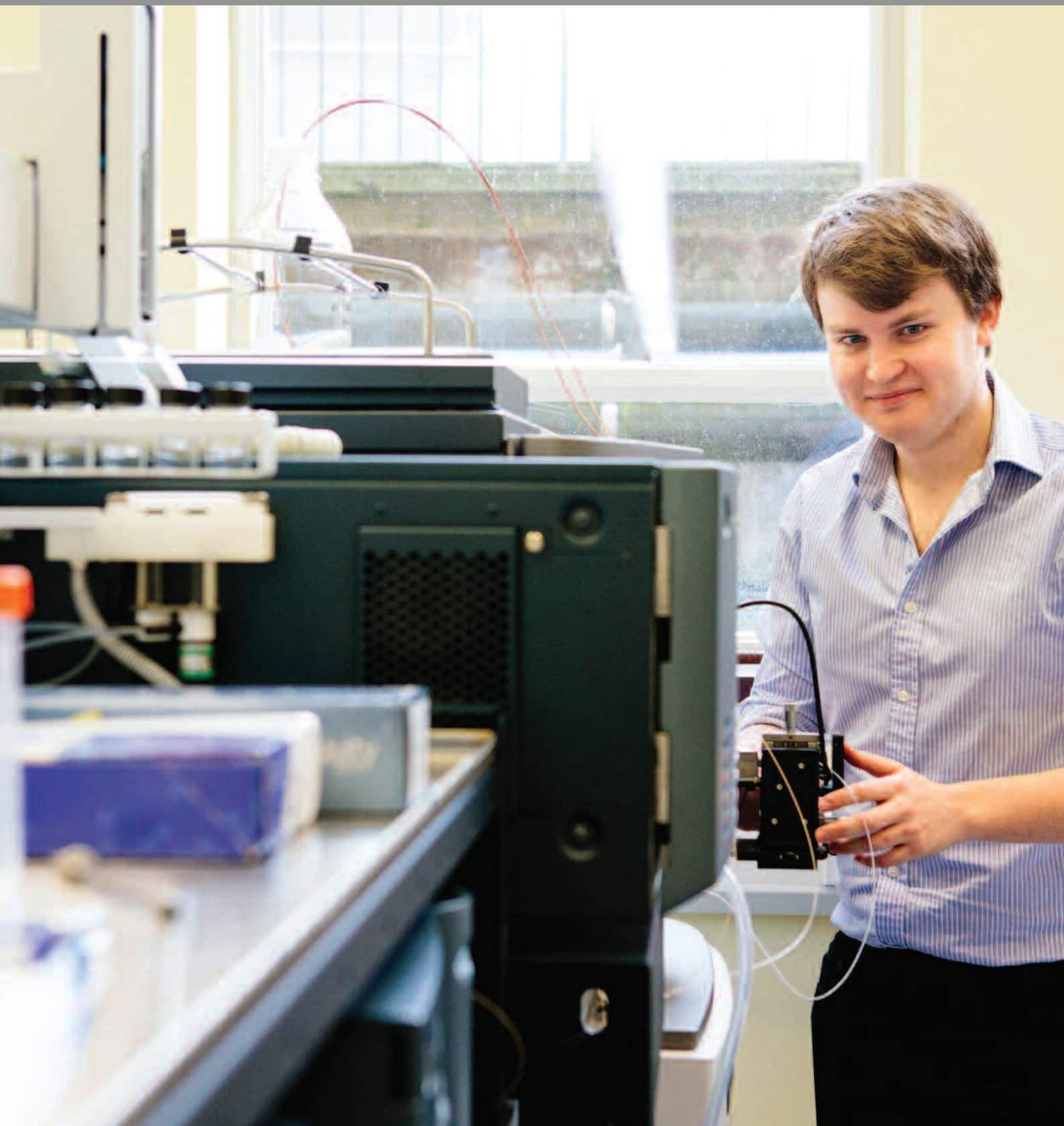


chem@cam

Chemistry at Cambridge Newsletter

Spring 2014



Creating colours without pigments
Measuring gases **above the Pacific**

The potential of **modified proteins**
What holds **our bones** together?

Could we start by taking a look at how things are going in the department at the moment?

Sure. Scientifically, we are very successful, and in the past few years we have attracted a number of excellent new staff members, including four lecturers and a professor. Our academic and teaching staff continue to win national and international acclaim – members of staff have won more than 20 prizes in the past year, continue to increase the amount of money brought in to support research, and publish the work they do in major journals.

If things are going so well, why is a programme of fundraising so important?

The department delivers excellence on a fraction of the resources available to our competitors in countries such as the US. Our research staff are very successful at raising money via grant applications, but these sources don't necessarily provide start-up funds or money that can be used flexibly and strategically. Our research priorities cannot, and must not, be set solely by the priorities of external parties.

Flexibility is particularly important for young scientists as they build up their groups. For example, they may need to buy a piece of equipment and consumables to allow them to perform initial experiments in a new and emerging area of research that might, at a later date, form the basis of a large bid to a government or charitable funding agency. It may also enable them to recruit or retain staff between grants.

Our donors have been incredibly important to us in the past, and we believe they will be even more important in future.

The Next Generation Fellowship programme has been transformative, hasn't it?

It certainly has. Many of our staff have benefited from the generosity of donors in setting up their research groups here in Cambridge, via these unrestricted grants that enable them to get their research up and running. Most recently, Silvia Vignolini has been awarded a NGF from Philip & Patricia Brown.

We are continually bringing new young people into the department, and this scheme gives them a fantastic boost in the early days of their career. We are now also looking to expand the Next Generation scheme to benefit a wider group of people in different ways, from students through to lecturers.

Can you tell me about these Next Generation studentships?

The Next Generation scheme would allow us to fund individual students through a four-year PhD. One might think we already have enough stu-

Numerous fundraising initiatives are under way in the department, designed to support our scientists and their research. Sarah Houlton spoke to head of department Daan Frenkel about what we're doing

“Many of our staff have greatly benefited from the generosity of donors when setting up their research groups in Cambridge”



Photo: Nathan Pitt

dentships – we have about 280 PhD students in the department at the moment – and, indeed, it's not that we can't fill our fume cupboards. But, increasingly, funding sources for PhD students are directed to particular areas of research and restricted to specific groups of students. This can hamper the pursuit of new 'blue sky' research projects, or even prevent us from exploring interesting areas that don't fall within the scope of one of our current doctoral training awards. Yet these are exactly the sorts of projects that at least some Cambridge students should be carrying out.

There is thus a great need for us to be able to say, simply, 'Here is a fantastic project, you are a fantastic candidate, you've got the place.' Or maybe a truly exceptional candidate wants to do a project no one had ever contemplated – if we had the funding we could let them do it. A donor who funded a Next Generation student might be able to see something really exciting happening.

So the plan is to expand the Next Generation programme through all the steps of a chemist's early career?

That's right. The next step of support is what we're calling the Research Springboard. Many of the young researchers starting out their independent career have a university research fellowship from an organisation such as the Royal Society. These prestigious fellowships are extremely competitive, and only go to the very best. Typically, the fellowship lasts for five years, allowing the scientist to become established as a top-level researcher on the international stage. These people are important

for the future of chemistry, and not just in Cambridge – many successful Cambridge URFs and holders of other senior fellowships have gone on to lectureships, readerships and even professorships at other universities.

However, while these fellowships are prestigious and important, unrestricted top-up funding to help the research get off the ground would really help. Research Springboard money could support travel to meet potential new collaborators, or provide consumables to explore new directions in research. The donor would have the privilege and satisfaction of knowing they had an important input in launching a young scientist's career, and laying the foundations for their future success.

So the Next Generation Fellows are the next step in the career sequence. What follows that?

We would love to be able to support Next Generation Lectureships. It's important to say that we have no plans to increase our overall numbers because we feel that our current academic staff level of 55–60 is about right to make a real impact on a number of areas of chemistry. There's no need to spread ourselves too thinly by expanding that, and there isn't the space, either.

However, the lectureship scheme allows us to do something slightly differently. Academic staff places tend to open up when people move elsewhere or retire, and it may be that we find someone who is so brilliant, and aligned with our priority areas of research, that we would love to hire them immediately.

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Are you in Cambridge for the university's Alumni Festival in September? Why not visit us in Lensfield Road for our Student Showcase and Lab Tours?

Come and learn about the latest cutting-edge research in chemistry, as some of our talented young researchers give brief presentations about their projects. There will also be lab tours for interested alumni and guests.

Friday 26 September 2014 at 4pm in the Todd Hamied Room – put it in your diary!

From Eagle to Arms

Dear Editor

I read with interest J.A. Green's article in the Autumn 2013 issue of *Chem@Cam* about his memories of the move to Lensfield Road and early days working there. I had not heard the story about my father and the White/Green confusion before, but can well imagine the scene!

I do remember the adjournments to the Spread Eagle, now sadly no more, in the

evenings. Others, particularly those from 'down under', preferred the Panton Arms. Both were worthy successors to the Eagle in Bene't Street as watering holes for chemistry graduate students and postdocs, where, I think, many good ideas emerged from the informal discussions.

Sandy Todd

Pub pursuits

Dear Editor

John Green's article, 'Memories of Lensfield Road', in the last issue of *Chem@Cam* brought back some memories of the Spread Eagle 50 or so years ago. By chance, I was telling some of the same anecdotes to my grandchildren only a few days ago.

I recall that John himself was a useful bar billiards player, although I think our contemporary, Peter Coates, was acknowledged as the local champion. Claims that we played the game to give us all a useful insight into molecular collisions proved to be unfounded!

eChem@Cam

Chem@Cam is now being sent out by email to those who have asked for a pdf version rather than a hard copy in the mail.

