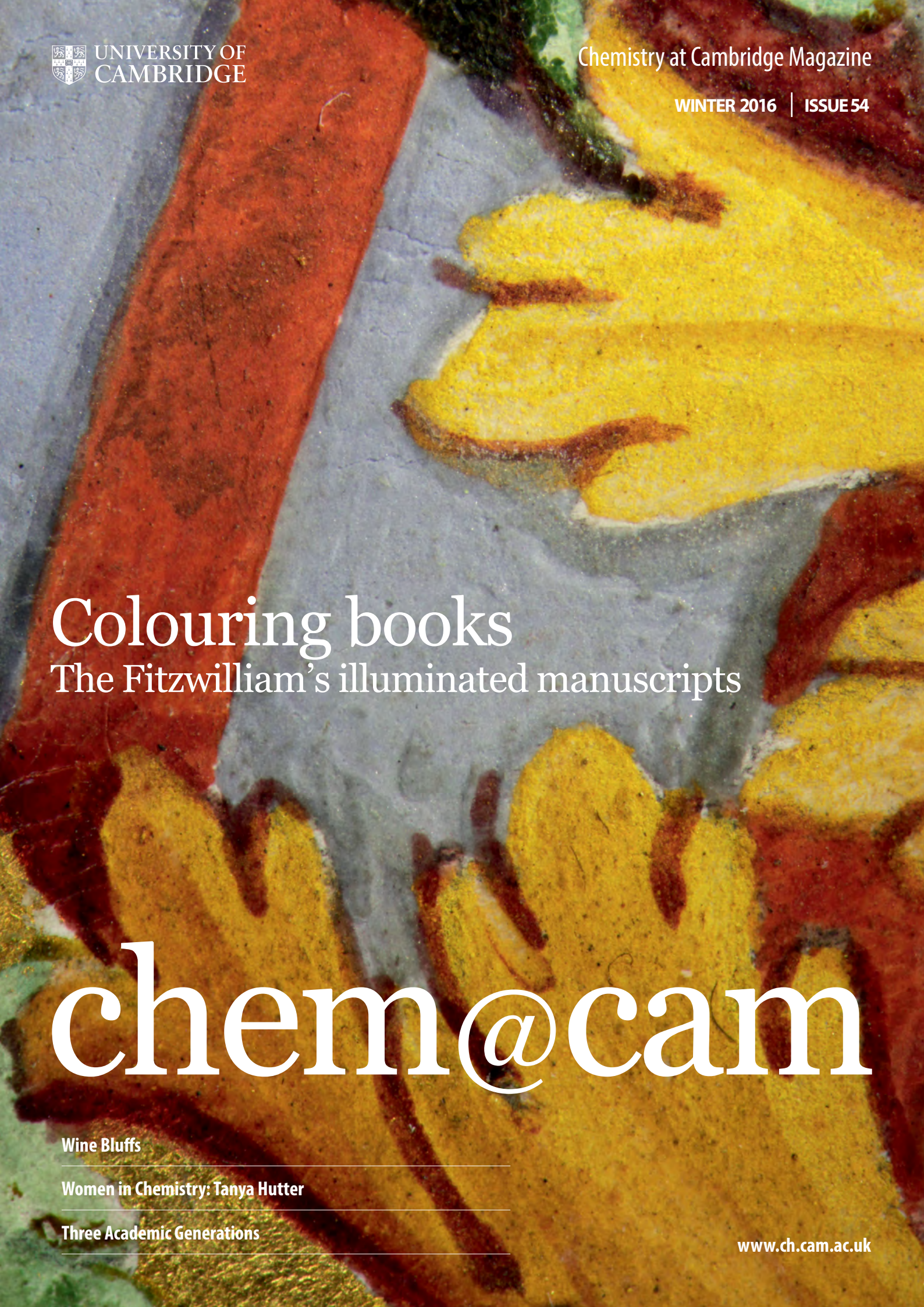

UNIVERSITY OF CAMBRIDGE

Chemistry at Cambridge Magazine

WINTER 2016 | ISSUE 54

Colouring books

The Fitzwilliam's illuminated manuscripts

chem@cam

Wine Bluffs

Women in Chemistry: Tanya Hutter

Three Academic Generations

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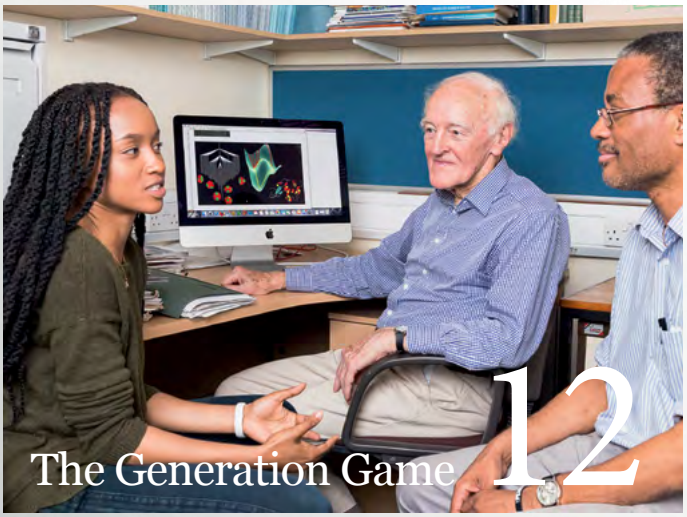

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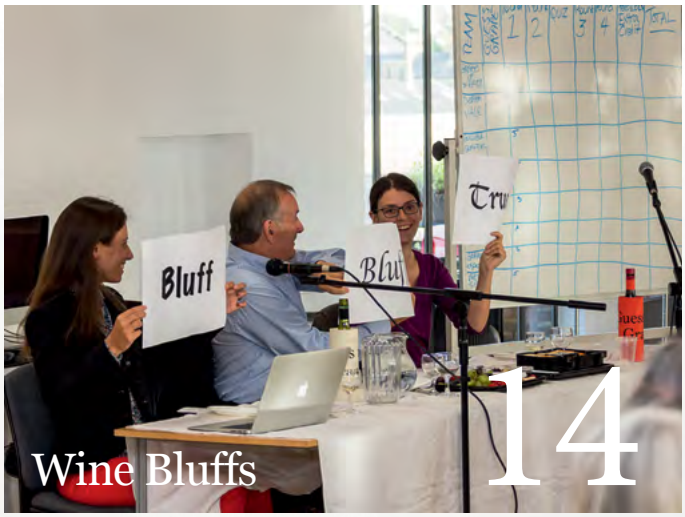
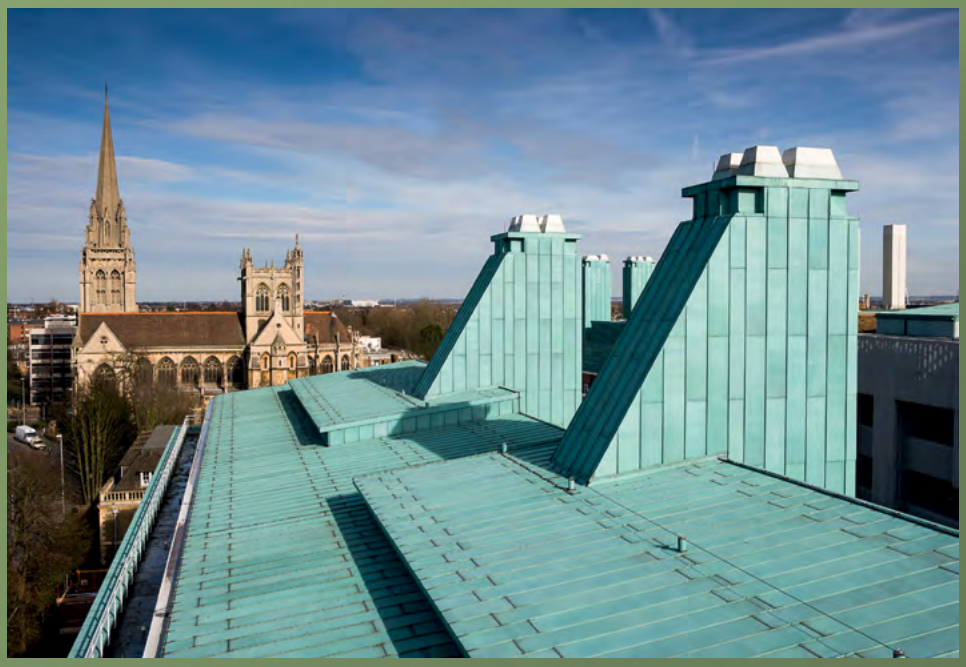


