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Chemistry at Cambridge Magazine

SPRING 2016 | ISSUE 53

Yusuf Hamied receives first Chemistry Alumni Medal

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Chemistry Open Day 2016

Women in Chemistry: Ruth Lynden-Bell

How many ways can you arrange 128 tennis balls?

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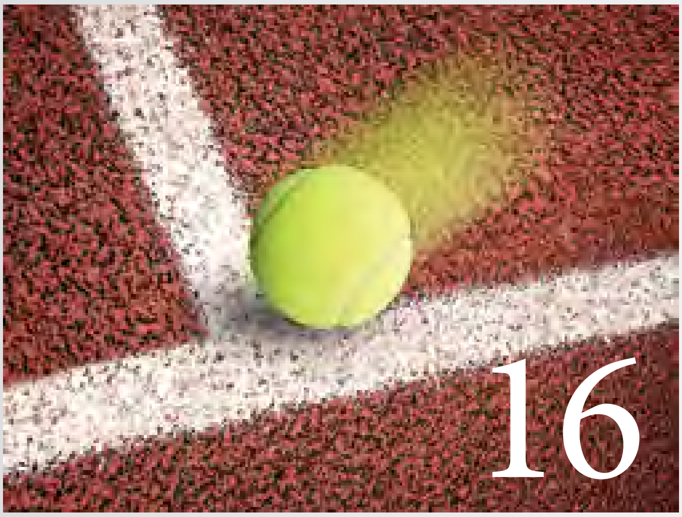

How many ways can you arrange 128 tennis balls?

Welcome

to the Chemistry at Cambridge Alumni Magazine

Welcome to the Easter term issue of Chem@Cam. The last three months have been exceptionally busy, not just for me, facing only my second turn of the editorial wheel, but also for the department – it was events season. In March we hosted the ever-popular Chemistry Open Day for the annual Cambridge Science Festival. Dr Peter Wothers and team entertained and educated visitors with his demonstration lecture, 'Just Add Water', which he delivered three times on the day and five more times over the course of the festival! The Salters' Festival chemistry challenge coincided with the arrival of Dr Yusuf Hamied, who was in the department to receive the first Chemistry Alumni medal.

Our researchers have continued to deliver breakthrough stories: neurostatins for neurodegenerative diseases, photochemical cells for sustainable energy and even using theoretical physics to answer the complex counting problems that are found in materials chemistry.

In this issue we also have correspondence from Professor Robin K. Harris who matriculated in 1958. Interestingly, Robin is a contemporary of Professor Ruth Lynden-Bell, who features in 'Women in Chemistry', a new section that highlights the achievements and successes of women working at all research levels and in other areas in the department. Enjoy.

Carmen Pryce
Editor

On the cover....

2016 Alumni Medal

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Views expressed in this magazine are not necessarily those of the Editor, the Department of Chemistry or the University of Cambridge

Chem@Cam is produced on behalf of the Department of Chemistry by CUDAR

Printer:Hobbs the Printers

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Department of Chemistry, University of Cambridge
Chem@Cam is published three times per year, two hardcopies and one email version, and is sent free to chemistry alumni, postdoctoral researchers, retired staff and friends of the department.

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Q&A

Peter Wothers

Dr Peter Wothers, a celebrated teaching fellow in the department who has made numerous television appearances as a chemistry specialist, took to the stage during the 2016 Cambridge Science Festival.

He delivered his demonstration lecture 'Just Add Water' eight times during the festival, including two exclusive schools performances to years five and six which left over 800 nine- to ten-year olds (and a few science teachers) gob-smacked and enthused in the BMS lecture theatre. The lecture explores some of the surprising properties and reactions of water, the world's most ubiquitous substance.

Peter, who was awarded the Royal Society of Chemistry's Nyholm Prize for Education in 2013 and the MBE in 2014, gave us this Q & A in between lectures on Chemistry Open Day, March 12.

What is your earliest memory?
I come from a farming background and I can remember visiting my uncle's farm when I was quite young. That's probably my earliest memory.

What did you want to be when you were growing up?
A chemist! In fact, I remember being interviewed for secondary school and telling the headmaster that I wanted to do chemistry experiments. He later told my parents that I was completely bonkers and that 'kids say all sorts of silly things'. I sometimes think about going back there to give a talk…

What makes you happy?
Chemistry. It gives us an understanding of the world that's very different to other sciences – it's all about the substances, the test tubes, the smells, the colours. I love understanding molecules and how they interact in the world around us. I find it very, very exciting – still. That's what attracts me to teaching: the opportunity to share my passion for this subject that I love so much.

Which dead scientist do you most admire?
Humphry Davy has got to be up there. He not only discovered lots of new elements, but he also saved thousands of lives with his miner's lamp. When I gave the Royal Institution lectures (editor's note: Peter presented the RI Christmas Lectures in 2012) I was able to handle a set of lecture notes that had been hand-written by Michael Faraday when he attended Davy's lectures. To hold those accounts in my hands was so exciting. I think it's the biggest shame that he doesn't have an element named after him.

What is the trait you deplore most in chemists?
From my perspective as a teacher, it's when things aren't presented clearly. Being a good researcher is very different from being a good teacher and the two don't necessarily go together, so sometimes when things aren't explained as straight-forwardly as possible that bothers me.

What's your most embarrassing moment on stage?
Things don't necessarily go as planned and

there's always something that doesn't quite work. You're constantly thinking 'Is this on? Is this hot enough? Is the next experiment ready?' and through all this you're meant to be narrating a story. Sometimes you forget what you're talking about because you're actually thinking two experiments ahead. That's what makes it challenging, but also what makes it interesting. Fortunately the only minor mishap was when the tubing came off a gas tap and lit; not too bad considering some of the more crazy demos we do!

What is your most treasured piece of lab equipment?
I'm very interested in the history of chemistry, so I was excited to get an original Döbereiner lamp, which is a mid-19th century version of a cigarette lighter. It generates hydrogen gas by reacting zinc with acid, which is then passed over platinum gauze. The gauze glows, which sets fire to the hydrogen and gives you a flame. It's hugely inconvenient, not at all portable and slightly liable to explode.

What is the closest you've come to death (Döbereiner lamp notwithstanding!)?
Probably some of the dangerous reactions I deal with. However, I have a healthy respect for the substances I work with and always allow for the worst to happen.

What do you most dislike about your appearance?
The mass/time graph has not followed the desired trend!

Who would play you in the film of your life?
Leonardo DiCaprio.

What is the worst job you've done?
Pea-picking – it's so much worse than potato picking. That may be back breaking, but eventually you get into the swing of it and there are only so many potatoes you can pick before filling a sack. With peas, each sack takes so long to fill!

What was your biggest discovery?
It's nice to come up with a new way of explaining something. It's particularly satisfying when, after hearing a concept explained well, people say 'Oh, that's obvious.' In fact, it's only obvious because you've spent a lot of time thinking about it and working out how to present it in a clear way.

What's been the hardest thing that you've done?
Organising the 2009 International Chemistry Olympiad, alongside Emma Powney (chief organiser of the Chemistry Open Day). I have never been so exhausted!

Why do you do these demonstration lectures?
To get kids excited about science, particularly because I was hooked from a young age myself. They love the bangs and flashes, but I hope they also learn something about science.

Letter from the Head of Department

I am writing this a few days after the presentation of the Inaugural Department Alumni Medal to Dr Yusuf Hamied. This was a wonderful occasion, with some excellent talks, a glowing tribute from the Vice Chancellor and a dignified, inspiring speech from Yusuf. He is the perfect recipient of this first award. He and his wife Farida have been extremely generous to the department over the years, for which we are so very grateful. However, the Alumni Medal is not awarded for philanthropic work but instead will go to a chemistry alumnus or alumna who has made a massive difference to the world. Yusuf's work with Cipla, in making generic antiretroviral drugs for HIV available at less than a dollar a day, has been truly heroic. It has made a massive difference in the developing world and today many thousands of people owe their lives to him. We in the chemistry department are proud to call Yusuf one of our own.

The event caused me to muse on the nature of 'impact', by which government increasingly wants to measure performance. The department's research base is incredibly wide ranging, from studies of molecular structure and the concomitant very short time scales, to research at the other end of the space and time spectrum on global change and degenerative diseases. Our impact cases for the last REF reflected this impressive range – from single molecule research, which has led to a huge industry in genome sequencing, through impacts as diverse as the design of drugs and lubricants, to policy impact via the Montreal Protocol. Nevertheless, true impact cannot be achieved without superb fundamental science and transformative impact is often driven by serendipitous science (usually many years later).

Yusuf told us how much he owes to Lord Alexander Todd with whom he did his PhD. I'm sure that Todd's work on vitamin B12 would have led to an impressive impact case. But how do we measure the impact of Todd on Yusuf? Surely, our influence on the next generation is the most important thing we pass on. We lose sight of that at our peril.

There have been other causes for celebrations during the Easter term. We heard in April that we had received the Athena SWAN Silver award, a really important signal and recognition of the superb efforts by many people in the department to address equality and diversity. There was success too with the Silver Green Impact award. Most recently we have celebrated the accolades given to a number of academics. Chris Abell and David Wales are newly elected Fellows of the Royal Society, Daan Frenkel has become a Foreign Member of the National Academy of Sciences and Jason Chin is a new Fellow of the Academy of Medical Sciences. So, the department is in good health.