If you would like to swap your paper magazine for an e-version, send an email with the subject line 'eChem@Cam' to jsh49@cam.ac.uk, and we'll send it to you electronically from the next issue. Don't forget to tell us your postal address so we can check that the correct person is removed from the mailing list for the paper magazine.

You can check out e-back issues at www.ch.cam.ac.uk

Kingsley Amis was a friend of my supervisor, the late J. Howard Purnell, and also played a useful game of bar billiards. On at least one occasion, the landlord of the Spread Eagle arranged a match against a team from a pub somewhere near Barton or Comberton, and I think I recall that Kingsley played, although the rest of the team came from the department.

Yes, the Spread Eagle was popular with members of the department and it was rumoured, although never substantiated, that Professor Norrish even chose the same wallpaper for his sitting room at home as that in the Spread Eagle public bar!

Tony Kallend (1956-62)

Physical origins

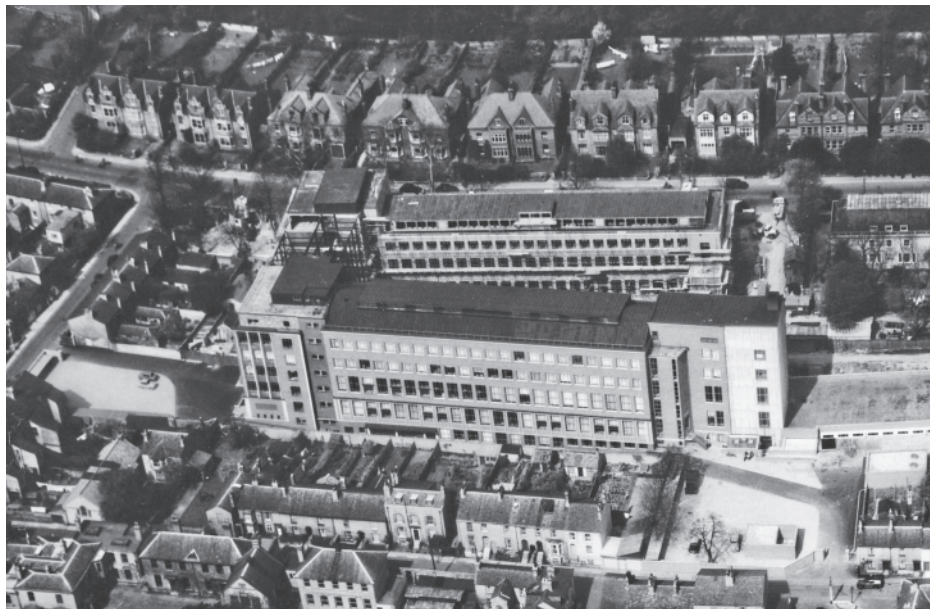
Dear Editor

On reading my autumn 2013 copy of *Chem@Cam*, I wondered how you can write about wavefunctions without mentioning the late John Pople or Bob Parr?

And how about a list and origins of the Physical Chemistry group at Pembroke? I recall an Australian but not his name.

G.J. Mains

Can anyone help us with his question about the Pembroke group, or reminiscences about Pople or Parr? Let us know!



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Chemistry at Cambridge Newsletter

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Cover



Part III student Ben Stewart tests out our new mass spectrometry capabilities

Photograph:

Caroline Hancox

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.

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Photo: Nathan Pitt

Just before Christmas, a delegation from Aramco Overseas visited Cambridge. After a tour of the West Cambridge site, Daan Frenkel welcomed them to a morning of presentations in St Catharine's, including Peter Wothers speaking about outreach. The company generously sponsors the Cambridge Chemistry Challenge, and Peter finished off with a fiery demonstration, with managing director Nabil Aldabal being (safely!) 'set alight', with bicycle power provided by Rajeev Shankar from AO's London office

Three of 100

In an aim to challenge the UK's 'narrow and old-fashioned' view of science, in January the Science Council published a list of the country's 100 leading practising scientists. And some of the names on the list will be rather familiar to Chem@Cam readers.

The list was split into 10 groups of 10 different types of scientists – different by role, not discipline. Investigator scientists included Sir Alan Fersht, who was chosen for his pioneering research in protein engineering, which he developed as a primary method for analysing the structure, activity and folding of proteins.

Shankar Balasubramanian is on the list of entrepreneur scientists for his work in the applications of chemistry to biological and medical sciences, and his part in the invention of Solexa DNA sequencing technology.

And Peter Wothers is named as a teacher scientist, being recognised for his role in helping to bridge the transition between sixth form and university, through his leadership in developing the syllabus for the chemistry pre-university qualification.

Other familiar faces include Chris Bishop from Microsoft Research here in Cambridge who has given demonstration lectures in the department and is on the investigator scientist list, as is Janet Thornton, director of the European Bioinformatics Institute at Hinxton, and formerly an honorary professor here. And university chancellor Lord Sainsbury is cited as a policy maker scientist.

You can see the whole list at <http://bit.ly/1dNeelj>

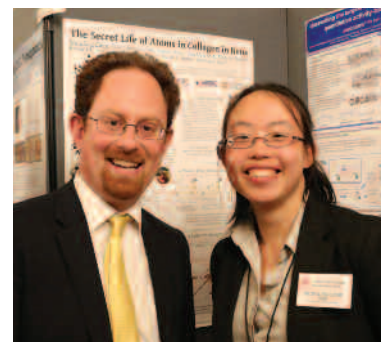
Parliamentary poster presentation

Wing Ying Chow, a postdoc in Melinda Duer's group, presented a poster on her chemistry at the SET for Britain event, held at the Houses of Parliament in March. The aim of the event is to encourage, support and promote scientists, engineers, technologists and mathematicians, whom it describes as the 'engine room' of continued progress in and development of UK research and R&D and, ultimately, UK plc.

Held in collaboration with British scientific societies including the Royal Society of Chemistry, the sessions included more than 100 posters from across the breadth of science, engineering and technology – or SET – subjects, and just getting your poster accepted is something of an honour.

'My poster was about the secret life of atoms in collagen and bone,' Ying says. 'It described our work on developing a solid state NMR experimental approach that allows us to look at atomic changes in collagen proteins in intact tissues, which is really challenging as collagen forms large, insoluble aggregates.'

The event was held in the House of Commons' terrace marquee, which overlooks the River Thames. 'It was packed full of people giving their posters, and we were all really busy explaining them to the competition judges, parliamentarians and industrialists who attended the event,' she says. 'I had to work out really quickly how



MP Julian Huppert, Ying, and her poster

much chemistry knowledge they had, and what level to pitch my explanations at for each one.'

Her poster drew a lot of interest, both from chemists in industry and from Cambridge MP – and former Cambridge chemist – Julian Huppert. 'It was very inspiring to talk to all these people, as many had a chemical background and were really interested in what I'm trying to do in the lab and what its applications might be,' she says.

'It was also fascinating to speak to the other poster-givers around me, and find out what they were doing. At a conference, everyone will be doing things that are at least vaguely related to your own work. Here, it was all of UK science, so it was good to be able to talk to people who are doing cool things from gravity waves to graphene!'

Linnett lecturer

This year's Linnett visiting was given in early February by Emily Carter of Princeton University, where she's the Gerhard R. Andlinger professor in energy and the environment, as well as professor of mechanical and aerospace engineering and applied computational mathematics.

Her Linnett lecture, entitled 'Running combustion backwards: fuels from sunlight, from first principles', described her pioneering science in the field of solar energy.



Spectral enhancements



Photo: Caroline Hancock

Two new mass spec machines have been installed in the department recently. The Waters Synapt G2-Si and Xevo G2-S will now allow proteins and protein complexes to be analysed in their native state, as well as proteins in complex with small molecules, denatured proteins, peptides, and even DNA and RNA.

As well as running spectra for chemists in the department, Dijana Matak-Vinkovik says the mass spec team of herself, Paul Skelton and Asha Boodhun will be more than happy to train people to run their own.

Asha Boodhun with one of the new machines

Solar in (moving) pictures



Fancy finding out a bit more about the chemistry that goes on in Erwin Reisner's lab? Well, thanks to the power of the internet – and the creativity of five of his group – you can, via a youtube video that gives an introduction to their work on solar fuels.

'There's been a real drive to increase the amount of outreach research groups do, particularly for government-funded projects so we can show what is being done with taxpayers' money,' says post-doc Chris Windle. 'And quite a few of us really enjoy talking about our science, and trying to explain it to non-scientists. Creating a video seemed like a perfect way to do this.' So the team of Chris, Christine Caputo, Dave Wakerley, Claire Wombwell and Jenny Zhang got to work.

The video started out as a storyboard – lots of squares on a big piece of paper, where they drew their ideas for visuals for each of the points they wanted to get across. 'We then worked hard to make sure the script balanced explaining what's going on in a clear way, but also

making sure it was accurate, even though we'd simplified things quite a lot,' he says.

As the intro video is bite-sized, they now plan to make a series of follow-up videos where they'll go into some of their areas of research in more detail. 'The first video doesn't go that deep – it gives a broad picture of what we do and why, and touches slightly on how we do it in a colourful, cartoon kind of way,' he says. 'Then we give a very rapid tour of the lab, showing real people doing real science, with quick captions about what they're up to.'

They're now busy working out what to put in the next one. 'We plan to cover the potential of enzymes and chemical synthesis in solar energy, artificial photosynthesis, and also the concept of energy storage and potential energy in future videos,' Chris adds. 'It helps that our science has obvious real-world applications!'