RESEARCH

WOMEN IN CHEMISTRY

Welcome

to the Chemistry at Cambridge Magazine



As I mark my first anniversary as editor, I'm mindful of the enormous amount of research work that takes place in Cambridge. In the last ten years members of the Department of Chemistry have published well over 5000 papers in top journals, which have been cited almost 140,000 times. In this Michaelmas issue of Chem@Cam I've tried to draw together a small selection of 2016's published research with the most recent paper, from the Hunter Group, coinciding with the magazine going to press. I've also added a subliminal (not) festive message with the inclusion of *Adoration of the Magi*, Italy, Venice, c. 1567–1572, an illuminated manuscript from the Fitzwilliam Museum that features in our cover story, 'Colouring books' (see page 16). It's not quite a Christmas card but I hope you appreciate the thought.

Carmen Pryce
Editor

On the cover....

Detail of *Adoration of the Magi*, Italy, Venice, c. 1567–1572: illuminated manuscript Marlay cutting It 40. © Fitzwilliam Museum, Cambridge. See back cover.

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Q&A

Andrew Scott

In 1977 Andrew Scott started his PhD in organic chemistry in Prof Battersby's group, working on the stereochemistry of enzyme-catalysed reactions. Science was his passion, but the setbacks of research made him realise that lab-based science was not for him. After graduating in 1981 the way forward seemed clear: he became a science writer. Now a contributor to many publications, including Nature, and the author of nine science books, Andrew returned to Cambridge, for the first time in more than 30 years, for the Festival of Science in March 2016. We found him taking a look around the department on Open Day.

What is your earliest memory?
In a room in Edinburgh just being aware of the difference between dark and light, understandably I am not sure how old I was, but younger than two.

What do you owe your parents?
Existence!

What did you want to be when you were growing up?
I wanted to be a fighter pilot because I read Biggles books. When I was in primary school I replied to an advert in the newspaper and somebody from the RAF turned up at our doorstep. My mum had to explain, "He's still in primary school – he's only 9." I was very precocious!

What makes you happy?
The countryside.

Which living chemist do you most admire?
That would be my old bench mate Andy Hamilton, because of what he's achieved. He was just a scruffy student in a T-shirt on a bench beside me and then he became Professor Andy Hamilton and the boss of Oxford University. I'm just astonished at what he managed to achieve.

Which dead chemist do you most admire?
Frederick Sanger because he solved two major problems in protein structure and nucleic acid sequencing, leading to two Nobel Prizes in chemistry.

What is the trait you deplore most in yourself?
Ah, so many to choose from, I'll go with procrastination.

What was your most embarrassing moment in the lab?
There is a thing about Scotsmen being mean, which of course is entirely untrue. Well, we had a tradition in the lab that when it was your birthday you had to buy everyone a drink. But when we went to the Panton Arms at lunchtime, I just kept quiet about my birthday. When we got back to the lab, Hiko, a Japanese researcher, said: "Andrew, your mother

phoned to say happy birthday." And everybody just turned on me – 'You didn't buy us drinks!' That was very embarrassing.

What is your most treasured piece of equipment?
My computer, it allows me to write so much more effectively. My first book was typed out on a typewriter and corrected with Tipp-Ex® and that was a nightmare. I can't understand how you could do it now - writing an entire book and not being able to go back and change things. Now I have two computers: a PC and a Chromebook. I've become a Chromebook convert.

What is the closest you've come to death?
When I was 10 I was knocked unconscious. I was in a wheelbarrow race in the school gym. I just remember this thud and I was out for long enough for my mother to get from some way away to me. She was playing the piano for some reason up on stage at a Boy's Brigade meeting and when I came to she was there with a crowd of people around. So as far as I'm concerned I know what it's like to die and it's dead easy (pun not intented).

What or who is the greatest love of your life?
My wife! *Ed. - Everybody says that.* Well I'm not going to say somebody else's wife!

Who would play you in the film of your life?
Who's that actor that played Gollum? Andy Serkis, not that I know what the actor really looks like but I am getting close to looking like Gollum.

What has been your biggest disappointment?
That I didn't sell more books and have a best seller.

What inspires you?
Science and our ability to analyse and figure things out. What people have been able to achieve just by thinking about things.

Where were you three hours ago?
I was in the University of Cambridge library. They have all my books.

Are you a religious person?
I'm not in the least bit religious. People so often just sneer and say you're a scientist you think science explains everything. I say science doesn't explain anything ultimately; it describes a lot of things. The reason I'm not a religious person is because I don't have a clue what's going on. A lot of religious people pretend that they do!

Letter from the Head of Department

Chemistry is a discipline of extraordinary breadth. Much of our current research involves collaborations with physical and biological scientists as well as, increasingly, contact with the social sciences. I am delighted to see that breadth reflected in this issue of Chem@Cam. From heritage science, we see Stephen Elliott working with the Fitzwilliam Museum on the MINIARE project; in palaeontology, Silvia Vignolini travels to Kenya to study fossils. These are just two examples of our increasingly wide-ranging research portfolio.

The link with our traditional research partners continues to strengthen with the School of Physical Sciences close to appointing nine interdisciplinary lectureships, all of which will be held in at least two departments. Three of the lectureships feature chemistry: one in my own field of climate modelling, as well as in nanoelectrochemistry and statistical mechanics. Bringing different disciplines together to solve the big questions facing society in the 21st century is a global trend. This is a valuable step.

With about 30% of our research funding coming from Europe we are naturally concerned about the uncertainty surrounding Brexit and Julian Huppert, former Cambridge MP and colleague, gives his own very forthright views in *'As I see it...'* To retain our world-leading position in science we must collaborate with the very best; clarity on how we will continue to do this in Europe is essential.

Finally, it is sad to report the loss of three former colleagues: Roger Tsien, Ian Smith and Eric Smith. Our thoughts and best wishes go out to their friends and families.