There is no room for complacency and much work to be done to maintain our high international standing. The department still produces outstanding PhD students, who go on to do great things in academia, industry and life. We currently have nearly 300 PhD students but the reality is that very few are now funded through the old, traditional Research Council route. It's another area where we in the department have to work hard to maintain our research and training base and where we would be delighted to have your help.

Yours,

Salters' Festival 2016

A group of 80 school students, aged 11–13, recently enjoyed a day in the department taking part in fun practical experiments, and carrying out investigations 'like real chemists', as part of the Salters' Festival of Chemistry. The aim of this event, sponsored by the Salters' Institute and supported by the Royal Society of Chemistry, is to inspire young people to enjoy chemistry.

20 schools from the east of England were represented by teams of four pupils at the Cambridge event on 17 March. The teams competed in two different challenges, both of which tested their analytical chemistry skills. The first, 'Murder comes to Salterstown' had them cracking codes, performing paper chromatography and tackling a series of test tube experiments in order to solve a murder mystery. For the second University challenge, designed by members of the department, the students used a chromatography column to separate a mixture of food dyes into their constituent colours.

The competition concluded with a prize-giving ceremony. The Salters' Challenge winners were Catmose College, Oakham, followed by The Perse School and Parkside Community College (both Cambridge). The University Challenge was won by Trumpington Community College, Cambridge, with Culford Preparatory School, Bury St Edmunds, taking second and Stowupland High School, Stowmarket, in third.

Once the challenges had been completed the group were treated to a performance of Peter Wothers' demonstration lecture, 'Just Add Water', which was enjoyed by all.

Green Impact Silver Award

The department has been awarded a Green Impact Silver Award. The 'Chemistry Green Imps' team, led by Dr Richard Turner, has been working to achieve the Green Impact Silver Award, after gaining Bronze in 2014-15.

Green Impact, a National Union of Students programme coordinated by the environment and energy section of the University, is an environmental accreditation scheme aimed at encouraging individual departments and colleges to reduce their impact on the planet. To gain the Silver Award, the team had to demonstrate cultural and behavioural changes within the department across a range of areas, from waste management to laboratory practise to travel.

Richard, who provides analytical, chemical detection and synthesis equipment support to the Ley research group said, "I am so happy to be part of this winning team and for achieving this. Congratulations and thanks to everyone for your efforts and support, both large and small."

The Silver Award will be accepted by Richard on behalf of the department at the Green Impact Awards Ceremony on 2 June 2016 at the Old Schools Combination Room, and will be presented by Dame Fiona Reynolds, DBE.

The department Green Imps: L-R Michelle Cain, Richard Turner, Peter Lumb (Estate Management) and Krishma Sharma.

Steve Ley Symposium

On April 8 Professor Steven Ley celebrated his 70^{th} birthday with a one day symposium held at the Department of Chemistry. Professor Matthew Gaunt organised the event, which included a keynote speech by Nobel laureate Robert H. Grubbs from Cal Tech.

The symposium highlighted the outstanding career and achievements of Professor Ley, focusing on his significant contributions to the fields of flow chemistry, catalysis, natural product synthesis and medicinal chemistry.

The BMS lecture theatre was full. Over 120 former students returned to the department for the event. Ley Group member Claudio Battilocchio reported that it was a fantastic celebration: "So many people attended, not just for the science, but for the wonderful person that Professor Ley is." Professor Ley, known as the Father-Doctor within the group, said to the attendees, "You have all been a big part of my life, I hope I'm only a small part of yours."

Ley joined the department in 1992, filling the prestigious 1702 Chair of Organic Chemistry (later the BP (1702) Chair). He supervised the education of more than 200 graduate students and 250 postdoctoral research associates over the course of his career, many of whom have gone on to significant posts in academia and industry.

Professor Ley's long list of honours includes a CBE in 2002, the Royal Medal in 2011 and the RSC's Longstaff Prize in 2013. His name appears on The Times list of the '100 most important people in British science 2011'.

Professor Steven Ley timeline

- **1969:** BSc, Loughborough University
- **1972:** PhD, Loughborough University
- **1972-74:** Postdoctoral researcher, Ohio State University
- **1974-75:** Postdoctoral researcher, Imperial College
- **1976-83:** Lecturer, Imperial College
- **1983-92:** Professor of Organic Chemistry, Imperial College
- **1989-1992:** Head of Department, Imperial College
- **1990:** Elected FRS
- **1992-2011:** Head of Organic Chemistry, University of Cambridge
- **1992-2013:** BP (1702) Professorship of Chemistry
- **2002:** CBE Commander of the British Empire
- **2005:** F.Med.Sci The Academy of Medical Sciences
- **2009:** C.Biol. FRSB Fellow of the Royal Society of Biology
- **2013-2017:** Director of Research, University of Cambridge

First Lord Lewis Research Studentship in Chemistry

Aurimas Narkevicius will become the first candidate to receive the Lord Lewis Research Studentship in Chemistry. He will take up the position in October 2016.

The studentship was created after the Lord Lewis Memorial Symposium in 2015 and is funded jointly by the Department of Chemistry and Robinson College. Aurimas will be based at Robinson College.

The studentship fund already stands at £230,000. The department hopes to establish a permanent endowment, which will allow outstanding PhD candidates who could not otherwise be funded to study chemistry at Cambridge.

Jack Lewis was an exceptional mentor, an insightful scientist, and exerted a great influence on science in the department and beyond. He became the first Warden of Robinson College, overseeing the construction of the main buildings and the establishment of its academic and social structure.

Athena Swan Silver Award

The Department of Chemistry has achieved the Athena SWAN Silver Award, which recognises commitment to tackling gender inequality in higher education.

Athena SWAN committee chair Dr Nick Bampos thanks everybody in the department for their considerable effort and commitment to this process.

Head of Department Professor John Pyle said, "This is quite wonderful news and recognition of the superb efforts that have been invested by so many people to make the department a more inclusive, supportive and rewarding environment in which to work."

Some of the initiatives developed as a result of Athena SWAN include pro-active recruitment and promotion, the introduction of a mentoring programme, and the adoption of family friendly working hours and practices.

Both John and Nick acknowledged the hard work of Professor Jane Clarke and Support Services Manager Marita Walsh, who started the endeavour and worked tirelessly to support the department throughout its Bronze and Silver submissions.

The Athena SWAN charter was established in 2005 to address gender related issues in the STEMM subjects (science, technology, engineering, maths and medicine) from undergraduate through to professorial level. In 2015 it was extended to arts, humanities, social sciences, business and law for the first time.

The Charter is owned and managed by Equality Challenge Unit (ECU), which promotes equality and diversity in universities and colleges. Ruth Gilligan, ECU's Athena SWAN manager, said, "Our Athena SWAN Charter is a catalyst for real change within individual departments and whole institutions."

The award was presented at a ceremony at the University of Sheffield on 30 June.

Equality Challenge Unit: www.ecu.ac.uk

Athena SWAN charter: www.ecu.ac.uk/equality-charters/athena-swan

Twists and Turns

Professor Jane Clarke FRS spoke on 10 March at Lucy Cavendish College on the "twists and turns" in her protein folding research, as well as her journey into a science career. The talk was followed by Jane's admission as an Honorary Fellow at Lucy Cavendish College.

Jane highlighted the variety and diversity within science and among scientists. Jane said, "You can't put science and scientists into boxes," and went on to explain that although she's in the Department of Chemistry, her research area is molecular biophysics and is funded by the Wellcome Trust, a medical charity.

Jane stressed that she is not focused on looking for cures for disease. Instead, she is interested in understanding the fundamental processes: how proteins fold and why and how one sequence folds to one structure and how that structure gives a protein its function. "Understanding why proteins don't normally misfold may shed some light on the processes which go on to cause disease," said Jane.

Jane explained how she came, almost by accident, to her research career; she started her PhD aged 40, which some people thought was too old, but she maintained her ambition. Jane is now Professor of Molecular Biophysics in the department and a Fellow of the Royal Society. She is also involved in mentoring, career development and leadership training for scientists at all stages in their careers. Jane is particularly keen to ensure that girls and young women have every opportunity to have a career in science.

Jane has received numerous awards for her protein folding and misfolding research. Most recently she was awarded the Pauling Medal by Stanford University, and the Stein and Moore Award by the Protein Society, which "recognises eminent leaders in protein science who have made sustained, high impact research contributions to the field". Jane, a former Deputy Head of Department, is quick to share the honours bestowed on her commenting, "It's wonderful but it's recognition for all the people that I've worked with, my friends and colleagues and all they've done."

Equality and Diversity

Equality and Diversity was the focus of two events held in the department on Thursday 11 February.

The first event was a lunchtime talk given by Dr Fionnuala Murphy and Dr Roger Kievit of the MRC Cognition and Brain Sciences Unit, organised by Athena SWAN. The two speakers gave a compelling (and often amusing) review of research into sexism in academia and, after a stimulating 20-minute Q&A session, the discussion continued over a lunch with all the attendees.

In the evening, all postgraduate students, postdocs and academics were invited to the Cybercafé for the Departmental Winter Mingle, organised by the Graduate Chemistry Social Committee. As department members chatted over drinks and snacks, they were invited to help illustrate the wide diversity of nationalities within the department by putting a pin in a world map to show which country they were from. By the end of the event, the map had become a celebration of one of the many strengths of this department: its diversity.

Everything you always wanted to know about climate science*

*But were too afraid to ask!