You can see the first video at <http://bit.ly/1o8Nrky> – and look out for the next instalment later in the year.



Documentary times



Photo: Kurt Prinz, OMV Group

With a cameraman, sound guy and the director all squeezed into the lab, the photos had to be taken from the corridor!

It's been a bit of a media frenzy in Erwin Reisner's lab recently – in March an Austrian documentary team spent three days there filming a documentary about renewable fuels for the Austrian national TV network ORF. Erwin and several of the group were interviewed about what they're up to and experiments were filmed in the lab. The documentary is being sponsored by the Austrian petrochemical company OMV, which also funds chemistry in Erwin's Christian Doppler Lab.

One of the interviewees was PhD student Dave Wakerley, who spoke about using gas chromatography to detect the hydrogen generated by catalysts 'I think they're going to dub my voice into German, hopefully with a deep James Bond-like voice!' he says. 'They also filmed plenty of segments of the group doing chemistry around the lab, such as a demonstration of a catalyst making hydrogen bubbles from water, and we explained what was going on.'

With a cameraman, sound man with a boom mike and a director, plus a stills photographer to take pictures of the process, the lab was rather fuller than usual while the filming was going on. And at the same time, the lab was visited by OMV's chief executive and its head of science and innovation, the Austrian federal minister of science, research and economy and the chief and his deputy of the Kronen Zeitung, Austria's largest newspaper.

'It was an exciting visit for our group,' Erwin says. 'It's great to see interest on our work from beyond the scientific community, and that people in my home country take such an interest in what we're doing. The feedback was uniformly positive, and we are already looking forward to my group's visit to OMV's headquarters and refineries in Vienna during the summer.'

There are also plans to make an English language version of the documentary. If that happens, we'll let you know where you can watch it!



Photo: Caroline Hancox

This year's Alex Hopkins lecture was given by materials scientist Mark Miodownik from UCL. The lecture, entitled 'Strange materials', looked at how new materials transform technology, change behaviour and shape the world around us, and the changes to the material world that are coming our way. The annual lecture, which relates chemistry to everyday life and contains an element of humour, is given in memory of Alex Hopkins, a much-loved teaching fellow at Churchill and Fitzwilliam, who also played an important role in the department's inorganic teaching. The lecture is supported in his memory by Alex's father, John Hopkins.

Teaching award for Sally

Sally Boss has won one of this year's Pilkington Teaching Prizes. These coveted awards recognise outstanding contributions to teaching within the university. She splits her time between chemistry and Churchill, where she is an admissions tutor and director of studies for chemistry.

Sally says that news of the award was a very welcome surprise. 'I had no idea that I had been nominated and am grateful to those that put me forward,' she says. 'I feel very lucky to be involved in teaching in the department, and to have the opportunity to teach such bright and focused students.'

Matthew's organic poster prize

Matthew Grayson, who's in the fourth year of his PhD with Jonathan Goodman, recently won the Organic & Biomolecular Chemistry participants' prize at the Royal Society of Chemistry's organic division poster symposium.

Held in the Chemistry Centre at the RSC's London headquarters in December, the Roche-sponsored event gave 37 PhD students the opportunity to present their chemistry to a group of senior organic chemists from academia and industry.

As well as the 'official' poster winners, all the participants got to vote for their own favourite poster, and that's what Matthew won. His poster described his work using both computational and experimental techniques to gain an insight into important asymmetric chemical transformation.

'The knowledge we gain from mechanistic work can then be applied to the rational design of new reactions in other complex and challenging areas of synthetic chemistry,' he says.

Visions of China...



Oren and his visiting group members after devouring several Peking ducks at Quanjude... From the left: Anna Andreou, Zarah Walsh, Dongsheng Liu (now a prof at Tsinghua, and formerly a postdoc with Shankar Balasubramanian in Cambridge), Lee Cronin from Glasgow University (who was visiting), host Xi Zhang, Oren, and Emma-Rose Janecek

Oren Scherman is half way through a one-year sabbatical in China. He's being hosted by Xi Zhang at Tsinghua University in Beijing. The chemistry community in China is really buzzing, Oren says, and it's proving a fascinating experience.

'I'm really learning from all Xi's experience and expertise in supramolecular self assembly of thin films and single-molecule force spectroscopy of polymers,' Oren says. 'We've been doing pull-off experiments of a functionalised AFM-tip from surfaces, and we're trying to get to the bottom of a fundamental energetic value for a supramolecular host-guest interaction that fascinates us both. We already know how to exploit this interaction, and now we're trying to find out what is going on at the most basic level.'

In return, Xi's group are learning from the synthetic knowledge of Oren and his group, particularly the derivatisation of

the cucurbituril macrocyclic host molecules that a lot of his work has focused on in recent years. 'It's a really great give-and-take,' he says. 'Being out here for a long stint is enabling me to get so much more out of the experience than I would in just a month or two. I've also been able to go to local conferences, interact with other faculties at the university, and it's been really interesting to watch the ups and downs of the PhD students.'

Oren is also organising exchange visits for the members of his group in Cambridge to Beijing. The first group of five students were in China for a month or so in February/March, and a further six will be making the trip soon. He's also hoping that some of the Chinese students will be able to make a return visit to his lab in Cambridge.

Keeping up with his group in Cambridge means some very long days, however. 'I'll work from 8am to 4pm at Tsinghua, and at 4pm, it's 8am in the UK, and I spend hours on Skype and email with my group, including group meetings twice a week,' he says. 'Modern technology makes it possible! I've also done some teaching as a guest lecturer, including a class on technical writing in English for native Mandarin speakers. There's a real hunger for knowledge and discussion among the students. Fortunately, they speak good English, as Mandarin is tough. I can describe where I need to get to to taxi drivers, and the Google Translate app has been invaluable.'

He adds that, scientifically, the exchange has already been extremely

fruitful. 'It will allow us to build some really strong networks and interactions, which will really help our research in the future.' Xi has also helped Oren meet and interact with chemists in other parts of China, and he's travelled around the country a fair amount already. 'I love how Chinese chemists have been eager to listen and talk science, but also show me their wonderfully rich and historic culture.'

Being in China with his family has proved an interesting experience. 'The haze and pollution over the winter months really affected our breathing, and something surely has to be done at a political level about the city's air quality,' he says. 'But now it's spring, the skies are blue, and the frozen lake near our house melted really rapidly. Within the space of 10 days in March we went from winter gloom to T-shirt weather.'

■ In other news, Oren has won the Cram Lehn Pedersen prize for 2014. The award, sponsored by RSC journal ChemComm, recognises work in supramolecular chemistry by emerging investigators. It's named in honour of the 1987 chemistry Nobel prize winners.

Oren will receive the prize at the International Symposium on Macrocyclic and Supramolecular Chemistry, which is being held in Shanghai in June. This may sound convenient – but in fact he won't be travelling from Beijing, he'll be flying in from Saudi Arabia, and then going on to Poland for another meeting. 'My travel schedule has been interesting, to say the least, while I've been out here!' he says.

How do you measure atmospheric gases?

As part of Cambridge Science Week, a team from atmospheric chemistry took over the lecture theatre in the Polar Museum next door to explain what goes on during a field campaign – complete with a model of part of the aeroplane they use to make measurements.

Michelle Cain, Nicola Warwick and John Pyle are part of a multi-institution project studying Arctic methane levels in northern Sweden. 'We fly on the national Facility for Airborne Atmospheric Measurements research aircraft, so we can make measurements of methane, which is a greenhouse gas, in places that are difficult to reach,' Michelle says. 'Everyone assumes the Arctic is frozen, but in the summer there is a lot of wetland, which is a big source of methane.'

Last year, the atmospheric chemistry group at York had the plane mock-up made for an event, and the Cambridge team borrowed it for the Science Week demo, also enlisting the help of some other members of the collaborative team. The mock-up includes four seats, the floor, and a side complete with a couple of windows, plus one of the instruments that measures methane levels on board.

'We took people through what we'd do on a normal flight,' Michelle says. 'John gave a briefing, then an instrument specialist explained what the machine did, and the flight manager explained what we did on board with the data.'

They simulated flying over a ground station, where another scientist demonstrated taking measurements in a chamber on the marsh. 'One of the pilots was there too, and we even had a safety briefing from the cabin crew!' she says.

The whole experience was interactive – the audience had voting buttons to answer questions, with their answers appearing on the screen. 'Some of the questions showed if they were paying attention to what we'd been saying, but one asked if we should abort the mission and go back to base – a weather front was coming in, making visibility poor, which is dangerous when you're flying just 500 feet above the ground.' They voted to keep going – fortunately John declared that 'science is not a democracy' and returned to base, so the simulated flight did not end in a simulated plane crash!

'The idea was to give the audience a flavour of what it's really like trying to

take these measurements, and the feedback we had on the sessions was really positive,' Michelle says. 'The project is a collaboration between many different universities and institutes, linking up aircraft and ground-based measurements. We wanted to bring it to life by giving a taster of what we do in the real world, and what happens when things go wrong!' The session was filmed, and once it's been edited, look out for a short video on the internet.

Sam Illingworth from the University of Manchester shows a volunteer from the audience how to strap himself in to the 4-way seatbelt



Photo: Nathan Pitt

Chemistry in colour

Some of the most stunning colours found in nature don't involve dyes or pigments, but otherwise colourless nanostructures. Silvia Vignolini is trying to find out how they work, and make her own

Colours in nature don't always arise from pigments or dyes. They can also be created from otherwise transparent materials, if the way they interact with light creates a colour. Silvia Vignolini's research focuses on studying the physics and chemistry behind these phenomena, and creating synthetic materials in the lab inspired by them.