Steve Ley secures FET grant

The Ley Group have been awarded a four year Future and Emerging Technologies (FET) grant as part of a European consortium to study catalyst cascade reactions in a 'one-pot' or 'one-flow' system within a compartmentalised, 'digital synthesis machine'. Part of the €3.9 million award will finance a postdoc research position in the department for two years with the aim of delivering an end-to-end sustainable process design for producing pharmaceuticals. Professor Steve Ley said: "By designing these new multiple step processes in which the first step creates the functionality to trigger the second reaction and so on, you can radically improve on the pharmaceutical manufacturing processes of today by favouring cleaner, flexible and more efficient methods."

Shankar celebrates 50 with a symposium and an ultra-marathon

2016 was a big year for Professor Shankar Balasubramanian, who marked his 50th birthday with a 100Km run and a party. First he did the Thames Path Ultra-marathon on 10 September, in 12hr 40mins, through rain and a lot of mud. Then on 24 September he had a party, which in the Department of Chemistry translates to a symposium.

Over 80 people representing past and present members of the group gathered in the department to hear some of the assembled academics speak about their current work. The selection was done at random and covered the duration of Shankar's time in the department. They included talks from: Viji Arumugam, Vertex Pharmaceuticals Inc., on the discovery of Ivacaftor for cystic fibrosis treatment; Zoë Waller, University of East Anglia, on i-motif DNA; and Marco Di Antonio on the group's latest work with DNA G-quadruplex structures (see page 21).

After dinner, at Clare College, Liberal Democratic politician and former group member Dr Julian Huppert recounted funny (you had to be there) stories about Shankar's past. Shankar was gifted a tankard, with engravings representing three significant areas of his work: DNA, a G-quadruplex and 5hmC (5-hydroxymethylcytosine).

Professor Shankar Balasubramanian

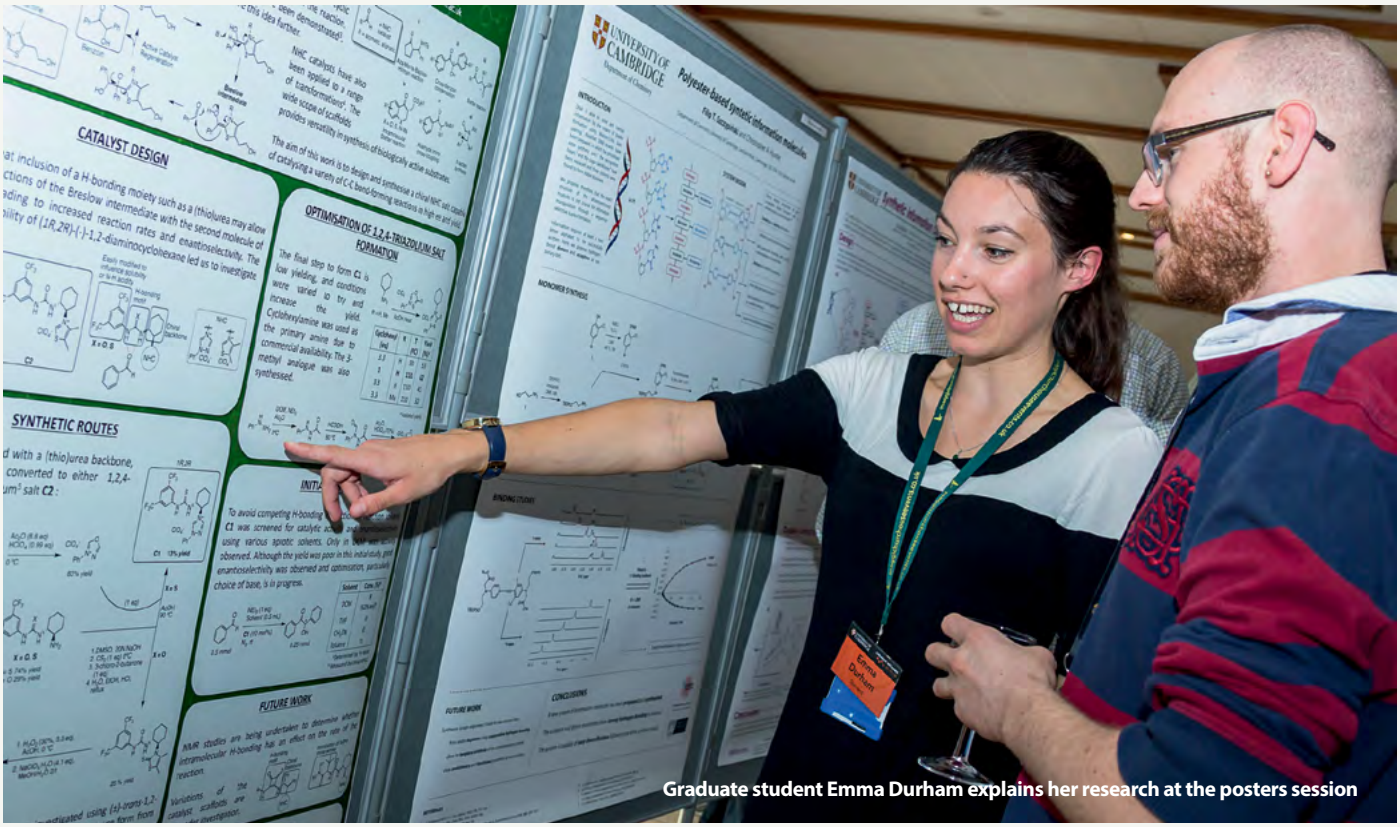
After the event Shankar, who conducts research in both the Department of Chemistry and the University's Cancer Research UK Cambridge Institute, praised his colleagues: "The symposium is really about their achievements. I just sat there and enjoyed it. It was a lot of fun but it's also impressive to see what they've achieved."

Inaugural Chemistry Network Event

Over 20 companies and funding bodies attended the first ever Chemistry Networks event, held in the department on 29 September.

The event was opened by Head of Department John Pyle, who gave a broad overview of the department's research, noting its excellent REF performances and touching on the breadth of its interests from the nano- to global scale.

The Chairs of the department's five research interest groups (RIGs) then gave presentations about their areas of science, detailing the specific contributions of individual principal



Graduate student Emma Durham explains her research at the posters session

investigators (PIs) or groups of PIs and the potential for practical applications in the future.

A poster session showcasing the work of graduate students and postdocs and a drinks reception followed, which gave researchers, industry and funding body representatives the opportunity to discuss the science going on in the department in an informal and relaxed setting.

"As the leading chemistry department in the UK, our expertise attracts a lot of interest from both national and international industry," said Dr Yolande Cordeaux, the department's Knowledge Transfer Facilitator. "This event has brought together many of these interests and we hope over time that this will promote even more successful ways of meeting academic and industrial research needs, with the ultimate goal of developing practical applications which benefit society."

Companies ranging from the large and well-established to small and medium sized took the opportunity to find out more about the department's large number of internationally recognised research groups who work in fields from molecular biology to geophysics, which align with a wide range of industry sectors.

"We intend to make this an annual event, in which we hope to provide our industry friends with the opportunity to get to know us better while also giving our students and postdoctoral workers the chance to present their work to both department members and visitors alike," said John.

Industry representatives meet academics at inaugural Chemistry Network event

Roger Tsien obituary

Roger Tsien, a former Todd Professor in this department and co-winner of the Nobel Prize for Chemistry, died 24 August 2016.