Dr Michelle Cain, a postdoctoral researcher in atmospheric chemistry, spoke about extreme air pollution and climate on 10 March as part of the Cambridge Science Festival. The interactive discussion, with a well-informed audience, ranged from the importance of methane as a greenhouse gas to the difference between weather and climate.

Other speakers included Dr Tom Bracegirdle from the British Antarctic Survey and Dr Peter Hitchcock from the Department of Applied Mathematics and Theoretical Physics.

Correspondence

Dear Ed.,

I noticed the short article by Tony Kirby in issue 52. This appears to contain an error, since it says (or at least strongly implies) that in his PhD days Lensfield Road was "without NMR". I was an exact contemporary of Tony and did my PhD under the supervision of Norman Sheppard – on NMR.

The spectrometer (a Varian 40 MHz system) had been installed in the basement of the department at least a year before I started my PhD, that is by 1958 at the latest. Indeed, Colin Banwell and Jim Turner were already in the second year of their PhD studies, based on NMR, when I started research in 1959 alongside Ruth Lynden-Bell (Truscott as she was then). Eric Liddell was the technician who ran the service.

Maybe we could jog Tony's memory. Of course, it is possible that he never personally made use of the NMR service?
Yours sincerely,

Professor Robin K. Harris
Department of Chemistry, University of Durham

Chemistry Open Day

The chemistry department threw open its doors once again this year as part of the Cambridge Science Festival. Donning labcoats and goggles, children and parents alike dove into the magical world of chemistry to explore hands-on what makes our world tick.

Children gasped and gagged at exploding bicarb volcanoes, colour-changing carbon dioxide lava lamps and bouncing blue goo. The more mature marvelled at their forensic prowess as they coaxed DNA from strawberries and, as always, Dr Peter Wothers' 'Just Add Water' lecture did not fail to raise shrieks of laughter and surprise.

Thanks once again to Emma Powney for coordinating this epic event and to all the undergraduate, PhD, postdoctoral and other staff volunteers who donated their time to make it a resounding success. Special thanks also goes to the Walters-Kundert Foundation for its crucial financial support.

Madeline Kavanagh, PhD Student

Reisner Group Activity

In a fun-filled atmosphere of hands-on science education, the Reisner group's contribution aimed to raise awareness of the benefits of solar power, and introduce the concept of storing this energy as solar fuels for later use in the absence of sunlight. We presented a series of activities, from fruit and vegetable batteries to hydrogen-powered cars, designed to illustrate the principles behind solar fuels, and demonstrate the feasibility of this technology. The remote-controlled cars drew the initial attention of many of the younger guests, but it was often impressive to see just how much they already knew. Many thought-provoking questions tested our understanding and our ability to communicate with both young and old alike. Parents showed their interest, with topics ranging from hydrogen-powered submarines to awareness of environmental issues and how these may affect their children. Overall, the day of interaction proved a remarkable success in stimulating interest in many areas of chemistry and communicating how scientific understanding is being employed to address the future energy challenges society faces as a whole.

Kristian Dalle, Postdoctoral Researcher







Yusuf Hamied receives first Chemistry Alumni Medal

Dr Yusuf Hamied was awarded the first ever Department of Chemistry Alumni Medal in a ceremony on 17 March 2016. The Vice-Chancellor of the University of Cambridge, Professor Sir Leszek Borysiewicz, presented the medal "for services to the community that have brought honour to the Department of Chemistry".

As CEO and Chair of the Indian pharmaceutical firm Cipla, Dr Yusuf Hamied campaigned to provide low-cost generic antiretrovirals to people primarily in sub-Saharan Africa with HIV and Aids, reducing the cost from $15,000 to $350 per person/year, or under a dollar a day. These actions saved millions of lives, and were memorialised in the internationally acclaimed documentary *Fire in the Blood*.

Head of Department Professor John Pyle hosted the ceremony, which included talks by Professors Christopher Abell, Christopher Dobson and Clare Grey on their high profile research. Chris Abell, a Fellow at Christ's College, also talked about Yusuf's happy and productive time there as a young Chemistry undergraduate and graduate student in the 1950s.

In his acceptance speech, Yusuf spoke movingly about the lifelong influence of his chemistry supervisor and mentor, Lord Alexander Todd, and reminisced about his first encounter as a young student in 1953 with Todd in Mumbai. When asked if there were any special qualifications required for admission Professor Todd replied, "We have no rules, we admit anyone whom we consider suitable to be a student." How times have changed.

Yusuf also recalled the many other notable scientists and teachers who influenced him, including Professor Ronald Norrish, Dr Herchel Smith, his senior tutor Dr Lucan Pratt, and his contemporaries, now Emeritus Professor Ian Fleming and Dr Mike Blackburn.

Yusuf reminded the audience about the wave of scientific associates called the "Toddlers" who arrived from Manchester with Todd in 1942, and introduced one of the original Toddlers, Professor Cedric Hassall, who was in the audience. Professor Hassall, 95, then presented his "Toddler Tie" for the Todd-Hamied seminar room, which has a display of Todd memoriabilia. Yusuf said, "Its presence will provide us with an indelible link to the glorious past history of this great chemistry department."

Yusuf also spoke about critical issues in healthcare such as antimicrobial resistance, resistant TB and cancer, and the huge healthcare divide between the developed and undeveloped world. After hearing Dobson's talk, Yusuf added Alzheimer's and other protein misfolding diseases to the list, and said: "lives cannot be sacrificed at the altar of corporate profit and greed... the overall achievement of an industry, company or an individual cannot be judged by monetary gain, but by the capacity and capability to contribute towards the moral and social obligations to society."

Lastly Yusuf paid tribute to his parents and the department saying, "My parents gave me life. Cambridge educated me, taught me how to live, and how to contribute to the world. I will always be indebted to this great institution and what it stands for."

A reception for Yusuf's family, friends, associates and members of the department was held after the ceremony in the Todd-Hamied room.

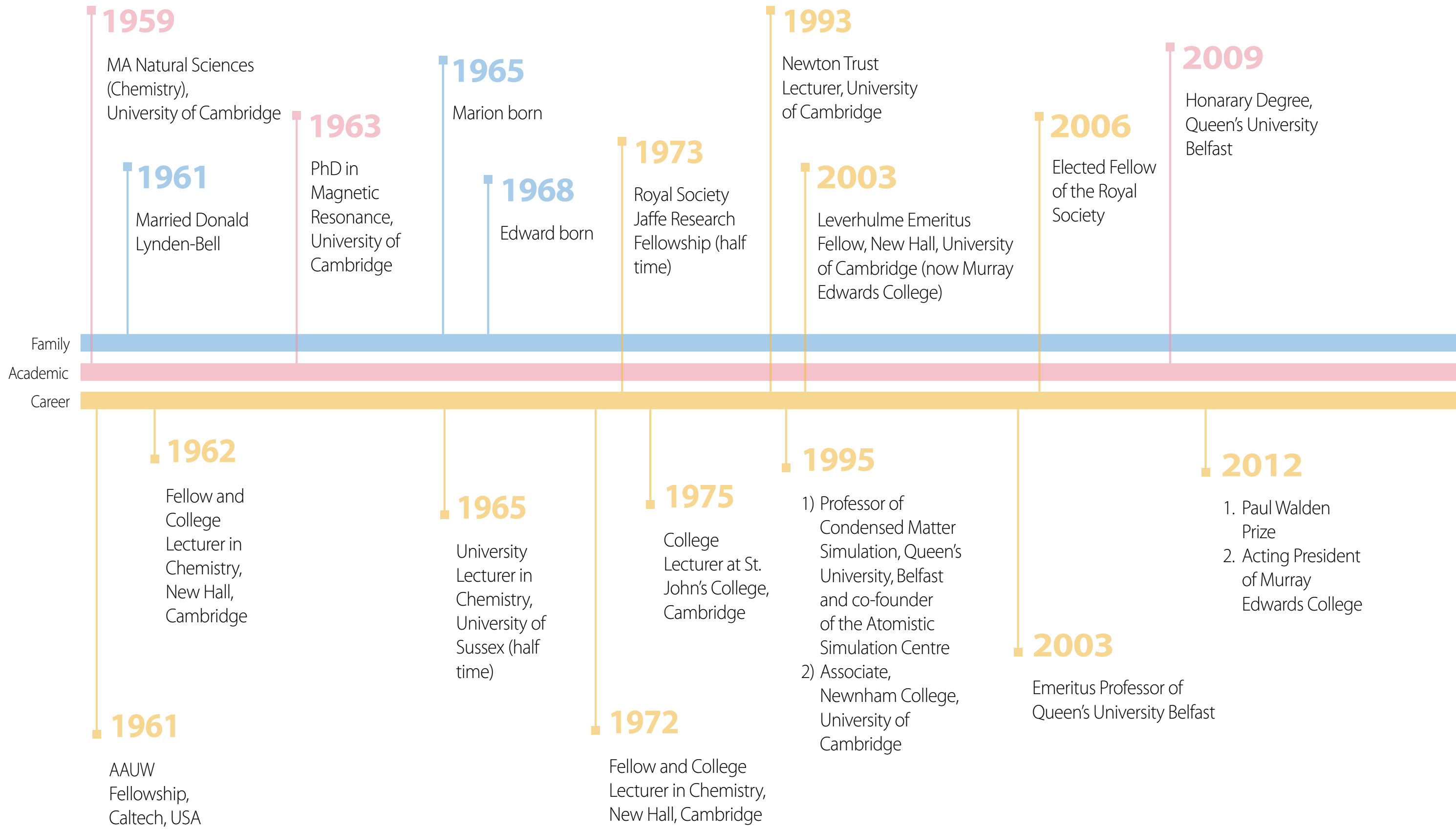
Ruth Lynden-Bell

Women in Chemistry

This feature started life on our website to highlight the achievements and successes of women working at all research levels in the department. Here we talk to Ruth Lynden-Bell, Department of Chemistry alumna and Professor Emerita of Queen's University Belfast. Ruth is now a long-standing visiting professor. We asked Ruth how it felt to be a woman chemist in the fifties and how motherhood impacted on her work.