'My PhD was on photonics, and while I was a postdoc in the Cavendish, I started looking at the optical response of natural, coloured structures, such as flowers, leaves and fruit,' she says. 'Plants – and many animals – can use simple materials such as cellulose or chitin to create nanostructures that interact with light to produce strong coloration, with no need for pigments to generate the colour.'

Familiar examples in the animal kingdom include the blue metallic colour of the morpho butterfly, and the buprestidae family of jewel beetles, many of which have beautiful colours and gold tinges. However, plants also use this photonics strategy to achieve iridescence in many flowers, including tulip and hibiscus, and also fruits like the metallic blue of *Pollia condensata*, or marble berry.

This ability to create coloured effects relies on the colourless polymeric material forming nanostructures whose scale is comparable to the wavelength of light – about 300–700nm. Perhaps the most familiar example of this phenomenon is the soap bubble. The liquid soap is transparent, but if a bubble is blown, this creates a thin film, and beautiful colours start to appear.

'The colours are the result of constructive interference of light reflected at the interface of air and the thin water soap bubble,' Silvia explains. Many different kinds of nanostructures can create this effect and, as well as thin films, more complex 3D structural architectures can create colour.

'Jewel beetles, for example, have really

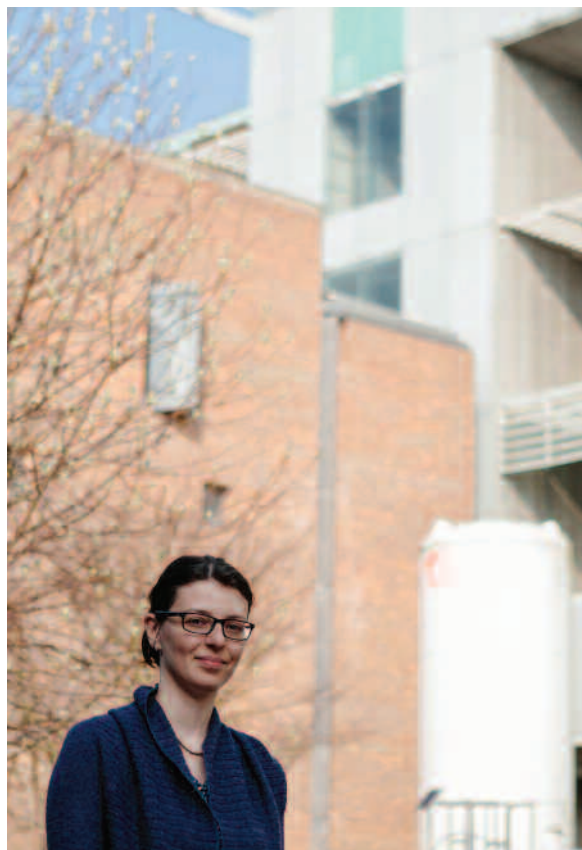


Photo: Caroline Hancock

strong colours created by chitin nanostructures, while in plants the colour arises from cellulose-based nanostructures,' she says. 'I started working with cellulose to try and replicate the structures found in nature following a biomimetic route – by using the same materials that nature uses.'

Understanding how the plant cell walls assemble these fascinating structures in nature is not as straightforward as it might appear at first sight. The cell wall structure contains many more complex elements than simply cellulose – cellulose microfibrils are embedded into a pectin matrix, linked via a hemicellulose such as xyloglucan, and lignin fills these gaps to give it strength. They also contain small amounts of other substances including structural proteins, enzymes, and structures such as microtubules that regulate growth. And, of course, the composition varies from plant to plant.

At the heart of Silvia's research is the application of physical chemistry techniques to try and understand how plants use cellulose to assemble pho-

tonic structures, and how the cell wall works to produce the colour-generating material. 'It's really challenging to understand how these kinds of structures are formed in plant cell walls,' she says. 'By using my background in optics, I'm looking to find out how the materials work both *in vitro* and *in vivo*, and comparing the synthetic materials to those observed in plants,' she says.

In many cases where plants create pigment-free colours, this is done via cellulose assembled in a chiral nematic architecture, similar to the liquid crystal molecules commonly found in display screens. Similar structures with strong optical response can be also obtained *in vitro* by using cellulose nanocrystals.

NOVEL MATERIALS

'Cellulose nanocrystals dispersed in water, and at specific concentrations form chiral nematic liquid crystalline phases,' Silvia says. 'Importantly, these structures can be preserved in a dry state and can be exploited as sensing and diagnostic tools. I hope this information will help me create novel nanostructured cellulosic materials. If we could have sufficient control over the assembly and the nanostructure, we might be able to make pigments that are, essentially, made of paper.'

Cellulose is one of the cheapest and most abundant polymers on the planet, and of course, is readily renewable. Working out how it is arranged in a coloured plant cell wall should provide the basis for fabricating pigment-free coloured materials, Silvia believes.

'There are so many exciting possibilities,' she says. 'I'm trying to extract cellulose from sources such as wood pulp and cotton, and use it to create bio-inspired materials with strong optical functionalities, with colour generated by cellulosic nanostructures. This would have real advantages – coloured materials could be created without having to use expensive or toxic pigments.'

Born: Florence, Italy, where she went to school.

Education: A first degree in physics from University of Florence in 2005 was followed by a PhD with Diederik Wiersma on light propagation in semiconductors at the European Institute for Non-linear Spectroscopy (LENS), also in Florence.

Career: She came to Cambridge in 2010 for a postdoc with Ullrich Steiner and Jeremy Baumberg in the Cavendish on the optical properties of natural materials, receiving a BBSRC fellowship. She was appointed lecturer in chemistry in December 2013.

Interests: Her main passion is cooking, and she says that, as an Italian, she loves eating out, drinking wine and wine tasting. She also enjoys theatre and cinema.

Did you know? Her nanny was British, and when she was a kid she decided that when she grew up, she'd go to the UK to teach all the British children Italian, because English is too difficult to learn!

Silvia Vignolini



The potential of modified proteins

It's not easy to modify individual amino acids in proteins without destroying them. That's what Gonçalo Bernardes is trying to do



Photo: Caroline Hancox

Proteins consist of long strings of amino acids, and the order and identity of these amino acids, as well as the way the proteins then arrange themselves into 3D structures is key to their biological function. Altering individual amino acids to modify the biology is very difficult to do specifically, and the main focus of Gonçalo Bernardes' chemistry is to develop reactions to do this. Importantly, they should take place in protein-friendly water. The ultimate aim is to create chemically defined protein conjugates that assist in developing an understanding of key biological processes, and also conjugates that could be used as targeted drugs in cancer and inflammatory diseases.

One project he's working on is to take reactions that have already been applied successfully to small molecules, and use them on proteins. 'This is usually extremely challenging!' Gonçalo explains. 'The reactions have to work under aqueous conditions and at physiological pH if the proteins are going to maintain their folding correct and retain biological function. We want to use very mild and efficient chemistry to modify proteins at pre-determined points on the chain.'

An example is the hematopoietic growth factor interleukin-7, which plays a pivotal role in aggressive T-cell acute lymphoblastic leukaemia, and some other cancers. Gonçalo wants to understand what happens to IL-7 after it binds to its receptor on the cancer cells. 'We don't know how it is taken up into

the cells, or even if it is taken up at all, or how trafficking between the cells works,' he says. 'We're trying to create homogeneous conjugates of IL-7 where we've made specific modifications at points of the protein that aren't involved in receptor binding, but will allow us to study what happens after it binds to its receptor. We then hope to use this information to devise delivery strategies for cancer-killing drugs using IL-7 to target the diseased cells.'

Antibody–drug conjugates can be used to direct highly potent cancer drugs precisely to cancer cells, but in order to release the drug, a chemical reaction has to take place once it reaches the cell to break the link between the antibody and the cancer drug. If he can work out where in the cell the protein ends up after it binds to its receptor, this will allow them to

design the conjugate in such a way that the linker between the two parts will break, releasing the drug molecule, in the right place at the right time.

He's also looking at small molecule drug conjugates. Antibodies have their drawbacks – they do not easily travel through the blood vessel walls into the disease targets, and typically only 0.1% of an injected antibody will actually reach the tumour. 'We'd love to be able to engineer small drug-like molecules or peptides that would find it easier to reach the diseased cells while sparing healthy tissues,' he says. 'But there are a number of challenges. Smaller molecules tend to be cleared from the circulation quickly, so we need to engineer them so they remain in the circulation for longer, reach the targets, and are taken up by the diseased cells.' This is particularly important if the drug target is inside the cell.

In some cases, however, the drug should not be internalised by the cell. 'Perhaps a cytokine could be conjugated to the targeting molecule, which would attract the body's own immune system to kill the cancerous cells,' Gonçalo says. 'In this case, we need it to stay outside the cell. But if it is designed to interact with DNA inside the cell, say, it needs to be engineered to be internalised by the target cell, and the linker will also need to be engineered so that it lets go of the cancer killing molecule at the right time, once it has reached the right place to have its effect.'

Vaccines are another potential use of the technology. In collaboration with Novartis Vaccines, he's looking to create glycoprotein vaccine candidates – proteins attached to sugars, essentially. 'The idea is to engineer defined glycosylated peptides based on disease-causing antigens that give an immune response,' he says. 'The normal way to do this is to attach the sugars to lysine residues on an immunogenic protein. There might be 50 lysines in the protein, so that's 50

Born: Lisbon, Portugal

Education: An undergraduate degree from the Faculty of Sciences, University of Lisbon in Portugal with a year in Oxford led to a DPhil with Ben Davis, followed by a brief postdoc.