Roger came to Cambridge from Harvard in the early 1970s to study for a PhD in the Physiology Department.

He decided that it was important to know the concentration of calcium in cells, and he had an entirely novel idea about how to measure it: using fundamental principles of physical organic chemistry, he developed organic dyes inspired by EDTA (Ethylene-diamine-tetraacetic acid) that twist when they bind calcium, dramatically changing the dyes' fluorescence. He found a way to protect the dyes so they could pass through the cell membrane without having to be injected.

Roger came to the Department of Chemistry in search of suitable lab facilities and practical advice on the synthesis of these dyes. He was encouraged and "supervised" by several of us, notably Andy Holmes and Gerry Smith, but his insights and his determination in the face of practical difficulty and scepticism in physiology were inspirational.

Roger's original molecule, and its descendants, have transformed our understanding of the role of metal ions in cell biology. His three key Cambridge papers have been cited a total of over 5,000 times, while his 1985 paper, describing the second generation of calcium dyes, has been cited over 20,000 times.

Professor Roger Tsien

His Nobel Prize was for his more recent contributions on the discovery and development of the green fluorescent protein, GFP, but the original Cambridge work was surely Nobel-worthy too.

Roger was the most talented scientist I ever worked with, and he will be much missed.

Professor Jeremy Sanders

Researchers visit Kenya to study 12 million year old fossil

In September 2016, Dr Silvia Vignolini and PhD student Rox Middleton visited the National Museums in Kenya to study a 12 million year old *Pollia* fossil. The researchers took with them a powerful Axio Scope microscope donated by Zeiss.

"We were thrilled to have the opportunity to examine the fossil, which was discovered and stored at the Museums in 1989," said Silvia, whose research group studies plant structures and how they manipulate light to obtain brilliant and iridescent colours. *Pollia* is a good subject, because its fruits are a striking example of iridescent colouration in plants.

PhD student Rox Middleton said: "It was very exciting to be the first researchers ever to examine the *Pollia* fruit specimens under the microscope." Earlier this year Rox received the SET for Britain Silver Award for her research poster on "Biomimetic Optical Materials Made of Cellulose."

The Zeiss Axio Scope microscope was donated to the Kenyan researchers in the palaeontology section of the Museums at the end of the trip. "We are proud that local and visiting researchers who travel to the National Museums from all over the world will now be able to use its advanced capabilities to examine the huge wealth of valuable specimens in the museums," said Silvia.

Dr Silvia Vignolini working with Dr Job Kibii and Ms. Cecila Kathenya at the National Museums in Kenya.

The two researchers discovered that the fossil specimens share many characteristics of modern species. "We now understand more about the preservation of the fruit body over the course of 12 million years," said Silvia. They hope to publish their results early next year.

Newman Foundation gift makes microfabrication laboratory a reality

Professor Tuomas Knowles has received a £250,000 gift from the Frances and Augustus Newman Foundation to set up and run a state-of-the-art microfabrication laboratory.

The new Sir Rodney Sweetnam Laboratory will allow researchers to develop next-generation microfluidic devices for applications in the biomedical sciences over the next ten years.

"It is a great privilege to see our future work in microfabrication being undertaken in a laboratory that honours the legacy of Sir Rodney Sweetnam," said Tuomas. Sir Rodney was the previous chairman of the Frances and Augustus Newman Foundation. "His interest in and support for our work was instrumental in establishing the biomedically-oriented microfluidics programme in our lab," said Tuomas. Over the past five years, the Knowles Group has set up a programme to explore and implement the use of ultra-small volume assays in protein science. This approach has allowed researchers to perform measurements that simply would not be possible in conventional bulk experiments.

"To take our work to the next level, a dedicated microfabrication laboratory is absolutely crucial, and the generous donation by the foundation is the fundamental catalyst to allow this development to take place," said Tuomas.

Tuomas and his research group are developing new microfluidic platforms to address biomedical questions, and are keen to use these devices to probe the molecular origins of neurodegenerative disorders.

"I am extremely grateful and very honoured that the Frances and Augustus Newman Foundation is supporting our research in this manner," said Tuomas. "This support will transform our research into microfluidic device development."

Prospective graduates open day

The department opened its doors to approximately 100 prospective applicants at the Graduate Admissions Open Day on 21 October. The purpose of the day is to introduce potential MPhil and PhD candidates to the research going on in the department. Visitors were able to get a taste of what life is like for postgraduate students, and had the opportunity to speak to current students and department members about life in Cambridge.

During the day all five of the department Research Interest Groups (RIGs) delivered presentations about their work.

A buffet lunch and social reception, along with posters displaying the research, and tours of the labs and facilities, gave further opportunities to learn about the world leading work going on in the department.

Head of Graduate Education, Dr Deborah Longbottom said: "The day was a great chance to highlight why chemistry at Cambridge is such an attractive subject to study, and we look forward to welcoming new students in the coming year. We also give a huge thank you to all those who gave such enthusiastic and passionate presentations about their work, and everyone who helped make the day a success."

Clare Grey opens Lancaster University chemistry department

Professor Clare Grey officially opened the new chemistry building at Lancaster University, 13 October 2016. £26 million has been invested into chemistry facilities and equipment at the university and the opening completes the rebirth of Lancaster's chemistry department, providing a cutting-edge environment for research and teaching.

Clare gave a guest lecture to an audience of academics, students, alumni, schoolchildren and business leaders where she said: "The building and its new equipment and facilities clearly demonstrate the department and university's commitment to make a significant impact in cutting edge areas of chemistry that have far reaching potential in areas of particular relevance to our rapidly changing world."

Sir John Meurig Thomas receives Royal Medal

On Wednesday 12 October Professor Sir John Meurig Thomas, former Head of Physical Chemistry, received his Royal Medal from HRH the Duke of York at The Royal Society in London.

Sir John with HRH the Duke of York

HFC phase-out agreed

In Kigali, Rwanda at the 28th Meeting of the Parties to the Montreal Protocol, 197 nations agreed to drastically reduce their use of hydrofluorocarbons (HFCs).