"I'm in the same year as Ian Fleming and Tony Kirby (fellow emeritus professors). I think there were three women doing Part II, if I remember rightly. Then when I became a graduate student, I was probably the only one, I couldn't swear to that. But I stayed at Newnham College (women only) where I'd been an undergraduate, so I had a lot of friends who were doing PhDs, although not in chemistry - in other science departments and the arts. For me the women's college, and there were only women's colleges then, provided very good support and was a very different environment from the department. But it's also true that if there's only one of you, you don't notice you're different. It's when you get more than one you start to notice.

"My research supervisor, Norman Sheppard, who died last year at the age of 93, was always very careful to make sure when we had visitors that it was clear that I was a graduate student. And the other thing is that being a member of a women's college, the people who supervised us were all people who wanted to teach women and were quite prepared to treat us equally. It was only later, in the 70s, when there were a lot more women and there were mixed colleges that some women felt that they didn't belong.



ABOVE: Timeline taken from the book Parent Carer Scientist, The Royal Society, in which Ruth's life in chemistry features.

"I would say my generation never had any feeling that we didn't belong. I think that was one of the strengths of the women's colleges. We could see successful women academics. All the fellows were women and they were academics. It was important for me as a research student to have the network and the social life of the college, to meet other research students in college as well as here in the lab."

How did motherhood affect your career?

"Well, what I did was to work part-time for a number of years.

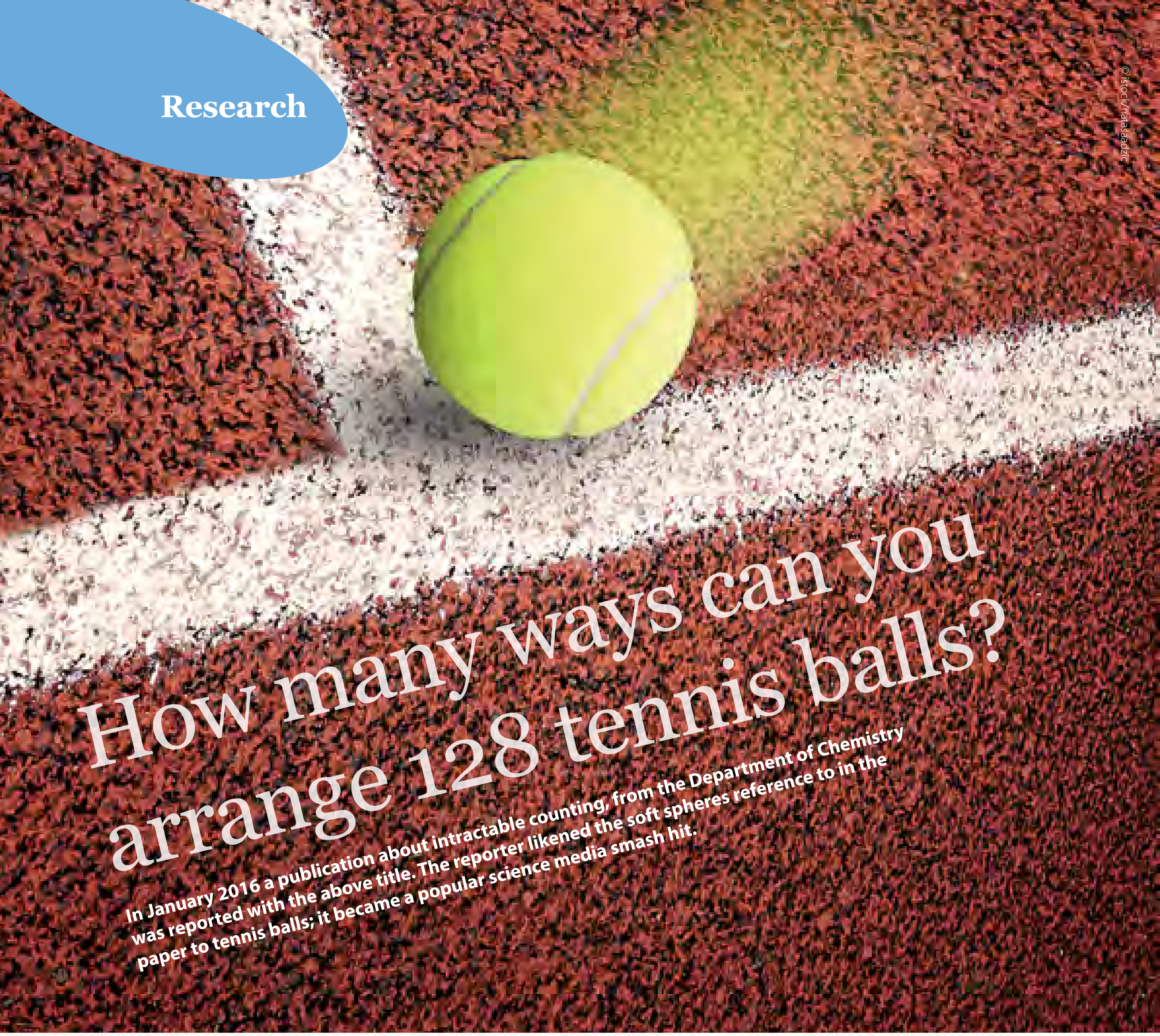
It happened that when our first child was born we moved down to Sussex, and so I went to see the Sussex University chemistry Professor and said I wanted half a lectureship. I mean if there's only one of you, you can say these things. He shook his head and said they'd never done that before, and as the university was by then two years old, I thought that was a pretty poor argument but actually they did give me half a job. And so I was there for seven years and always had strong support from my colleagues. I also changed the direction of my career. I started as an experimental spectroscopist in NMR. There was always a theoretical side to what I was doing, but in Sussex I did move to being entirely a theorist. The great advantage about being a theorist is that you can put it down at three o'clock or whenever you have to go home, whereas if you're doing experiments it's much more difficult. It was a way of giving your family and your career a good shot, particularly in those days when one felt slightly guilty about going out to work.

"Things have changed (e.g. maternity leave, nurseries) but employing help was relatively less expensive. It would be interesting to compare experiences with a postdoc with children, working in the department today. But I would give two bits of advice to women starting out now:

(1) Don't be afraid to ask for things such as part time work. Apart from the Belfast job, every job I got was by asking for it.

(2) When opportunities arise take them, it's worth trying. I never imagined going to Belfast.

Currently Ruth uses computer simulation to study the behaviour of liquids. Her main interest is ionic liquids (molten salts such as dimethyl imidazolium chloride) and solutions in them. She collaborates with spectroscopists in Texas and simulators in Spain, Ruth can be found in her office most days and has no plans to change that pattern.



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How many ways can you arrange 128 tennis balls?

In January 2016 a publication about intractable counting, from the Department of Chemistry was reported with the above title. The reporter likened the soft spheres reference to in the paper to tennis balls; it became a popular science media smash hit.

Daan Frenkel

According to Professor Daan Frenkel it was a sudden realisation, 26 years after hearing Professor Sir Sam Edwards speak on the subject of statistical thermodynamics applied to granular materials, which led to the paper that could answer the question. By the way, the answer is - more or less - 10^{250} – that's one followed by 250 zeros!

"Sam Edwards was one of the giants in theoretical physics," says Daan, former Head of Department and Boltzmann Prize winner 2016. Edwards was a theoretical physicist at the Cavendish Laboratory who died in 2015. "He should have had a Nobel Prize, he didn't get it," says Daan, still upset on Edwards' behalf.

In the late 1980s Edwards described a method for predicting the behaviour of granular materials. The problem was that, at the time, nobody could actually compute the crucial quantity that is the number of stable arrangements of a number of spheres.

"I heard him speak about this in 1990 when the theory was new. It wasn't until 2007 when I was speaking with colleagues about something else that suddenly I could see how, in principle, you could compute this quantity. I thought that Dr Ning Xu, then a postdoc with my colleague, Professor Angela Liu, could probably do this calculation in two, maybe three months: I seriously underestimated how hard it would be." It actually took nine years to get the result for spheres.

Daan explains: "To do these three-dimensional computations, you have to study the behavior of what is called the energy landscape. Luckily for us, the world's expert on energy landscape sits two offices away from me, it's David Wales."

David Wales, 2015 Tilden Prize winner and elected FRS in April this year, continues the story. "The locally stable configurations on the landscape correspond to our usual notion of molecular isomers. In principle, all the observable thermodynamic properties can be calculated from these local minima. For example, to determine the entropy we combine the number of minima with the contribution from each of these local basins, which are like valley bottoms in a mountain range. We call the number of minima the landscape entropy. Even for relatively small clusters containing a few dozen atoms the number of minima is too large to evaluate deterministically. Instead we must formulate the problem stochastically, and fortunately, Daan Frenkel is the world leader in Monte Carlo sampling."