Career: He moved to Berlin in 2008 on a Marie Curie fellowship with Peter Seeberger at the Max Planck Institute, before moving to the world of biotech at Portuguese-American company Alfarma in 2009. In late 2010 he returned to academia and Dario Neri's group at ETH, Zürich, developing an anticancer antibody–drug conjugate. He arrived in Cambridge in June last year as a Royal Society university research fellow, spending Monday to Thursday

here, before returning to his family in Lisbon, and the Institute of Molecular Medicine where he's the director of a new chemical biology unit.

Interests: He splits his time between Cambridge and Lisbon; his wife Filipa, also an Oxford DPhil chemist, will have their first baby this summer. In Lisbon, he lives by the sea and surfs every Saturday, and loves snowboarding in the winter. He's also fascinated by computer engineering, and founded a company in Portugal that makes hardware systems that monitor and control devices in real time.

Did you know? In his younger days, Gonçalo played roller hockey for Portugal, reaching the heady heights of U17 European champion.

Gonçalo Bernardes

CV

different glycoproteins that might be made, and each one can generate different biological responses. We're focusing on generating chemically defined protein conjugates whose activity will be much more specific.'

Another drug-related project, following on from some of the work he did during a spell in industry at Alfarma, is on CO-releasing molecules. 'Current technology to do this uses metal carbonyls that release CO only after they react

with albumin in the circulation,' he says. 'When these molecules dissolve in plasma they start to fall apart and react with exposed nucleophiles on plasma proteins. It is the slow release of CO from these newly formed protein adducts that accounts for the therapeutic CO observed in animal models of disease.'

Gonçalo is now engineering proteins to create chemically defined CO-releasing metalloproteins in vitro. 'We've now demonstrated that we

can release CO from them in live cells,' he says. 'CO is a signalling molecule, and we've shown it can also act as an immunomodulator, suppressing important markers of tumour progression in a mouse model. We've had some interesting results that we've yet to publish where the model mice were given our metalloprotein alongside standard of care. These early results on the combination therapy are very promising, and I'm excited to see where it will go.'

Chasing western Pacific storms

Neil Harris has just got back from six weeks in the western Pacific, coordinating a campaign to measure gases released by the ocean during the big convection storms that are common there in January and February. 'The sea surface temperatures are the warmest in the world, and it gets the most vigorous storms,' he says. 'The ocean releases gases containing chlorine, bromine and iodine, all of which can deplete ozone if they make it into the stratosphere. And this is the major time and place for them to get into the stratosphere.'

The lifetimes of these gases in the atmosphere ranges from a few hours to a few months, and so for significant amounts to reach the stratosphere they have to head up pretty quickly – so if they're emitted from the ocean during a big storm, they get up there in a few hours. 'We wanted to see how much was released by the ocean,' he says. 'We're particularly interested in bromine compounds, as if you add up everything known from human activities, there is still an unexplained fraction of stratospheric bromine. These storms have been proposed as the most likely cause.'

Three different projects were running at the same time. The UK one, which Neil was coordinating, involved the NERC research aircraft, the FAAM BAe-146, measuring gases low down in the atmosphere – the bottom five or six kilometres, including very low down near the ocean surface. The US National



Science Foundation's Gulfstream 5 aircraft made measurements from the top of the 146's range up to about 15km. The third craft was a NASA Global Hawk unmanned vehicle, a reconnaissance vehicle built for the military, which measured between 14 and 20km above the ground. It can stay in the air for a whole day.

'The idea was that we measured what went into the convection storms at the bottom, with the other two measuring what comes out at the top,' Neil says. 'The storms are enormous – the biggest ones reach heights of more than 15km.'

Just getting the short-range BAe 146 aircraft out to the base in Guam was a challenge – it took nine flights and five days to get there, with overnight stops in Italy, the Middle East, India and Malaysia. 'My main responsibility was coordinating with the other aircraft, and coming

The FAAM BAe-146 takes off above the US NSF's Gulfstream 5

up with flight plans on the ground,' he says. 'We had about 20 flights, and I flew on about a dozen of them. Other members of the department were also involved – Rod Jones had an instrument on board, and he and three of his group were out there at different times, and John Pyle's group are doing some modelling. About 10 other UK institutions are also involved; all of these measurement campaigns are very collaborative.'

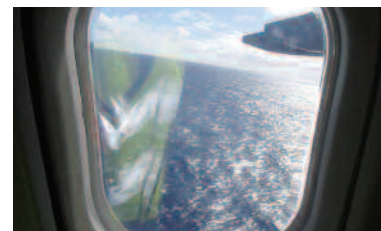
Although the main base was in Guam – a US unincorporated territory, which is small but reasonably affluent – the measurements were being made in more remote areas. 'We flew to a couple of small islands four hours away, landed and refuelled, and then flew further south to reach the equator,' he says. 'We stayed in these small islands overnight, returned to the equator the next day, and then headed back to the north.'

That was the plan – but it didn't always quite work out. 'Rod was stuck for a week on an island called Chuuk in the Federated States of Micronesia because of problems with the aircraft,' Neil says. 'There are 70 Japanese wrecks from World War 2 there, so the divers love it, but the island is really poor, and the potholes in the road so bad it takes a long time to drive anywhere in the tiny island. They saw a very different side to the region from Guam – one of the hotels there was also occupied by a lot of tropical wildlife! But Rod reports it was a great experience for team-building.'

There has been no campaign like this in the past because the region is so remote. 'It was an amazing experience, both in Micronesia, and Palau where we also stayed with the plane,' Neil says. 'Everyone there was extremely friendly and helpful. These islands are atolls and extremely flat, and so they are at real risk from climate change. And from a funding point of view, it was a real achievement getting three entirely separate but inter-related projects up and running in the same remote place at the same time.'

The UK team pose with the FAAM aircraft. Neil's wearing orange in the centre, and Rod's on the far right of the photo

Rod took this pic from the window of the aircraft. It's scarily close to the water – the front of the plane is 100 feet above the ocean, and the rear, where he was sitting, even lower!



A crystalline mystery...

New active drug molecules sometimes pose huge challenges to the formulators whose job it is to turn them into dosage forms that patients can take. Increasing numbers of exciting potential medicines have low solubility or other poor physicochemical properties, making it difficult to form crystals that will dissolve effectively in the stomach when they're made into tablets. Sometimes this can be fixed by turning them into salts, but if there is no acid or base functionality in the molecule, that's not possible – and even if it is, the properties might still not be right. An alternative is to make a co-crystal, where two different molecules are crystallised together. This alters the physical properties, while leaving the pharmacological properties unchanged.

Finding the right partner molecule isn't simple, though, and sometimes pairs of molecules that on paper look like they should form co-crystals refuse to crystallise. Bill Jones' group is looking to make it easier to pinpoint all potential co-crystals for an active drug molecule, and which would be best. 'Multiple groups had reported that a model system of caffeine and benzoic acid wouldn't form co-crystals,' explains Krešo Bučar, who's a Royal Society Newton international fellow in Bill's group. 'That was very curious, as the two molecules are equipped with the functional groups that should mean a co-crystal would form easily, and imidazoles like caffeine are often partnered successfully with acid molecules.'

To determine whether co-crystal for-

mation involving caffeine and benzoic acid is thermodynamically feasible, former Cambridge chemist Graeme Day, now at Southampton, also ran crystal structure prediction calculations that showed the co-crystal really ought to exist. 'We used fluorinated benzoic acids to make co-crystals with caffeine, because fluorobenzoic acids are very similar in size and shape to benzoic acid, and are expected to yield co-crystals that could be isostructural to the elusive target co-crystal,' Krešo says. 'And when we used these to seed crystal formation, it worked, proving this elusive crystal form does, indeed, exist.'

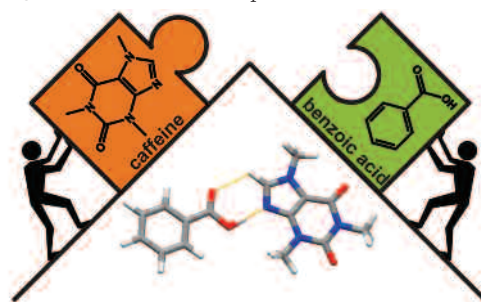
But that wasn't the end of the story. 'After we'd introduced the caffeine-fluorobenzoic acid co-crystals in the lab, we found that caffeine-benzoic acid co-crystals would happily form without using seeds at all,' he says. 'We assumed this must have been because only tiny amounts of the fluorinated seeds were needed to kick off the crystallisation, and some small and undetectable amounts of them must have contaminated the lab. This was very surprising to us.'

So they spoke to researchers at the University of Zagreb in Croatia, plus the University of Iowa and pharma company AbbVie in the US, and asked them to see if they could make the caffeine-benzoic acid crystals without any seeds. And they couldn't. 'We shipped them samples of our heteronuclear seeds, which enabled the co-crystals to form, and any attempts afterwards without the seeds also worked,' he says. 'Experiments at AbbVie

even showed that physical mixtures of caffeine and benzoic acid convert into the co-crystal within seconds after physical mixtures were exposed to the contaminated lab atmosphere! This is intriguing, because contamination of labs with crystal seeds has caused a lot of problems at some pharma companies in the past, even leading to product withdrawal.'

They're now trying to work out what's going on, and if the phenomenon is more widespread. They've identified other elusive co-crystal systems that might be expected to form, and are designing heteronuclear seeds to induce crystallisation. 'Ultimately, we want to be able to come up with guidelines for designing seeds that will allow co-crystals with better physico-chemical properties to be formed much more easily,' Krešo adds. 'Is the strange phenomenon we found with caffeine-benzoic acid generally applicable? And why did such small amounts of the seed change the outcome of crystallisation experiments that were performed afterwards? Caffeine and benzoic acid may not cure cancer, but it's really important to understand why some model compounds do not want to form co-crystals, which could help fix these issues for real drugs.'