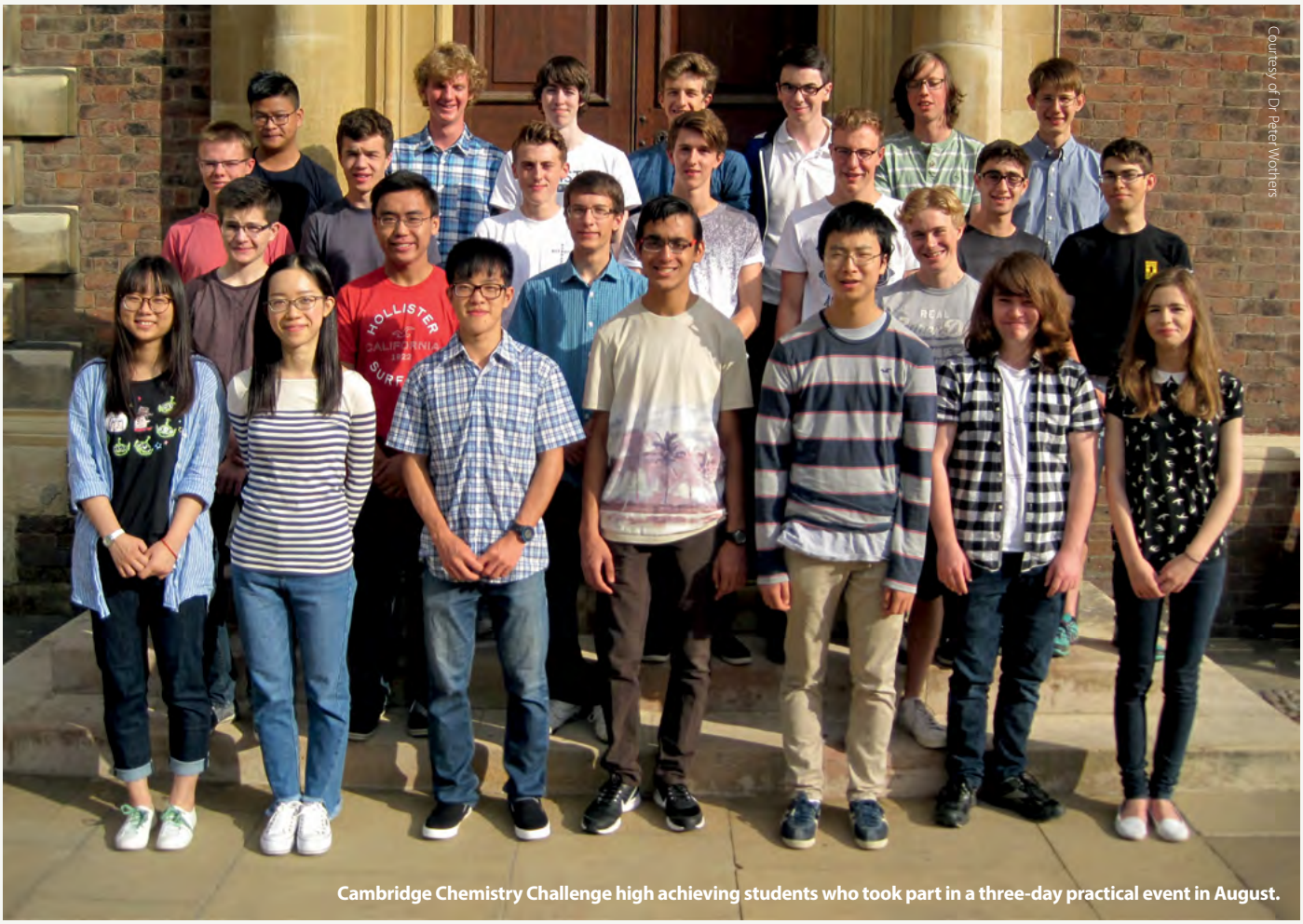
"This is good news. It shows that you can get things accomplished with the right combination of scientific input and recognition of the economic realities," says Head of Department Professor John Pyle, who is one of four international co-chairs of the Montreal Protocol Scientific Assessment Panel.

HFCs are extremely powerful greenhouse gases used mainly in air conditioners and refrigeration. They were developed in the 1990s to replace the ozone depleting substances being phased out under the Montreal Protocol, as they do not damage ozone. However, HFCs have been identified as major potential contributors to global warming, and were listed among the seven greenhouse gases targeted by the UN Framework Convention on Climate Change. In 2015, member nations agreed that HFCs could be brought within the remit of the Montreal Protocol, leading the way to this historic agreement to phase out their use.

"The compelling scientific evidence, along with compromise and economic support were all essential to reaching this agreement," says John. For example, High Ambient Temperature countries rely more heavily on using HFCs in air conditioning units, and developing countries do not have the financial resources to switch to safer alternatives. The compromise negotiated allows a slower phase-out of HFCs for some countries, who will also be helped to make the transition by a multi-lateral financial fund.

It is thought the elimination of HFCs by 2050 will prevent a 0.5 degree Celsius rise in global temperatures by the end of this century, vital for reaching the Paris Agreement target of keeping global temperature rise to below two degrees Celsius. The Montreal Protocol on Substances that Deplete the Ozone Layer came into force in 1987 in response to scientific evidence that human-induced depletion of the ozone layer was occurring. It is an example of how nations can successfully cooperate to prevent damage to the environment from human-induced atmospheric emissions.

"The original Montreal Protocol started out modestly, calling for limited regulation on the emission of CFCs," says John. "As our knowledge of how chemical emissions affect the



Courtesy of Dr Peter Wothers

Cambridge Chemistry Challenge high achieving students who took part in a three-day practical event in August.

earth's atmosphere has increased, the Protocol has played an increasingly key role in regulating harmful emissions. As co-chair of the Scientific Assessment Panel, I've been able to ensure that the research we are doing in Cambridge and other excellent research from around the world is effectively communicated to the policymakers."

Cambridge Chemistry Challenge 2016

More than 7,200 students from across the UK took part in the Cambridge Chemistry Challenge (C3L6) competition in June. The competition is designed to stretch and challenge the chemistry knowledge of Year 12 students.

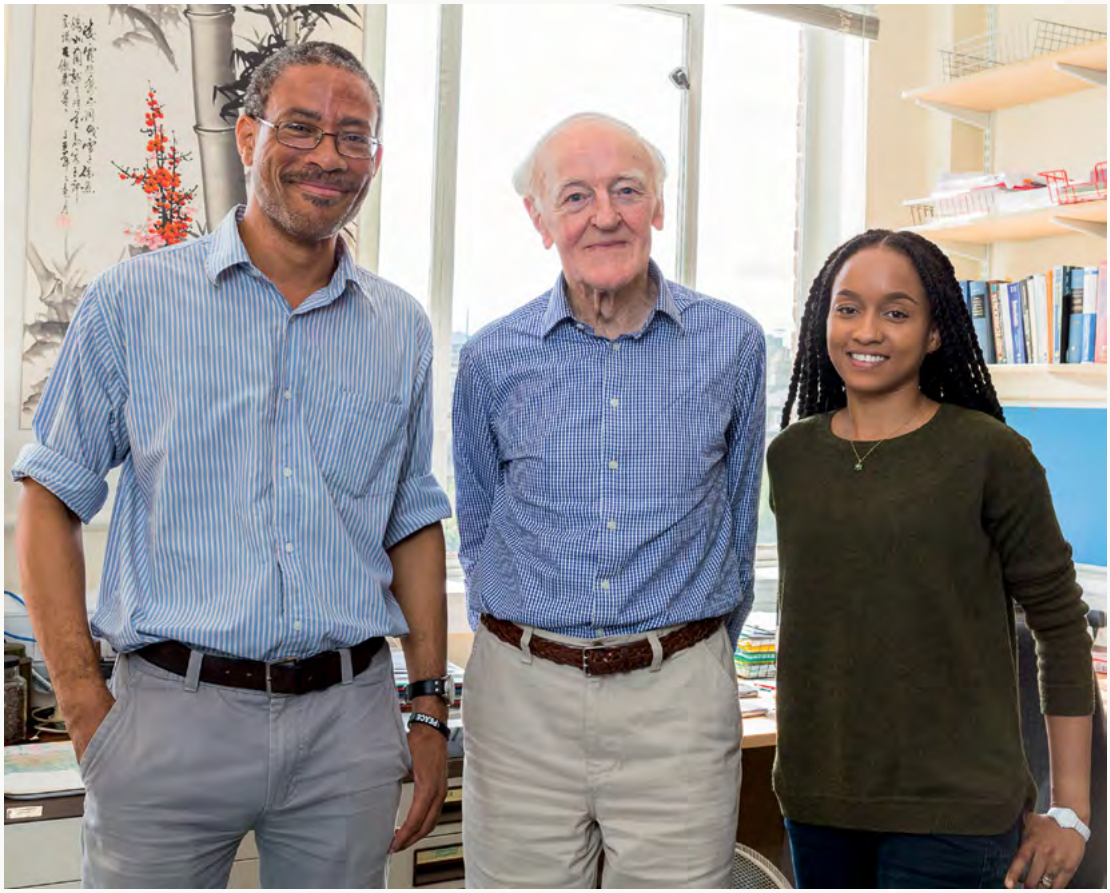
The competition involves a 90-minute exam that stretches participants beyond the AS-level chemistry syllabus. It is designed to show that chemistry can be interesting, challenging and relevant. This year the students were asked to consider two areas: antimalarial drugs and Noxer blocks, which help remove nitrogen oxides from the atmosphere.