Joining these two modern day giants of theoretical chemistry and statistical thermodynamics were computational physicist Stefano Martiniani, a PhD candidate and the youngest member of the team: Julian Schrenk, a physicist postdoc, both in the Frenkel group, and Jacob Stevenson, a theoretical and computational physicist working with the Wales group. Building on earlier work by Daan's former collaborators Daniel Asenjo and Fabien Paillusson, the trio of junior members were able to produce the computer program that could answer questions like: How many ways can you arrange 128 tennis balls?

"This is the sort of collaboration you get by mixing people in offices, they talk to each other. Jake was a postdoc with David but would sit in on my group meetings, Stefano would go to David's group, so we just have very close interactive people."

Far more important than the solution, is that the method they came up with can help scientists to calculate something called configurational entropy – a term used to describe how structurally disordered the particles in a physical system are, which brings us back to Sir Sam calculating granular entropy and allowing scientists to predict the behaviour of granular materials.

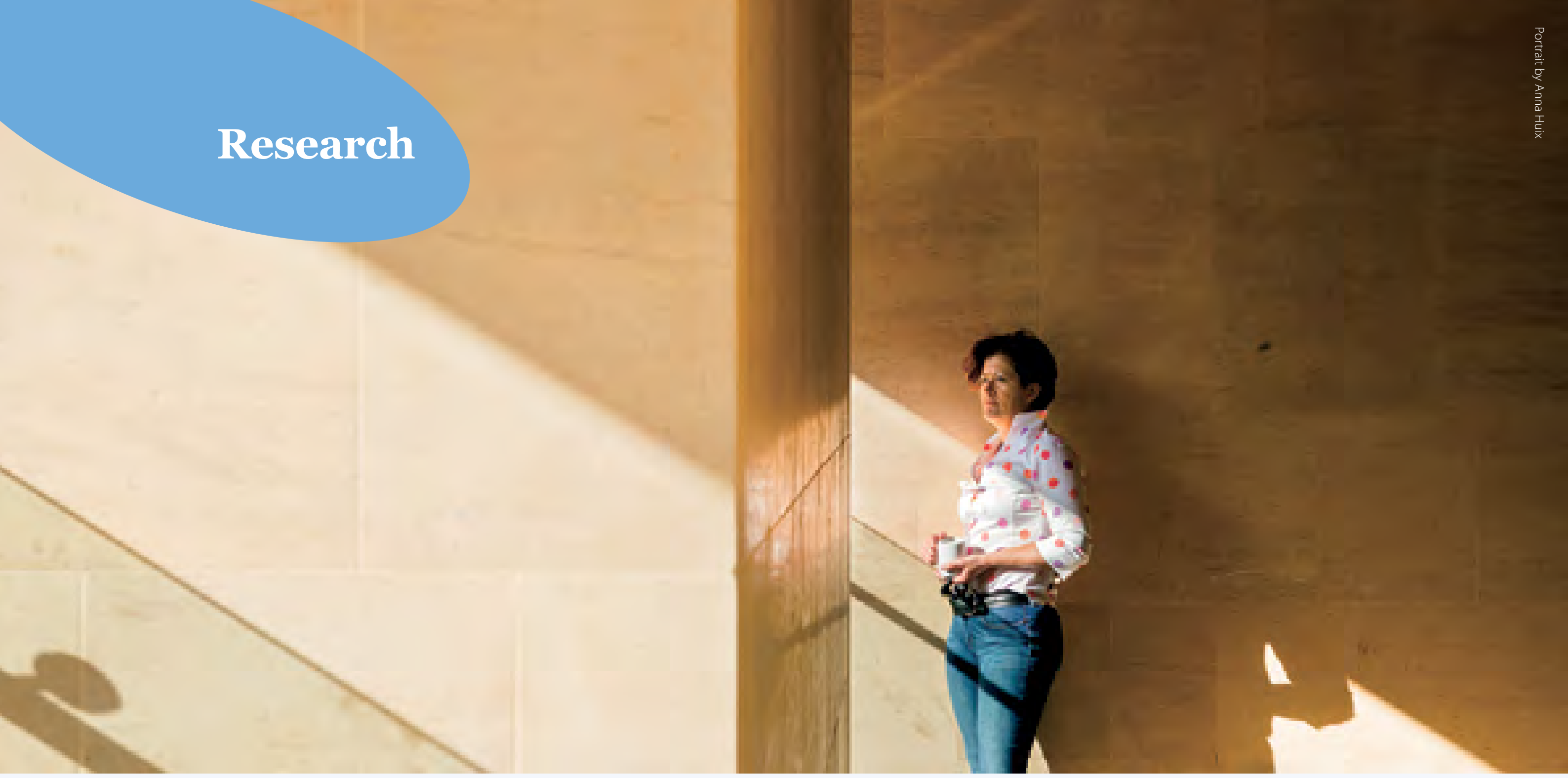
This could become a very powerful tool: suppose that you have a particular system, say powders, grains, snow or sand; they can be in very many different states. The number of states is so large that you can't calculate it manually. With this technique you can compute the number of states and how likely that system is to be in any given state. These problems exist in numerous fields: chemical engineering, materials science, machine learning, and various branches of mathematics, such as string theory.

"You could say this is a physics problem but the technique has potential applications in, say, biochemical networks. Stefano is working with people in New York on neural networks and pattern recognition (e.g. image and speech recognition). You can ask yourself, how many different ways can such a neural network be organised? The standard answer is probably a lot, but we can actually compute the number, and that's why some people mining data in social networks follow our work," says Daan.

With applications from machine learning to biophysics, this particular theoretical ball seems to have bounced a very long way.

Ref: *Turning intractable counting into sampling: computing the configurational entropy of three-dimensional jammed packings. Martiniani, Schrenk, Stevenson, Wales and Frenkel, Phys.Rev.E 93, 012906.*

Front: Daan Frenkel, Stefano Martiniani, David Wales
Back: Julian Schrenk, Jake Stevenson



Portrait by Anna Huix

Spotlight on...Melinda Duer

Sugar Rush

When Professor Melinda Duer was featured in the Michaelmas edition of the Cambridge Alumni Magazine, the focus was on her research into the structure of bones. But that, says Melinda, is now 'old work'. Here we take a look at her new work around sugar and its effect on our tissues.

The CAM article, *Bone Matters*, only lightly touched on the subject of sugar. Professor Duer's latest research asks 'does eating too much sugar damage cells?'

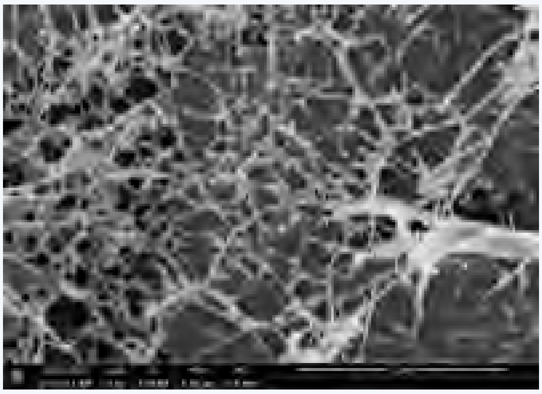
We now have evidence that it does, but not in a simple way. Melinda clarifies: "The issue with excess sugar in our diet is not so much that the glucose damages the structure of our tissues directly, but that it causes chronic inflammation, which kills cells. The natural sugars produced by those dead cells damage the structure of our collagen, the body's connective tissue." Worse still the reactions happen very rapidly, in a matter of hours. They can't be reversed, which means the body can't recover from the damage.

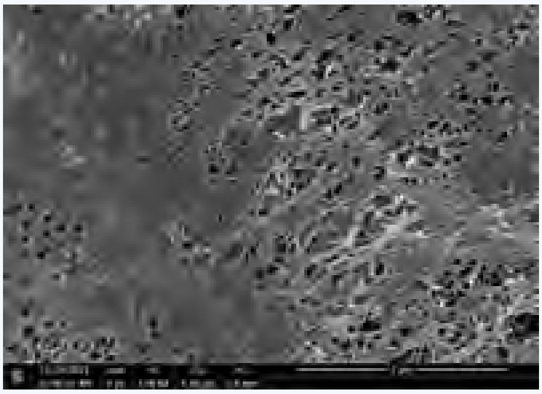
People have known for some time that when you have excess glucose in your blood, whether it's because you just eat too much sugar or particularly if you're diabetic, that the sugar can chemically react with the proteins in your body. What the Duer Group has found is that naturally occurring sugars, essentially aldehydes, can react with terminal amine groups on collagen proteins in our tissues, mainly arginine and lysine. This has the effect of cross-linking with collagen molecules, causing the collagen to lose its normal structure.

Collagen is hydrophobic; it does not like water. It self-assembles in tissues as long fibrils so that the hydrophobic functionalities are on the inside and

"The Duer Group found the chemistry between sugar and the debris from dead cells affects the extracellular matrix, destroying the fibrillar college structure."

what's on the outside is hydrophilic – cell binding sites for instance. This is important because all cell binding sites contain the amino acid arginine, and arginine is one of the first things that reacts with sugar.





Scanning electron microscopy images of extracellular matrix. Top: Normal matrix showing well defined fibre structures.