Forcing co-crystals to form is not always as easy as it might be...



Atmospheric data curation

For someone who retired in 2007, Tony Cox remains remarkably busy in the department. He remains a member of the IUPAC Task Group on Atmospheric Chemical Kinetic Data Evaluation, which provides evaluated chemical data for atmospheric chemistry used in global, regional and urban climate and air quality atmospheric models, data which have never been more important than today.

'The group's activities go back to the late 1970s, when it was set up to provide international data for modelling ozone depletion, and I was one of its original members,' he says. 'Back then, CFC-based ozone depletion remained a theory, and the data enabled calculations to be made for models of the atmosphere in an attempt to predict future ozone amounts in the presence of CFC breakdown products.' At that time, there was no standardisation of data, and this was an attempt to do this, and supplement the data that was already being collated in the US.

Over the years, its remit extended to other atmospheric chemistry questions, covering stratospheric and tropospheric chemistry. 'As it

turns out, it was rather timely, as we're now even more concerned about climate and atmospheric pollution, and these data are extremely important in those studies,' he says.

When Tony moved to Cambridge in 1995, he teamed up with Glen Carver, and helped develop a web-based portal for the IUPAC data, which went live in 2000 as an efficient way of getting it all out into the community. With funding from the EU's Accent project, further developments and improvements were made to the database.

However, Glen moved on in 2012, and the IUPAC group was concerned about the future of the Cambridge website in the absence of funding from the UK research councils. CNRS in France offered to host the database at its data centre in Paris, and at the beginning of 2014 it officially moved over to its new home.

Of course, any database like this needs a constant stream of new evaluated data to keep it up to date, and Tony continues on the panel that provides it. 'If a new chemical reaction is discovered in the atmosphere, for example, we will look at data that will be needed by mod-

ellers,' he says. 'We also keep a close eye on the literature for any new experimental data that is published, incorporate it into the database, and make sure that the recommendations are kept up to date.'

The evaluations are also published periodically in the journal *Atmospheric Chemistry and Physics*, which provides hard-copy peer-reviewed versions of the material on the website. 'Six volumes have been published in the past eight years,' Tony explains. 'We have just heard from IUPAC that they have renewed the project's funding until the end of next year.'

And the future? Tony believes the scope will remain focused on the kinetics of gas phase, photochemical and heterogeneous reactions on atmospheric aerosols. 'There will be individual new reactions added, though,' he says. 'If a new pollutant thought to be significant, for ozone depletion, is discovered, we will certainly look at the data for it, and come up with recommendations. The database does not contain absolutely everything needed to model the chemistry of the atmosphere, but it's a fundamental part of it, and without it, we would not be in a position to carry out the important modelling studies that help us understand the changes in chemical composition of the air and climate.'

What's in your bones?

It's been known for years that bone mineral crystals comprise stacks of small, thin layers of calcium phosphate. But what's in between the crystals, holding them together to create bones, was unclear. Now, Melinda Duer's group has managed to find out – it's a gel-like 'goo' based on citrate.

'It was obvious that something bound the mineral platelets together tightly, but which had to have some sliding capability to give the bone its flexibility, allowing the crystals to move relative to each other, but also drag them back to their original starting place when they get moved out of alignment by external forces,' Melinda says. 'We thought it ought to be something that's flexible, so most likely something disordered and semi-fluid, but it wasn't clear what.'

Perhaps surprisingly, there is still a lot of conflicting data about the composition of bone mineral. Some suggest that it's predominantly hydroxyapatite; others think that at least half the phosphate is in the form of hydrogen phosphate, which is absent in hydroxyapatite; and it's known that there's a lot of water in there, but no-one has ever managed to pin down where it is.

None of the models satisfy all the requirements – but Melinda thinks her new model finally fits all the data we know about.

'About four years ago, one of my students, Erika Davies (now in a research position at the University of New South Wales), found an old paper in the literature about the formation of octacalcium phosphate with various different dicarboxylic acids incorporated in it,'

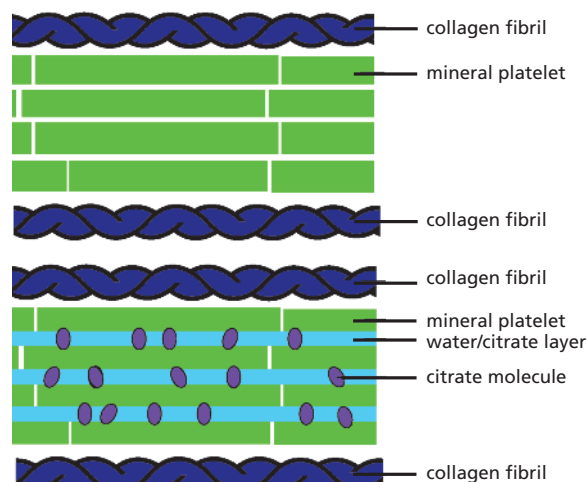
she says. 'There was a throwaway line in the paper that they'd tried citrate, but it gave a very disordered amorphous solid they couldn't characterise. We know there's a lot of citrate in bone, but not where it is. And this gave us an idea.'

Citrate has three carboxylic acids and a hydroxyl group, all of which can coordinate to calcium. 'We duplicated the literature experiment, and got the same apparently highly disordered solid,' she says. 'But its solid-state NMR spectrum was fascinating – half the signals were very sharp, and the other half incredibly broad. Our immediate thought was that there were two phases, yet electron microscopy experiments showed no suggestion of this – they said we had single crystals, with homogeneous size and shape distribution.'

They concluded that within both the octacalcium phosphate-citrate material and within bone crystals, there were regions of very solid plates of hard calcium phosphate, with gel-like mobile regions of citrate and water (and hydrogen phosphate) bridging the gaps between them.

'It works because citrate is an asymmetric shape, so even in an ordered calcium phosphate lattice, it will always create "holes" around it, which fill with water,' she says. 'The citrate can coordinate via any one of its four "arms", so can coordinate in many different ways. This means that region remains highly disordered and mobile – and crucially, non-solid.'

And that's probably a good thing for the health of our bones. Not only is the process by which large mineral crystals



form exothermic, risking causing nearby proteins (including bone's collagen matrix) to denature through heating, if bones comprised large solid crystals of hydroxyapatite they would be extremely brittle, and too weak to walk on.

The discovery might have potential in osteoporosis treatment, too. 'In healthy bones, the mineral crystals are formed in tiny tunnels between the collagen, where the citrate, calcium and minerals are forced together,' she says. 'Osteoporosis may happen because the holes in the collagen matrix are too large, allowing big, brittle hydroxyapatite crystals to be formed as the citrate can escape. Perhaps we shouldn't be focusing on building new mineral as an osteoporosis treatment, but building a new collagen matrix with the right sized holes for the citrate to be forced to be incorporated.'

Top: the old view of bone; below it, the new model

E. Davies et al. PNAS March 2014, doi/10.1073/pnas.1315080111

< continued from page 2

Could we appoint them five years ahead of a planned retirement and not miss this unique opportunity? It happens more often than you might think. The Next Generation lectureship scheme would enable us to be flexible and appoint exceptional scientists when we find them. This scheme would fund their initial salary; it would also be nice if someone gave a

Next Generation Lecturer a Next Generation Fellowship to boost their early research. And, of course, we don't exclude the possibility that a donor might want to fund an additional lectureship in perpetuity!

What about the building? Do we need investment there?

Absolutely. Lensfield Road is a very sturdy building dating back to the 1950s, so it's certainly not falling apart, but ensuring it meets the needs of modern research is increasingly difficult, and we want to move away from refurbishment and on to renovation. This will, clearly, require major investment, and not typically the amount of money a single donor would cover. But we do know that donors at different levels can make a huge difference.

We already have lecture theatres in Lensfield Road named after donors – Bristol-Myers Squibb, Pfizer and the Wolfson Foundation – plus, of course, the Unilever Centre for Molecular Sciences Informatics, and a seminar room named after the very generous donor Yusuf Hamied and his Cambridge mentor Lord Todd. When we move on to renovation, there will be a

huge opportunity for donors to help us.

In the near term, we have been raising funds for a Chemistry of Health building on the Lensfield Road site. With this building, we hope to achieve stronger interactions with industry, by encouraging industrial scientists to spend time in the department working alongside our staff on areas where chemistry can make real inroads into human health. This new building won't be the end, though – the ultimate aim is to make sure the whole department is housed in a way that is more fitting for the 21st century, and the exciting and important chemistry that is being done here in Cambridge.

For more information about how you might be able to help with our fundraising initiatives, please contact Daan at chemhod@hermes.cam.ac.uk – he would be happy to tell you more.

And if you're going to be in Cambridge for the Alumni Festival on Friday 26 September, do come and visit us! There will be a programme of talks and tours in the department that afternoon. Further information about the event and how to register will be in the next issue of Chem@Cam, and also on the department website nearer the time.