The students who achieved the highest award were invited to take part in a three-day practical event held in the department in August. They also attended a reception at Goldsmiths' Hall, London in December where they were presented with trophies.

Teaching Fellow Dr Peter Wothers, part of the team that runs C3L6, said: "The Cambridge Chemistry Challenge has become an established part of the school timetable and it is great to see so many students participate and try more challenging questions which show the relevance of chemistry in today's world."

The Generation Game

Three academic generations



Professor David Buckingham is professor emeritus in the Department of Chemistry. The Australian has been associated with the department since 1953. He did his PhD in theoretical chemistry supervised by Nobel Prize winner Professor Sir John Pople, and became Professor of Chemistry in 1969.

Sean McDowell is Professor of Theoretical and Computational Chemistry, University of the West Indies in Barbados, and a Fellow of the World Academy of Sciences, which supports science in the developing world. In 1992 he completed his PhD in theoretical chemistry, supervised by Professor Buckingham. Almost every year since, Sean has returned to the department, at first just to touch base, but since 2006 as a Visiting Professor to collaborate with Professor Buckingham.

Jerelle Joseph is a PhD candidate and Gates Scholar in computational chemistry, supervised by Professor David Wales. The Dominican completed her undergraduate and masters degrees in computational chemistry at the University of the West Indies in Barbados under Sean's supervision.

Together these three people form a little 'family' of academics here in the department, but what do these 'family' members have to say about each other?

Professor David Buckingham: 1st Generation

On Prof McDowell: I first met Sean in the early 80s when he came from Jamaica as a Commonwealth Scholar. From the first I admired his nature: Sean introduced a light-heartedness that produced a Caribbean warmth that was very good and valuable for the group, and I appreciated that. And he did some very nice work. He became very interested in the hydrogen bond and later the halogen bond. Nearly every time he's come back since his PhD has led to a publication. Our friendship and academic relationship has been very fruitful.

On Jerelle Joseph: I'm like her academic grandfather. I don't see her on a regular basis but whenever I see her we have a nice chat; she'll always give me a big hug. We wrote a paper together in 2015, well a comment on a paper she'd written with Sean in 2014. There was one issue in it that didn't ring true to me. So we did the work at a higher level of accuracy and found a much more acceptable result, which was published in Chemical Physics Letters. It's rather amusing commenting on their own paper but I'm the additional author. So rather nice that the three of us have a paper together, three generations!

Professor Sean McDowell: 2nd Generation

On Prof Buckingham: Our association goes back almost 30 years; I come back every year. You know he was a first class cricketer, so we always talk a little about cricket and especially the current state of West Indian cricket. We have no set agenda, there's no continuous project. I just come. I have one or two ideas. We sit, we talk and something interesting always emerges. He gives me valuable feedback and he's always very supportive and encouraging. We have been fortunate in that our collaboration usually yields a paper. Our personalities are very compatible.

On Jerelle Joseph: The course I teach in Barbados is physical chemistry, which is considered difficult, so most people are running away from it, but she'd usually be at the front of the class. So, I encouraged her. She was miles ahead of the other students; there was absolutely no doubt about it. She told me that I said she should come and work with me; I can't remember it but I probably did. She was my first PhD student. But I did tell her I thought she should go to Cambridge, even though it would be a loss for my research programme. We published nine papers and a book chapter together in two and a half years. I came to Cambridge in 2013 and I met with a lady at the Cambridge Commonwealth office and took the application form back to Barbados for Jerelle. I said, in no uncertain tones, 'make sure you get it back before the deadline'. She has the potential to go very far.

Jerelle Joseph: 3rd Generation

On Prof McDowell: I realised I didn't like the lab because I get lost and break things, so the next option was to do a theory and computational based project, and the only person who was offering that was Professor McDowell. I did the project with him and it was a lot of fun. I was his first graduate student and we had a very good working relationship. We were working on a relatively new topic, halogen bonding, and after the second month we got our first paper out. We had a very productive working relationship. But he was really keen on me going to Cambridge and encouraged me to go. He said it would be a good fit for me, a good environment. But I never wanted to leave the Caribbean. One summer he came back from Cambridge with the Commonwealth Scholarship application form. So I applied just to prove to him that I would not get in. But when I got accepted I didn't tell him. Later down the line I had to tell him because I was offered the Gates Scholarship and once you get the Gates Scholarship everybody knows. At that point I could feel Prof McDowell was kinda sad to see me go, even though he was the one that encouraged me.

On Prof Buckingham: Because I was undecided about leaving home, Professor McDowell asked Professor Buckingham for advice. And when I read Prof Buckingham's email I was like this is crazy - Prof Buckingham helping me with a decision! He thought that I might regret it if I didn't accept, so then I decided to go. And here I am. When I met Prof Buckingham for the first time I was so nervous, but he was so welcoming and he didn't make me feel intimidated. It was nice. It's always great to see him.

If you're part of an academic 'family' get in touch. We'd like to hear your story.

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Wine Buffs

In September, alumni returning to Cambridge for the Alumni Festival descended on the Cybercafé for the Department of Chemistry "Call my Bluff" wine tasting, whose popularity has spread rapidly after its first appearance last year.

Two of last year's panellists returned to the table, Head of Department and Professor of Atmospheric Chemistry, John Pyle, and materials chemist Dr Silvia Vignolini. Theoretical and computational chemist Dr Lucy Colwell made up the trio, promising to do her best to fill the mischievous shoes of former Head of Department and Boltzmann Prize winner Professor Daan Frenkel, who participated last year.

For each round the three chemistry experts (not necessarily in wine tasting!) described the wine samples being enjoyed by the audience. The audience teams then had to determine who was bluffing, and who was telling the truth. The simple but effective format offered opportunities for humorous banter, mixed with information about the panellists' research and the world-class work being done in the department.

Each panel member used their own special way of assessing the wines: Silvia produced an app with a probe that looked suspiciously like a cotton swab on string taped to the back of her smartphone. She claimed it was a low-cost photonic sensor based on cellulose, with the advantage of being renewable and biocompatible (see research story on page 19).

John used a "periodic table of wines" reference book, asserting that the grapes in a glass of wine constituted one of your five a day. A very persuasive panellist!