Bottom: The same matrix after reacting with ribose phosphate, showing a very disrupted structure in which the fibres appear to have been pulled apart.

Melinda details the process: "When naturally occurring sugar, from the breakdown of DNA and other sugar-containing molecules, chemically reacts with proteins in collagen, the collagen fibrils cross-link. This pulls the fibrils apart and the chemistry turns what were hydrophilic sites into hydrophobic. Instead of a well-ordered structure the collagen looks like a plate of congealed spaghetti, covered in the reaction products of what I call dead cell juice."

Apart from weakening the tissue, the reaction affects healthy cells, making them "go ballistic," says Melinda. "They go into oxidative stress, start producing all sorts of gunk and rubbish, cells can't find their binding sites and they die. And of course when cells die, the whole process starts all over again. The newly hydrophobic surface of the fibrils becomes a magnet for hydrophobic molecules, like low-density lipoproteins – LDLs, which are implicated in heart disease."

Interestingly, the reaction is part of the natural ageing process. Chronic inflammation happens again and again in different parts of the body and we gradually build up a matrix of damaged collagen.

"Throughout our lives we're always experiencing some degree of inflammation because we get colds or illness that cause inflammation," Melinda continues. "We think having excess sugar causes chronic inflammation, and is just one route to this cross-linking situation. Once this chemistry has happened it can't be reversed. Worse, there seem to be no enzymes that can break that matrix down – once it's formed, it's there for a long while."

Melinda and her group are interested in understanding how this chemistry contributes to vascular disease and how it accounts for changed tissue structure in cancer. The matrix in cancer tissue changes drastically and may facilitate cancer cells moving through the tissue (metastasizing).

Results from the Duer group's three-year research project, funded by the Medical Research Council (MRC) and the British Heart Foundation, are being prepared. When they are published, expect a rush to capitalise on the health-related possibilities for this sweet new chemistry.

"Throughout our lives we're always experiencing some degree of inflammation because we get colds or illness that cause inflammation."

Neurostatins:
Can Alzheimer's disease be prevented?

Research done in the department at the Centre for Misfolding Diseases (CMD) suggests that a new class of drugs may delay the onset of Alzheimer's disease. These drugs, dubbed 'neurostatins', could in principle do for neurodegenerative disorders what statins are doing for heart disorders and save billions of pounds in healthcare bills.

Michele Vendruscolo

Bexarotene, an anti-cancer drug, has been reported as the first potential neurostatin for Alzheimer's disease. The research done by the Centre for Misfolding Diseases (involving the Vendruscolo, Knowles and Dobson Groups) shows that the drug targets the first step in the protein aggregation reaction leading to Alzheimer's disease – before its onset (see panel). The findings suggest a whole new class of potential preventative drugs may exist for neurodegenerative diseases.

"The outcome of this collaborative project is a proof of the principle that small molecules can be found that act as neurostatins," Professor Michele Vendruscolo explains.

The goal is to find drugs that delay the onset of Alzheimer's disease by several years – that's the definition of a neurostatin. The next step is to go into clinical trials - but not with bexarotene because, Vendruscolo explains: "Through the drug discovery strategy that we have set up we have found a variety of related molecules that are even more effective than bexarotene as potential neurostatins."

Bexarotene was chosen for this study because it is already in clinical trials for Alzheimer's disease as a therapy – a treatment given after the disease has been diagnosed. However, Vendruscolo believes the clinical trials are not going well: "It could be the right molecule, but it is being tested in the wrong way. We chose bexarotene to demonstrate that knowing how a potential drug works is absolutely crucial."

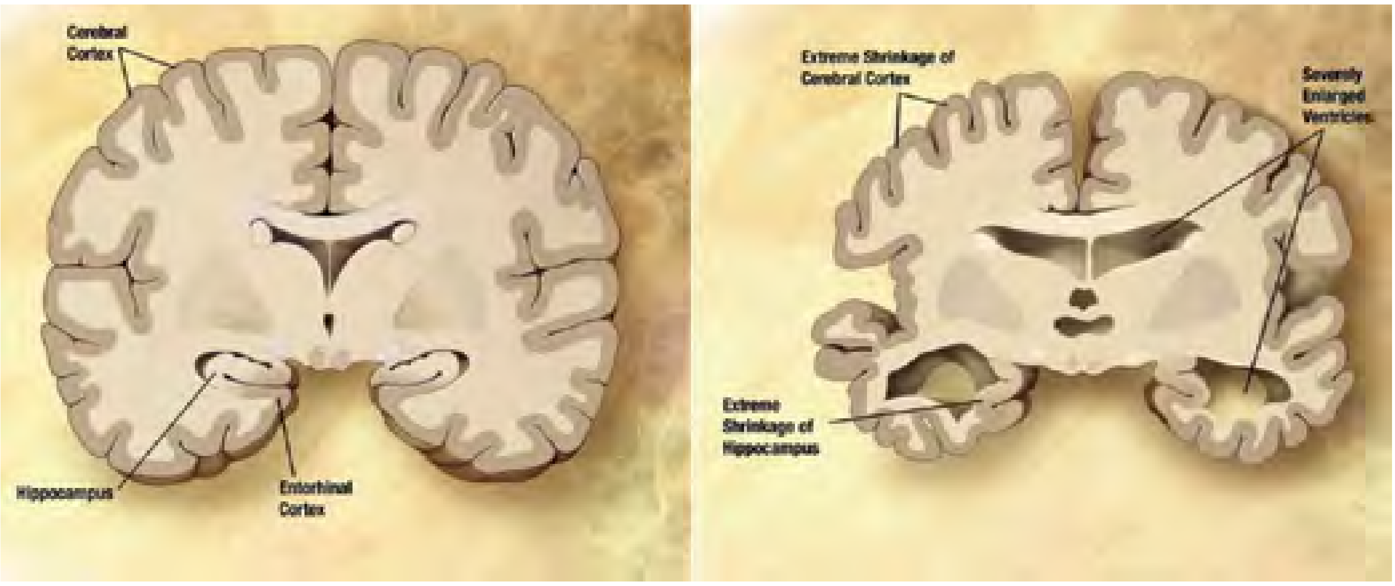
Neurostatins would not be a cure for Alzheimer's, but would rather reduce the risk of developing the disease. Unfortunately, late stage Alzheimer's may remain untreatable because the brain has suffered such massive tissue loss that there could be no way to reverse that. Preventative treatments could be possible but it will take time: "It's a long process, which will perhaps take 10 years, if not more," says Vendruscolo. Even so there is a lot of interest in the potential impact of this research, not only in preventing the disease but also in terms of projected savings in healthcare costs.

To find possible neurostatins the team looked at the disease process on a molecular level and disentangled the various components. They focused on the primary nucleation reaction that produces the toxic aggregates linked to Alzheimer's disease.

Panel 1: protein aggregation process associated with the development of Alzheimer's disease.

"In order to block protein aggregation we need an accurate understanding of exactly what is happening and when," says Vendruscolo. With the kinetic theory developed by Tuomas Knowles and collaborators it is now possible to describe the exact progression of the aggregation reaction, and how monomers, oligomers and fibrils interact in a non-linear manner. From this analysis it is possible to determine the rates of the microscopic processes underlying the overall reaction, which means that it becomes possible to say if a molecule delays the process or not.

Essentially the aggregation starts with a primary nucleation step, in which monomers clump together. Then there is an elongation step in which these initial aggregates grow and finally there is a secondary nucleation step in which the presence of existing aggregates promotes the formation of new ones. As aggregates replicate, the process speeds up exponentially and it is very difficult to stop. Thus the team decided to look for molecules that specifically interfere with the primary nucleation step.



Panel 2: comparison of a healthy brain (left) with an Alzheimer's disease brain (right), which has undergone massive tissue degeneration.