Next Generation Fellows past and present

Philip & Patricia Brown
Matt Gaunt
Silvia Vignolini

Walters-Kundert Charitable Trust

Jonathan Nitschke

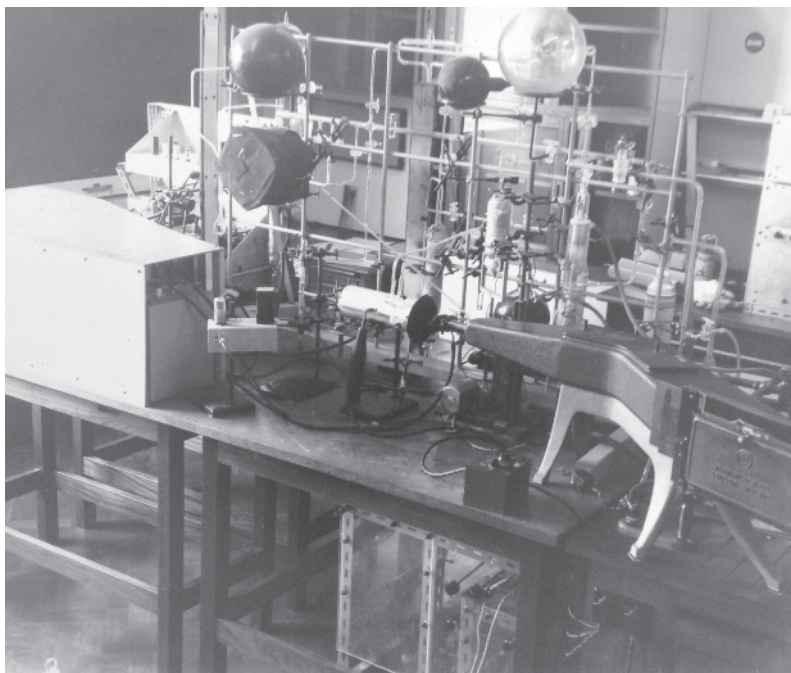
Frances & Augustus Newman Foundation

Carol Robinson
Oren Scherman

David Klenerman
Tuomas Knowles
David Spring

Welton Foundation
Sophie Jackson

Of princesses and ozone



Bob's apparatus in Lensfield Road, with ozoniser hidden safely under the bench

I was very interested in – and amused by – J.A. Green's article in the Autumn 2013 edition of *Chem@Cam*. I have to confess that the intervening years have removed my recollections of Dr Green, though I might cheekily point out that he has slightly demoted me by giving me only one 'eff' instead of two in my surname! I sometimes wonder what became of the third occupant of our lab. My recollection of Mike Osborne is that his appearances in the lab were sometimes sporadic.

As it is, I seem to have made something of a mark on the Department of Physical Chemistry in Lensfield Road – and it has left its mark on me. And like Dr Green, I too remember the intense colour of solid ozone.

Some months ago, an article in *Chem@Cam* drew attention to my being the only student in a formal 1960 photograph of the department who was not wearing a tie. As an aside, I have a memory of when Princess Margaret opened the new building. All the professors were lined up in the foyer, fully gowned and hooded. We research students were ranged round the back of the foyer, gowned but not hooded. My memory is the look on Princess Margaret's face as she came in – it was one of obvious uncertainty as to which way she was meant to turn.

Another memory is of the then Revd Hardy at Selwyn describing me as 'an earnest young man' so that, in self-defence, I do wonder whether I swore about the consequences of one of my little explosions. Tony Callear was also working with ozone at the time – did he not have any explosions?

On one of my explosions, a piece of the glass vacuum line landed rather close to a visitor. The mark that I have is of a scar on my right forefinger about an inch long, shaped like an elongated comma, the result of jabbing a piece of glass into my finger while repairing the vacuum line.

I married in 1957 after my first degree, and my wife and I were living in an upstairs flat in De Freville Avenue. Nature took its course, and we had to move to Barton to accommodate the newcomer. Indeed, by the time I took up a postdoctoral post in Liverpool in 1960, we had two daughters. Both of them followed me to Selwyn in due course to read biochemistry.

I might mention two other 'marks'. Having little money and no car, I had to cycle the three or four miles from the lab to Barton. On one occasion, I had to pass a car on Barton Road that was parked facing the 'wrong' way. No doubt being anxious about pulling out into oncoming traffic, the driver (I forbear to mention her gender) presented her bonnet to me, and I found myself spread-eagled on it. I still have a crowned tooth as a memento.

The other mark is one I made, probably on one of my explosive days. Being disheartened and facing into the wind, I was grinding my way uphill with my head down, with the result that I collided with a stationary car. That cost me. The car belonged to Robin Page, who was another inhabitant of Barton. His name may be familiar to some readers as a one-time presenter of the TV show 'One man and his dog'.

The only photograph I have is of my

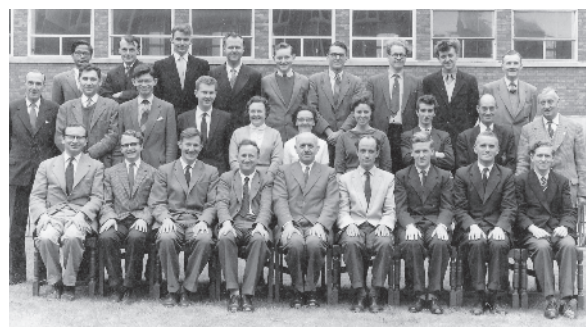
apparatus in Lensfield Road. The recalcitrant ozoniser is safely (sic) tucked away underneath the bench. At least, I had no problem with the other hazard on view, namely the bank of large condensers that were charged to a high voltage to generate the flash to initiate the flash photolysis. The HO₂ radical eluded me.

I think the glass shock tube explosion must have been before my time at Lensfield Road, I graduated in 1957, and the first months of my PhD research were spent in the basement of the department in Free School Lane. I had to dismantle the apparatus, and rebuild it in the new lab. This would have been in 1958.

The purpose of going to Liverpool was to combine kinetic spectroscopy with shock tube techniques. As the glass version indicates, the shock wave needs to flow down a vessel of constant cross-section. In order to have a sufficient optical path for spectroscopy, the shock tube I had in Liverpool was of rectangular cross-section. It was a copper wave guide. Unfortunately, on evacuating the low pressure side, the guide bowed inwards. This had to be rectified by glueing metal plates on the longer sides of the low pressure end of the guide. Operating the shock tube did cause a boom, but not a destructive one like the occasional one produced by ozone decomposition.

My family had some 'adventures' in Liverpool, but they are another story. Suffice to say that we rented a house in Penny Lane.

**Bob Tuffnell,
Long Bennington, Newark.**



Dear Editor

You were good enough to print a letter from my father, Dr. Byomkesh Biswas, in *Chem@Cam* Autumn 2010. Sadly, my father passed away some months ago, at the age of 85.

I am sending you this picture, because others in it may remember him well. It is of the Colloid Science Research Group back in 1960 or 1961, and my father is extreme left in the back row.

Best regards

Sanjoy Biswas

Is anyone else in the photo reading this? We'd love to hear from you!

Strictly chemistry?

Here at Chem@Cam, we love stories about the unusual things people do in their spare time. Rob Less definitely fits into this category – he's part of the Latin formation dancing team who are the current British champions.

Rob, a postdoc in Dom Wright's group working on dehydro coupling reactions for hydrogen storage, first took up ballroom dancing as a first year undergraduate more than a decade ago. 'This was before the Strictly Come Dancing phenomenon caused dancing to become really popular!' he says. 'The university dancing club is pretty big, and everyone around me seemed to be taking up dancing in my first term. So in the Lent term I went along to see what the fuss was about, and I've been hooked ever since.'

He started competing for the university ballroom dancing team during his PhD with Jeremy Rawson, but once he was no longer a student, it wasn't so

Rob pictured right with partner Rachel Hardisty (and trophy), and below in full formation action with the team



easy to carry on. Step up XS Latin (ex-student, geddit!?) – a Latin formation team invented as a way of allowing former students to continue with their competitive dancing. It meant a move from ballroom-style dancing to Latin (and more sparkly costumes!), but he loves it – and remains hooked.

Competition Latin formation dancing involves eight couples performing a six-minute routine, which has to contain elements of all five of the international competitive Latin dances – rumba, samba, cha cha, paso doble and jive. The routines are put together by the team's trainer/choreographer. 'He then gives us a hard time in training twice a week,' Rob says. 'The rumba is my favourite – probably because it's the slowest!'

The team won the British Championship late last year in Blackpool's Empress Ballroom with a

routine to music from Meatloaf. This is the sixth time they've been British champions, a record, and not only are they currently rated number 1 in the UK, they're highly rated internationally too. Next stop competition-wise is the European Championships in Germany in May, when they'll be dancing a new routine for the first time. This one has music by Shirley Bassey.

'Competing can be pretty stressful, as we've trained so hard for months and it all comes down to six minutes on the dancefloor, and you just hope nothing goes wrong,' he says. 'Anything can happen – you could miss a step, or someone might fall over, and all that hard work is for nothing. But once I'm on the floor, I find that autopilot kicks in, and I don't have to think about what the next step is. It's all about muscle memory, and not having to think about what you're doing – the training takes over.'

The team is always looking for new members, so if anyone in the department fancies giving it a go, give Rob a shout, or look at the team's website, xslatin.org. It even has videos of Rob and the team in action!

Once again, last December the South Cambridge Rotary Club borrowed most of the department's car park at the weekends so they could raise money for charity by charging Christmas shoppers to park here.

They report that of the £32,000 total raised by their various Christmas car parking schemes around Cambridge, nearly £5000 came from the chemistry department car park.



Readers with long memories may remember our pleas for members of the Lewis/Johnson group to get in touch as a 40th anniversary reunion was being planned. Somehow the report fell through the cracks, but we're pleased to say the reunion did indeed happen in November 2012, as Doug Yarrow belatedly tells us...

Dear Editor,

Many thanks for all your help in making contacts in advance of the Lewis/Johnson 40th Reunion. The event was a great success, with 20 of us sitting down for dinner in Jesus College. Unfortunately, Jack and Freddie were unable to stay with us for dinner, but they did enjoy the first 45 minutes over drinks meeting everyone again.