Lucy took a 'big data' approach (see research story on page 22) simply feeding detailed wine notes into her application that ran the information through an algorithm, which returned the "correct" grape variety.

The panel and other academic staff mingled with alumni during the interval, giving further opportunity to discuss both chemistry and wine.

The team calling themselves Bibendum won the ~~drinking~~ tasting competition, finishing three points ahead of their nearest rivals Grapes of Wrath. Next year will surely be a battle (Kir) royal.

The department would like to thank Professors Chris Hunter, David Klenerman, Oren Scherman, Shankar Balasubramanian and Robert Glen, who sponsored the wines for the event.

Illuminating Scientific Success:

A tribute to Roger Tsien

Careers advice from a colourful Nobel Prize winner, by M. E. Kavanagh

Madeline Kavanagh interviewed Professor Roger Tsien, who conducted research in the Department of Chemistry in the 70s, for Varsity magazine in 2015. As a tribute to Professor Tsien, who died in August 2016, we reproduce an extract from that article:

It is hard to beat career advice from a University of Cambridge alumnus and Nobel laureate. I had the privilege and delight of getting just that from Roger Tsien, 2008 Nobel Prize winner in Chemistry.

In the company of the author of more than 300 research papers and 80 patents, the driving force behind numerous biotech start-ups and the supervisor of 70 graduate and postdoctoral researchers, I asked, what is the secret to being a successful scientist?

Obviously familiar with this question, Prof Tsien succinctly summarised with five key points:

Various fluorescent proteins

1. "Try to find projects that give you sensual pleasure." He admitted that the beautiful rainbow of colours often seen in images of his early work, visualising biological systems, were arranged for aesthetic preference alone. He said, "you don't know what is going to work, so you might as well pick something that is fun…it makes getting up that little bit easier!"

2. "Your batting average will be low. In research there is a genuine likelihood of failure". He warned, "your best papers may be rejected from the most fashionable journals" and that this is not necessarily a reflection on the quality of the research.

3. "Learn to make lemonade from lemons". This is particularly good advice when considering the serendipitous nature of some of the most important scientific discoveries throughout history.

4. "Find the right collaborators". In the increasingly interconnected world of science, where large, multidisciplinary research teams often work together to address global challenges, Tsien highlighted that scientists who are successful learn to exploit their collaborators "kindly, and for mutual benefit".

5. "Put your neuroses to constructive use" and utilise your individuality as a positive force in their research.

Colouring books

The Fitzwilliam's illuminated manuscripts

Lapis lazuli, malachite, verdigris, woad, silver, gold are all materials that have been used to produce colour in art since antiquity. But recent chemical analysis of the Fitzwilliam's collection of illuminated manuscripts has brought some less well-known materials such as antimony black, smalt and manganese oxide to the attention of heritage science researchers.

Heritage science, also known as conservation science, is the application of scientific methods and technical analysis to art works and museum objects of cultural heritage. "Because the term conservation can be confused with ecology and environment issues, over the past 10 to 15 years the name in the UK has changed," explains the Fitzwilliam Museum's resident scientist Dr Paola Ricciardi. "Also not everything in heritage science is geared towards the conservation of the objects. When it started it was very much how can we preserve these objects, why are they degrading? Now it's much broader."

Dr Ricciardi works on MINIARE (www.miniare.org), an interdisciplinary project using a combination of advanced methods in the physical sciences to study the Fitzwilliam Museum's collection of medieval and Renaissance manuscripts. *COLOUR: The Art and Science of Illuminated Manuscripts*, an exhibition of 150 illuminated manuscripts at the Fitzwilliam Museum (open until 2 January 2017) is, in part, the result of MINIARE's research efforts.

The department's Professor Stephen Elliott Physical Chemistry principal investigator and leading chemical sensing researcher is a trusted advisor for MINIARE. "Stephen was especially important at the beginning of the project because of his specific research interests," says Paola. "He knows how to work with pigments and what's needed to identify them. He gave Dr Stella Panayotova, Keeper of Manuscripts and Printed Books at the Fitzwilliam Museum, advice about equipment, the analytical methods, non-invasive analysis. He worked very closely with us and continues to advise."

Manuscripts have not been subject to the same amount of analysis as other objects such as paintings. The reason for that is there are different conservation concerns. A painting can, almost always, be sampled. While with manuscripts, researchers are looking at very small areas and thin paint layers, so there's precious little pigment left to study that can be sampled in the conventional manner as any sampling might leave a visible hole. "Even though the basic pigments used by illuminators were known because of historic treatises, medieval accounts or very early analysis, we can't sample them and we can't shine 50 thousand lux on a manuscript because it may fade."

Technological developments in non-invasive analysis now give researchers the opportunity to analyse these objects without sampling. "We use near-infrared imaging and infrared reflectography to detect under-drawing or the sketches that are made before the actual painting of the composition. Also we can detect *pentimenti*, which are the changes made by the artists between the drawing and the painting stage."

LEFT: Dr Paola Ricciardi, Research Scientist, The Fitzwilliam Museum

RIGHT: XRF analysis of a 14th century manuscript

UV-vis-NIR reflectance, X-ray fluorescence, FT-IR and Raman, are all spectroscopic methods used in combination to identify a very broad range of pigments and some paint binders.

"XRF gives us elemental information, which chemical elements are present, like gold and silver metals. UV-vis-NIR and Raman spectroscopy give you molecular information, structural information. We use these methods in combination because they are good at identifying different things," Paola explained. "Raman is indispensable for yellow pigments that were used at that time. The reflectance spectroscopy works better for green and blue pigments.

"Then there's optical microscopy, which is a very basic technique but we use it to get a closer look at the surface, particularly on miniatures where the detail is very small, we can identify mixtures of pigments and look at the layering or edges and the individual painting techniques used by the artists for stylistic analysis. We can study the process of making the book."

These methods have led to the discovery of some unusual pigments in manuscripts. For example antimony black was identified in two of the Fitzwilliam illuminated manuscripts. Both date to around 1500. In one case the origin of the manuscript is Rome, Italy. Paola said: "We know that at the time easel painters in Rome were using antimony black and this makes a connection, from the materials point of view, between manuscript illumination and easel painting.

"We first had a hint that there might be something unusual when we did near infrared imaging. We were expecting to find carbon black, charcoal or soot, very cheap, very common in 1500, but the images weren't as dark in the infrared as we were expecting. We investigated with the UV-vis reflectance spectroscopy and found unusual spectra but we didn't know what it was. So next we did XRF and we found antimony. At that point we thought which dark antimony compounds are there and what do their reflectance spectra look like? And then we found stibnite (Sb_2S_3) – it's not a very common pigment, which happens to have a reflectance spectrum that matched the one we found. It's all a bit of forensic science and putting things together."

When the team discovered smalt, which is a ground blue glass used as a pigment, for the first time in a manuscript made in Venice it didn't come as a surprise. "Glassmaking in 1400s Venice was a thriving industry but nobody had ever identified smalt in a Venetian manuscript.

BELOW LEFT: Fitzwilliam Museum, Marlay cutting It. 40 (detail). *Adoration of the Magi*, Italy, Venice, c. 1567-1572 (see back cover).

BELOW RIGHT: Fitzwilliam Museum, MS 355-1984 (detail). *Flagellation*, France, Rouen, c. 1530. The grey hue of Christ's body is obtained mixing lead white with antimony black.