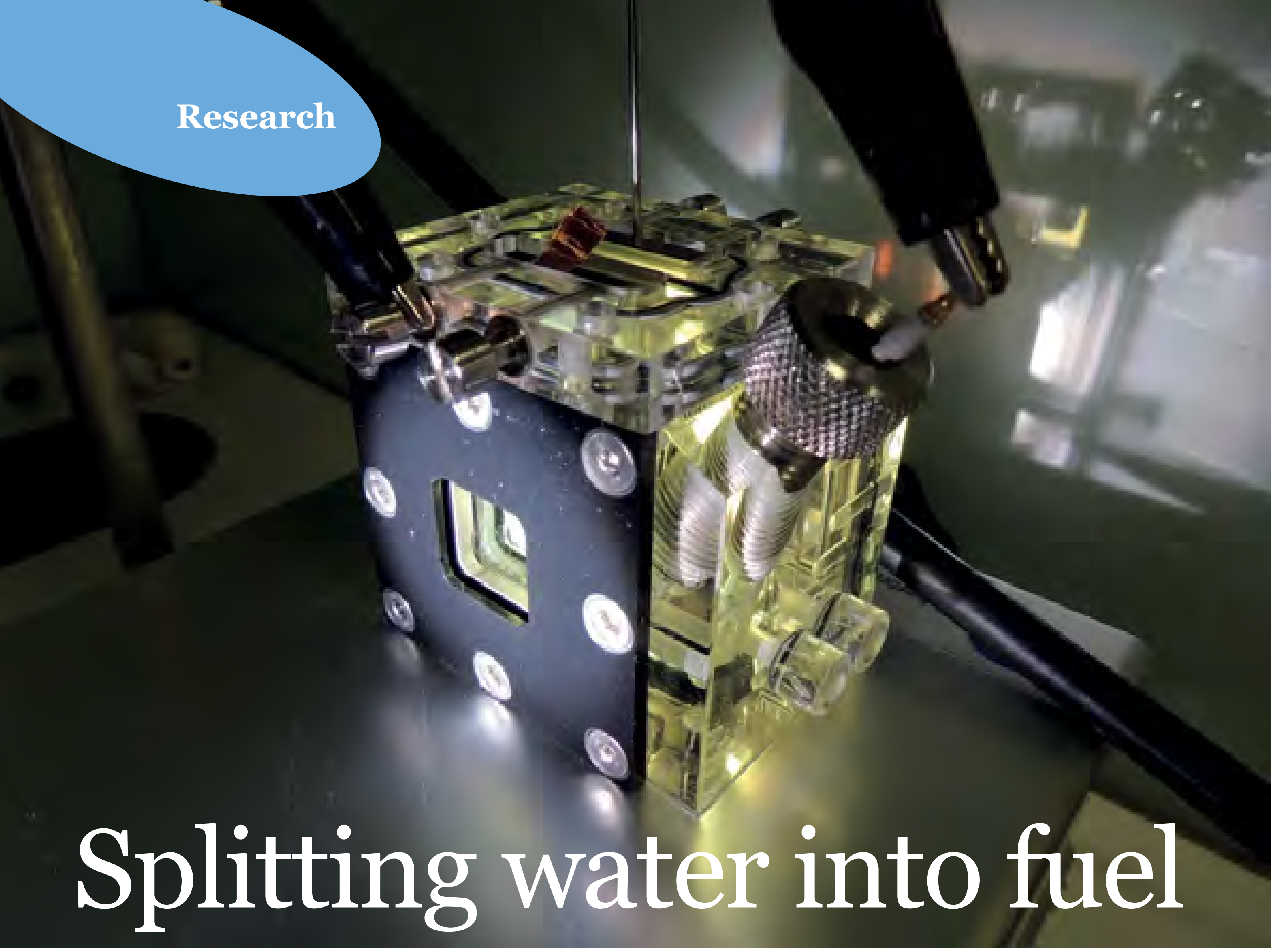
Vendruscolo says, we have natural defences against aggregation, which involve molecules called molecular chaperones that act by inhibiting the various steps in the process. But such defences become progressively impaired with age. Looking forward, the next phase of drug discovery is to find small molecules that block not just primary nucleation, as neurostatins do, but also secondary nucleation, and thus the proliferation of the aggregates – these would be early stage therapies for Alzheimer's disease. Eventually there could be a cocktail of drugs that work together to completely block the processes that lead to Alzheimer's disease.

Panel 3: Impact of a Treatment That Delays Onset by Five Years on Total Costs, 2015–2050

Projected health costs

The potential impact of this research on healthcare costs is profound. It is estimate that if a neurostatin could be found over $300 billion per year could be saved on US healthcare bills by 2050, and perhaps £30 million in the UK. Not to mention, of course, the thousands of people and families whose lives would benefit hugely. Vendruscolo and team are doing important wide-reaching research, which will continue in the new Chemistry of Health Centre taking shape on the south side of the Lensfield Road building.

Ref: *Johnny Habchi et. al. 'An anti-cancer drug suppresses the primary nucleation reaction that produces the toxic Aβ42 aggregates linked with Alzheimer's disease.' Science Advances (2016). DOI: 10.1126/sciadv.1501244*



Splitting water into fuel

The overall research challenge in solar fuel production is to develop materials and technologies that can harness and convert the sun's energy into sustainable fuels.

Erwin Reisner

Researchers in the Reisner Group have produced a new precious-metal-free photoelectrochemical device that uses molecular catalysts and sunlight to split water into hydrogen and oxygen. This development is an early step towards the possibility of industrial scale water splitting, which would represent the ultimate renewable source of hydrogen for chemical fuel, feedstocks and fuel cells.

A real problem for scientists looking to find renewable sources of hydrogen has been finding a catalyst that is both efficient and inexpensive, and functions under real-world conditions.

What's exciting about this solar water-splitting device is that it uses Earth-abundant elements, in this case nickel, iron, tungsten and titanium, which might enable scalability in the future.

At present many solar fuel generator prototypes use more expensive metal catalysts such as platinum. This is the first such device using molecular catalysts that do not contain precious metals.

Dr Erwin Reisner, who leads the group, explains: "The key to success is to make the catalysts operate in an aqueous solution and then integrate them into electrode materials. We use porous metal oxide electrodes into which we integrate our catalysts, and these metal oxide scaffolds can absorb the light, transfer the electrons to our catalysts and then make the hydrogen fuel."

"What's more, we confirmed that the molecular structure of the metal catalyst remains intact after prolonged hydrogen production, proving molecular catalysts are suitable for the development of effective hybrid materials."

The Solar Fuels Network (SFN) hosts a symposium yearly at different institutions across the UK. Funded by the EPSRC, the SFN aims to develop and raise the profile of solar fuels research, and promote collaboration and cooperation with other research disciplines, industry and international solar fuels programmes.

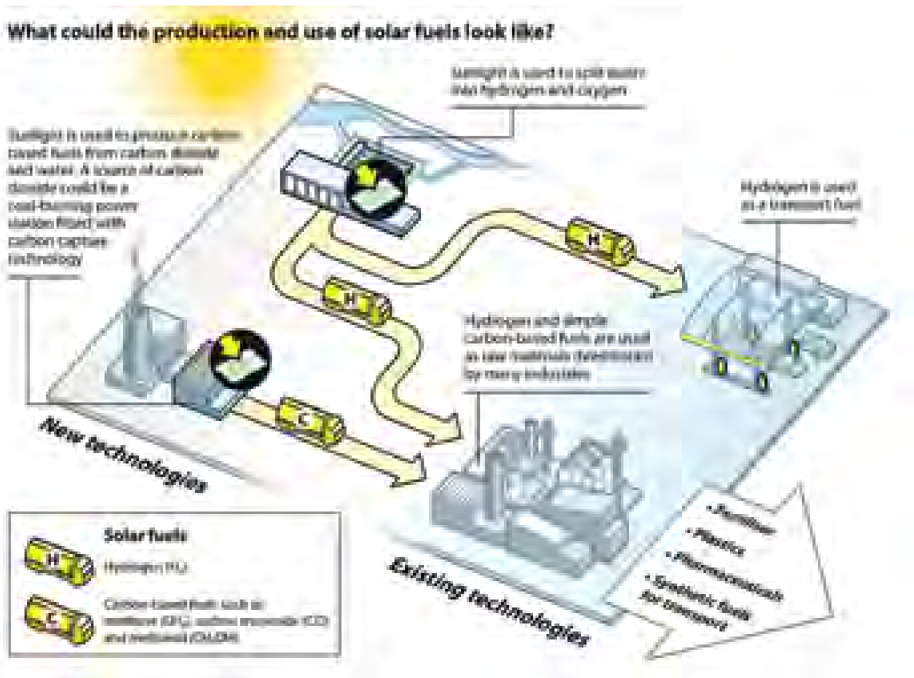
While this is encouraging, there are many more hurdles ahead, not least the efficiency of the device. "The amount of fuel we produce is very low, just a couple of bubbles," says Erwin. "At the moment we only have one light-absorbing electrode. If we were able to integrate two light-absorbing electrodes then we would boost the efficiency of the system quite dramatically. This is exciting work that my PhD student Tim Rosser is currently pursuing."

The challenges of efficiency and stability in solar fuel production are accompanied by an engineering challenge. "Our devices are anywhere from 1 to maybe 2 or 4 square centimetres," says Erwin. "We're used to our centimetres and we're very comfortable with that. But ultimately we are talking about technologies that need devices with square metres and kilometres of surface area. Sometimes it's difficult to think of scaling up into tonnes or square kilometres. Although it is too early for the implementation of such technology, we should be aware of these engineering challenges."

In January Erwin co-chaired the fourth UK Solar Fuels Symposium in collaboration with the SFN at St John's College.

Erwin says, "It's extremely important to bring all sorts of people from different backgrounds together to have them share their views; it clearly opens your horizon quite tremendously. Without exchange this task is pretty much impossible, so, I would say, solar fuel production is really a global effort now."

Ref: *Precious-metal free photoelectrochemical water splitting with immobilised molecular Ni and Fe redox catalysts, Rosser, Gross, Lai and Reisner, Chem.Sci. 2016, first published on the web 12 February 2016.*



Potential impact of solar fuel research courtesy "Solar Fuels and Artificial Photosynthesis" by the Royal Society of Chemistry

"There have been many advances in solar energy generation but the Holy Grail, as it were, is understanding how to store and transport the energy of sunlight in chemical bonds."

Professor James Durrant, Solar Fuels Network Director

Alex Archibald

As I see it...

Over the past few months stories on polar stratospheric clouds and reports on the effects of air pollution on human health have been in the news – what does atmospheric chemist Dr Alex Archibald make of it all?

Thanks to years of great fundamental research we are now in a position where we can put the man-made impact on the environment into context. Thinking back to the 50s, 60s and 70s, there was a bit of a throw-away attitude - the oceans were a dumping ground, the atmosphere was thought of as an ether into which anything could be emitted.