Jack was in very good spirits. Brian and Chris Johnson were with us throughout, with Brian in typically ebullient mood and little changed in physique or complexion from the Greek God of a centre-half who used to blunt opposition attacks in those classic inter-lab football encounters of the early

1970s (mind you, only Brian could remember this fact).

We even had colleagues from 1972 returning from the US, Portugal and Ireland. We also were able to make contact with several other colleagues from 40 years ago who sent on best wishes for the event but where logistics, and for colleagues in the US, the proximity of Thanksgiving precluded them from attending. Gerard Jaouen and John Welsman had hoped to be with us but unfortunately could not make it. The evening was so enjoyable that we have agreed we should have a 43rd Reunion in 2015! Therefore I would be grateful if you could include reference to this in Chem@Cam and ask any who were associated with Jack and Brian in or around 1972 to get in contact.

I was particularly disappointed unable to trace Colin Eady or John Segal, and hope if any of your readers have knowledge of them they could ask them to make contact.

Once again, thanks for all your help. I have been to other reunions where I had

not been sorry when the evening drew to a close. The measure of success of this one was that all of us felt the time had flown, and left wanting more.

Doug Yarrow

If you're holding your own reunion, do let us know and send us a photo! And, of course, if you need help tracking down your labmates for a reunion, we're always happy to print a plea...

L-R: Freddie Lewis, Jack Lewis, Doug Yarrow, Dave Howe, Pat McArdle, John Evans, Brian Johnson, Antonio Domingos, Jim Howell, Neil Connelly, Jonathan Ashley-Smith and Rob Edwards. Martyn Twigg was taking the photo!



Christmas cheer

The assistant staff Christmas party had an added extra this time, in the shape of the president of the university magic society amazing everyone with his sleight of hand. Nathan Pitt took the photos



Clockwise from above right: Claire Rutterford and Caroline Hancox are bamboozled by magician Evangelos Avgoulas; Vicky Spring, John Holman and Caroline Hancox; Andy Milner and Rachael Jefferies; Isabelle de Wouters and Daan Frenkel; Tony McPherson and Peter Wothers; Dave Plumb, John Davies and Roger Ward; Daphne Kaufhold and Glenda Harden



Last issue's solutions

ChemDoku Plus

The missing element in Keith Parsons' ChemDoku Plus was aluminium, with its atomic number 13 being the 'missing link' in the Fibonacci sequence, which all the other elements make up. A few readers had alternative suggestions! Correct entries came from Tim O'Donoghue (who claimed it was far from Alimentary this time), Richard Moss (who suggested that the missing element was krypton, named from the Greek 'kryptos' meaning 'the hidden one'), David Wilson, Mike Barlow, Paul Littlewood, Robert Broughton, Richard Brown (who says that looking back at his computer files, he was amazed to find that he has been whiling away his time on these puzzles since November 2003, but hasn't solved them all), Kim Whittaker, Tom Banfield, Bill Collier (who said the connection wasn't too difficult for anyone who has read 'The Da Vinci code' which, of course, features a Fibonacci sequence), Patrick Barrie, Karl Railton-Woodcock, Morgan Morgan, Diana Sandford (who says she recognised the sequence easily as she used to use the series as hotel safe codes while on holiday!), Ian Fletcher, Wendy Annan, Martin Robiette, Godfrey Chinchin, Robin Pope (who said it was mendelevium, as it was named after the chap who himself predicted so many missing elements in his memorable table), Paul Carr, Pat Lamont Smith (who suggested francium as the atomic numbers of Li and B add up to O, Se+Sc=Cs, and He+Fr=Se), Donald & Hazel Stedman, Audrey Herbert and Keith Parsons. And John Wilkins said he was struggling to complete the puzzle, but did work out the Fibonacci connection.

As Chem@Cam is currently in the depart-

ment, and 3000 miles away from Ginola the feline prize-picker (so, I'm afraid, Karl Railton-Woodcock's 'go kitty!' in his entry didn't work), we've had to resort to the more traditional bits-of-paper-in-a-Sainsbury's-bag technique. And the prize goes to... Martin Robiette.

An abundance of elements

This puzzle from David Wilson brought some interesting suggestions for high and low atomic values. John Wilkins suggests zirconia (Zr_2O_3 , 856) as highest, and the lowest he could come up with was uranium hexaiodide (UI_6 , -410). Paul Littlewood has zirconium diselenide ($ZrSe_2$, 550) and tetrauranium octadecafluoride (-530). Karl Railton-Woodcock, bemoaning the Australian heatwave while Chem@Cam was in the grip of the polar vortex, suggested $Zr(PO_4)_4$ at 1096 and $Y_5(P_3O_{10})_3$ at -570. Ian Fletcher suggests zinc nitride (Zn_3N_2 , 988) and phosphotungstic acid ($H_3PW_{12}O_{40}$, -1226).

Godfrey Chinchin confesses he failed to beat David's -413, but did rather better on the positive side, with an oxide of praseodymium, Pr_6O_{11} , which he calculates as 1286. Tim O'Donoghue, who says he was a member of the Lewis/Johnstone group, where colleagues were producing all sorts of clusters containing Os and CO groups, and Ru gives even better scores, so $Ru(CO)_{12}$ scores 744; he's also come up with -214 for an Fe macrocycle he synthesised as part of his research plenty of years ago. Robert Broughton has $ZrSi_2$ (742) and phosphotungstic acid again.

Richard Brown has zinc antimonide (Zn_4Sb_3 , 1297), and also says there are some 'rather silly' intermetallics, such as $Cu_{31}Sn_9$, or Chinese high tin bronze, which sums to 2782 but he's not sure it counts. He then also went down the osmium route with $Na_2[Os_4(CO)_{13}]$, a compound used in the synthesis of osmium cluster

compounds, which sums to -1002; he thinks there might be a potassium analogue, which would be -1056, but hasn't been able to confirm its existence; however, $K_2[(H)Os_4(CO)_{12}]$ does exist, and sums to -1043.

Julian Langston has an even higher one, with strontium ruthenium oxide ($Sr_2Ru_3O_{10}$, 1530), and matched Paul Littlewood's -530 with U_4F_{18} . Patrick Barrie, meanwhile, suggested a mineral found on the moon, $Fe_8Ti_3Zr_2Si_3O_{24}$, at 1641, and gives another vote to the far less exotic phosphotungstic acid.

But the winner is Keith Parsons, who managed to get by far the highest and almost the lowest numbers. Manganese carbide, $Mn_{23}C_6$, scores 3575. 'I didn't believe such a compound existed, and when I saw it first in my trusty 1940s inorganic chemistry textbook, I thought it must be a misprint,' he says. 'However, further searches revealed that it does exist.' And on the negative side, he suggests paratungstic acid, $H_{10}W_{12}O_{48}$, only 10 greater than the multiply suggested phosphotungstic acid. 'I have checked this on the internet, as it also seems a most unlikely compound,' he adds. Unlikely, maybe. But it's enough to win you the prize!

Who's who?

This one offered a little light relief after the brain-mangling inorganic salts of the previous puzzle - Alan is the protein chemist, is a fellow of King's, and drives a red car.

Correct solutions came from Richard Moss, David Wilson, Paul Littlewood, Robert Broughton, Richard Brown, Kim Whittaker, Tim O'Donoghue, Julian Langston, Bill Collier, Patrick Barrie, Karl Railton-Woodcock, Ian Fletcher, Wendy Annan, Martin Robiette, Godfrey Chinchin, Paul Carr, Pat Lamont Smith, Audrey Herbert and Keith Parsons. And the prize goes to... Wendy Annan. Congratulations!

This issue's puzzles

Pascal's triangle

Here's another brain-boggler from David Wilson... possibly a little less complicated than his abundant elements? Readers will be familiar with Pascal's triangle, in which each term in a given line takes the value of the sum of the two terms above it, thus

```

1
1 1
1 2 1
1 3 3 1

```

If the triangle is extended and these numbers are taken to be atomic numbers (so replace 1 by H, etc), what are the elements in the last permissible line of such a triangle, for known elements?

But David suspects that's too easy for C@C readers. So here's another Pascal's triangle, with some elements entered in. The catch is that the elements a, b, c, d and e have been entered after being transformed into a different element by a simple chemical rule, before going on to calculate the next line. Element x is not subject to this rule. Deduce the rule, and identify the elements.

```

      H
     H H
    H a H
   H Ne Ne H
  H b c b H
 H Ar d d Ar H
H e x Cf x e H

```

Sounds simple enough... well, actually it doesn't! Get those brain cells working, and good luck...

Double killer ChemDoku

Our other David puzzle-setter, David Thompson, has come up with yet another ChemDoku alternative. After his killer ChemDoku a couple of issues ago, he's made it even more complicated. This time, there are no internal 'cages' telling you which squares make up the groups whose atomic numbers add up to that of the element in the top left corner - just those top-left-corner elements. There are no single letter cages and, as a hint, Li can only be made from H+He (or, of course, He+H!). David says the idea of the transmutation of the elements may give some readers who do not possess a Philosopher's Stone some food for thought. Normal ChemDoku

rules also apply - so each row and column and 3x3 block can only contain each of the first nine elements once.

Ti	Ca			Al		N		O
		Ca		F		Si		
	O			Be	Al	Li	V	
	Si							Ne
Ca		Li		Ar				
		Ca	Cl	N		Ca		Al
O				Mg			Li	
B	Al		F		O	Si		
		Na					S	

Email your puzzle entries to jsh49@cam.ac.uk, or you can send them by snail mail to Chem@Cam at the address on p3



So that's what the ocean emits during storms!



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