Years of monitoring and scientific endeavour have given us a better picture of where people sit in the Earth system, and whilst we might be small in terms of biomass (there's more mass in insects than in humans), we have a disproportionately large impact on our planet.

It's because of this enlightened state of knowledge that we are finally fully aware that we are having a negative impact on climate and air pollution - it's unequivocal that it's down to us. Five or ten years ago people argued that the planet goes through natural oscillations and maybe the severe storms, droughts, etc are just part of these. It's unarguable that the changes we're seeing now are definitely related to our activities, and it's alarming, it's breathtaking, it's the reason that all these stories are in the news.

But it's not all doom and gloom. There are opportunities, ways in which we can reduce our impact on climate change and air pollution. So highlighting what those opportunities are is something I feel that people in science and in the media should also communicate.

The work that Professor John Pyle and Dr Neil Harris who recently left the department to take up a professorship at Cranfield University received their NERC impact award for was for decades of research on the stratospheric ozone hole (a huge area in the upper atmosphere over Antarctica where the amount of ozone has reduced dramatically). Their work has highlighted the role of chemistry and meteorology in determining the size of the hole, in predicting how it will change in the future and, importantly, determining the impact of doing nothing about it – and so providing valuable evidence for policymakers.

Polar stratospheric clouds

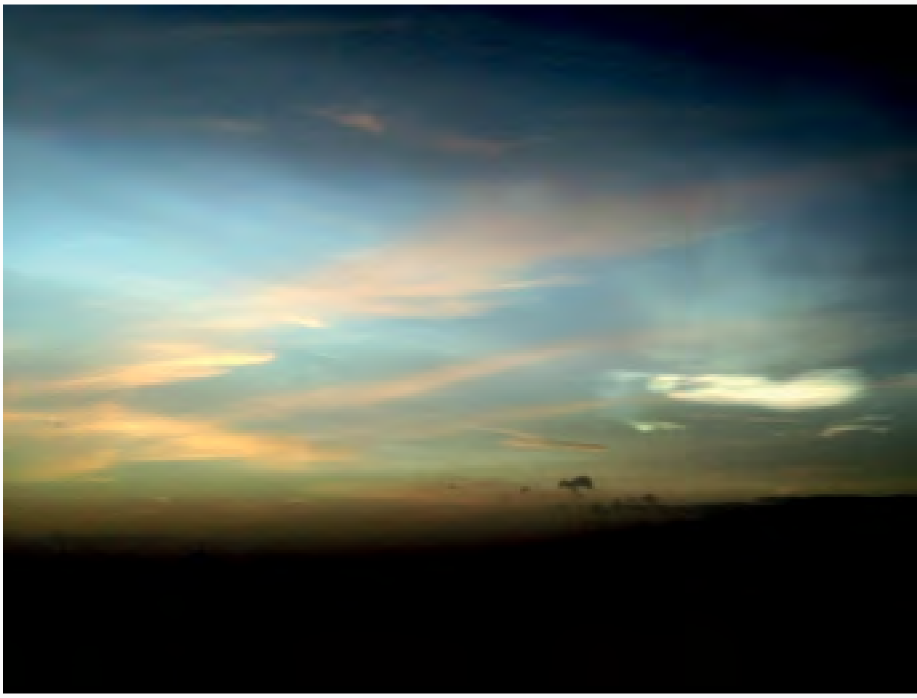
The polar stratospheric clouds we saw over Cambridge in February were beautiful. They are also known as nacreous clouds, because they often shimmer like mother-of-pearl. However, they are also alarming. These clouds form at very high altitudes, basically where clouds shouldn't really form. And they are a tell-tale sign of change. What they're telling us is that here in the northern hemisphere, the chemistry is primed to generate an ozone hole. That's quite scary for people who study this area of science (and the general public). The potential impact on human health where so many people live is frightening.

What can we do? I think there are many things we can do on an individual level, but we also need to devise legislation and enforce policies that change behaviour. The Montreal Protocol (an international agreement regulating substances that deplete the ozone layer) has been a great success story. It's clear that the reduction in emissions of ozone depleting substances is having a positive impact, and it appears as if the ozone hole is no longer getting larger.

Effects of air pollution

Duncan Scott, a Part III (undergraduate) student in my group is working on an exciting new project called 'The World Avoided'. The study asks the question: How bad would it have been if we'd done nothing and never imposed the legislation that limits air pollutants like carbon monoxide, NO_2 and SO_2? What we can see is, by having policies in place, we're saving something like 500,000 lives a year - a huge success story over the last 30 years. And hopefully a huge motivator to keep cutting emissions.

The effort that we've put into the science that has been translated into legislation and policy has had a measureable positive effect and impact. I would say my biggest interest in this area is in using models to answer questions that become important to policymakers and lead to positive change.



Polar stratospheric, or nacreous clouds over the skies of Cambridge on Monday 1 February 2016.

Noticeboard

Recognition and Awards

Professor Daan Frenkel has been awarded the Boltzmann Medal for 2016, the most important prize awarded in the field of statistical mechanics, and has been elected as a foreign member of the National Academy of Sciences.

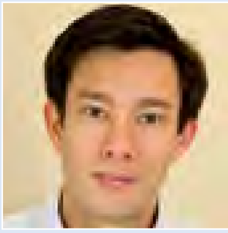
Professor Jane Clarke has been awarded the Protein Society Stein and Moore Award and the 2015/16 Linus Pauling Medal from University of Stanford. She has also been elected a Fellow of the Biophysical Society and an Honorary Fellow at Lucy Cavendish College.

Dr Gonçalo Bernardes has been awarded the RSC 2016 Harrison-Meldola Memorial Prize, Royal Society of Chemistry and received the Belgian Society of Pharmaceutical Sciences (BSPS) International Award for Medicinal Chemistry. He has also won the Chem Soc Rev Emerging Investigator Lectureship 2016 in Chemical Biology.

Professor Rod Jones has received the RSC John Jeyes award.

Professor Chris Abell has been elected Fellow of the Royal Society.

Professor David Wales has been elected Fellow of the Royal Society.



Professor Jason Chin has been elected Fellow of the Academy of Medical Sciences

Appointments and promotions

Professor Melinda Duer has been appointed Deputy Warden of Robinson College. She takes up office in October 2016.

Upcoming events

September

Friday 23 September 2016 4 - 6 pm
Call My Bluff wine tasting
Department of Chemistry

After its runaway success last year, the Call My Bluff wine tasting returns to the department as part of the Alumni Festival weekend. Booking details can be found at www.ch.cam.ac.uk/alumni/index beginning in July.

How you can contribute

On page 24, Dr Alex Archibald talks about the 'enlightened state of knowledge' that we now have about climate change and air pollution. Much of this knowledge has been gained through research in our own department, most recently demonstrated by the NERC impact award received by John Pyle and Neil Harris for the profound impact their research on stratospheric ozone has had on international public policy.

As a young researcher, Alex has benefited from working with these experts in the field, while at the same time developing his own research in order to build and lead a research group in his own right. Alex has recently become the recipient of a Next Generation Fellowship, generously provided by the Walters-Kundert Foundation, which provides research funding to his group of up to £50,000 per year for up to five years. During these crucial early years of his research, a grant like this will give Alex the resources to build a team and purchase equipment without devoting countless hours in a search for funding. It will also give him time to establish a successful research track record, which in turn will make future successful grant applications more likely.

Next Generation Fellowships are only part of our Next Generation Pathway, which helps attract and retain the most brilliant researchers at the Department of Chemistry through an entire career: from studentships, through early career researchers and lecturers, to Next Generation Professors at the pinnacle of their careers.

If you'd like to find out more about how you can help the Department of Chemistry maintain and enhance the quality research that has kept it continuously ranked as one of the top five chemistry departments in the world, please contact Head of Department Professor John Pyle at **chemhod@hermes.ch.cam.ac.uk**.

Online Giving
The University's Development and Alumni Relations Office has made it easier to make donations online to Chemistry.

If you wish to make a donation to the department, please go to: **philanthropy.cam.ac.uk/give-to-cambridge/chemistry**

Your donation will play a vital role in securing the future of the Department of Chemistry as a centre of excellence for study and research.

One-off donations by cheque
Your gift made by cheque, payable to the University of Cambridge, allows the Department of Chemistry to use the donation where it is most needed.

A Gift in Your Will
One very effective way of contributing to the long-term development of the Department of Chemistry is through the provision of a legacy in your will. One advantage of giving a legacy is that they are tax-exempt, and therefore reduce inheritance tax liability.

Further information on legacy gifts can be found at **philanthropy.cam.ac.uk/how-to-give-to-Cambridge**, which also has a very helpful downloadable document at the bottom of the page called "A Gift in Your Will".

For any further information on how you can help the Department of Chemistry, please feel free to contact our Head of Department, Professor John Pyle (**chemhod@hermes.cam.ac.uk**), who would be pleased to talk with you confidentially.

Gift Aid
If you are a UK taxpayer you can Gift Aid your donation, currently adding an extra 25p for every pound you give.

Data Protection
Any personal information you provide, both now and in the future, will be held in accordance with the terms of the Data Protection Act 1998. The University's website (**www.philanthropy.cam.ac.uk/data-protection**) contains further detail on how we will store and use your personal information."

Dear World,
I'll offer antiretrovirals at less than a dollar a day.

Yours, Yusuf

Yusuf Hamied (Christ's College 1960)
Chair of the Indian pharmaceutical firm Cipla