And also the date of this particular manuscript is about 50 years before the first documented use of smalt in easel painting in the area. So we can start to see a possible transfer of knowledge between glassmakers and illuminators and perhaps via illuminators to easel painters."

With the discovery of smalt the team thought they'd found lapis lazuli (ultramarine blue), which is very common. "But we did XRF, which is something we don't always do on blues and found a small amount of cobalt." Cobalt, when found in works of art can be a bad sign because most cobalt-containing pigments are modern. The team thought they were looking at a work that had been re-touched.

"But the other chemical elements suggested the possible presence of glass so we looked more closely at the reflectance spectra," Paola added. "We found some bands that were a good indication for smalt. What really clinched it for us, showing that it wasn't just a spot re-touch, was the macro XRF scanning that produces data across the entire surface. We found cobalt in a lot of blue areas and not just in one or two spots that might have been re-touched but across some very homogeneous areas of blue. That means it's part of the original composition. It makes sense that it's smalt."

Chemistry and chemical research underpin all of the most interesting discoveries in heritage science. They are also helping researchers to understand and to arrest (ethically), deleterious chemical reactions, preserving these beautiful and precious objects for many years to come.

Reference:
COLOUR: The Art and Science of Illuminated Manuscripts, S. Panayotova (ed.), Harvey Miller Publishers/Brepols, 2016 (Essay 7)

Reference:
'Estimation of semiconductor-like pigment concentrations in paint mixtures and their differentiation from paint layers using first-derivative reflectance spectra', A. R. Pallipurath, J. M. Skelton, P. Ricciardi, S. R. Elliott, *Talanta* 154 (2016), 63-72, dx.doi.org/10.1016/j.talanta.2016.03.052

Low-cost cellulose sensor breakthrough

Vignolini Group

Dr Silvia Vignolini and colleagues have produced a low-cost photonic sensor based on aqueous hydroxypropyl (HPC), a cellulose derivative. The water-based sensors demonstrate that biopolymers can be used as responsive large area coatings in commercial smart photonic devices including mobile phones, displays, and security devices.

In a paper published in *Advanced Optical Materials,* the researchers explain how they developed biocompatible pressure-sensitive photonic sensors that are scalable, sustainable and inexpensive.

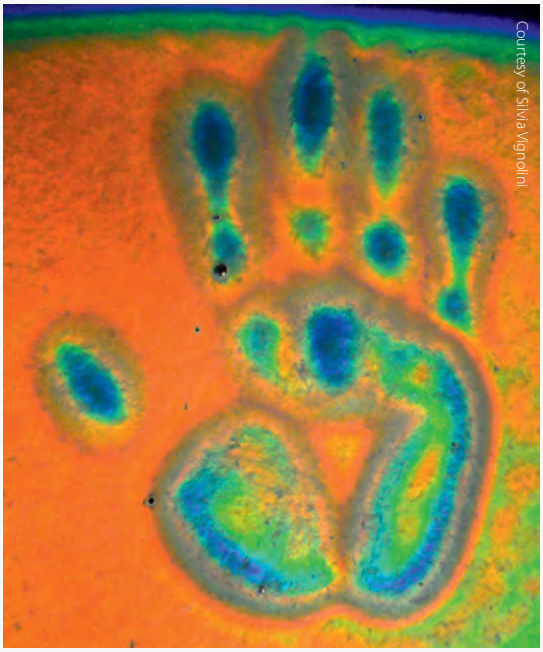
Cellulose and its derivatives are receiving increasing interest in sensor development because they are seen as an environmentally friendly alternative to plastics. "What is great about these sensors is their simplicity," said lead author Dr Gen Kamita, a postdoctoral researcher in the group. "The active component of the sensor consists of only two materials, HPC (hydroxypropyl cellulose) and water, and that is all you need."

The project started after Gen realised that her work encapsulating the liquid crystal HPC to create coloured materials could be combined with making strain sensors. The 'strain sensor' is able to measure, using the optical signature, the amount of pressure that is being applied to the biopolymer.

The team chose HPC because it can form a cholesteric liquid-crystalline phase, a state between liquid and solid form, or mesophase. Sandwiching this water-based HPC mesophase between polymer sheets produces a robust, large-area and flexible strain sensor, which can detect different types of pressure such as compression, shear and extension, based on the optical signature.

Silvia said: "These devices are manufactured using an extremely simple fabrication process with low-cost materials, which makes them suitable for both miniaturisation and large-scale manufacture. And HPC encompasses all the desirable properties of cellulose. It is non-toxic, water-soluble and responsive."

The new cellulose sensors also have advantages over conventional crystal sensors, which cannot be scaled or used in dry environments, and electric strain sensors that are less sensitive to changes in pressure. The cellulose sensor overcomes these drawbacks and has the added advantages of being renewable, biocompatible and, crucially, much less expensive to produce.



The image shows a hand pressing onto the HPC strain sensor. As the strain pattern of the hand is applied, the pressed region of the sensor shows a vivid blue colour. The different colours produced correspond to varying amounts of pressure. The colour change is reversible when the pressure is removed.

Reference:
Gen Kamita, et al., *'Bio-compatible and Sustainable Optical Strain Sensors for Large-area applications'* Advanced Optical Materials, DOI 10.1002/adom.201600451

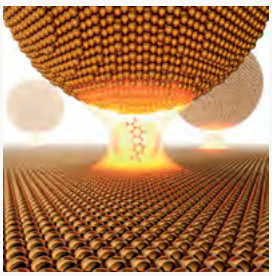
Nano Halls of Light

Scherman Group

A multi-disciplinary group of researchers, including chemists at the Melville Laboratory led by Professor Oren Scherman, have successfully used quantum states to mix molecules with light at room temperature.

The process, which is reported in a research letter to *Nature*, will aid in the exploration of quantum technologies and suggests new opportunities in photocatalysis.

Professor Oren Scherman explains: "From a chemistry perspective, what's very exciting is that we might actually be able to induce, watch and control reactions with light on a molecular level. The opportunity to have light control or catalysed chemistry of small molecules in a confined space at both room temperature and in mild conditions opens up new opportunities in sensing and photocatalysis, something that previously could only be done under extreme conditions." Having the ability to explore new chemistry in ambient conditions could be of great importance for sustainable and renewable energy production.



A longer version of this article first appeared on the Research website, University of Cambridge.

READ MORE
www.cam.ac.uk/research/news/nano-hall-of-mirrors-causes-molecules-to-mix-with-light

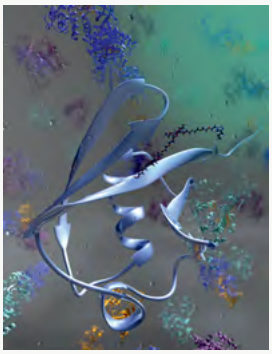
Reference:
Rohit Chikkaraddy et al., *'Single-molecule strong coupling at room temperature in plasmonic nanocavities.'* Nature (2016). DOI: 10.1038/nature17974

IMAGE ABOVE: **Plasmonic nanocavity containing a dye molecule.**

New class of antibody-drug bio-conjugates

Bernardes Group

A group of researchers led by Gonçalo Bernardes has developed a new site-selective method for the construction of complex protein/antibody conjugates. The scientists have designed a new class of carbonylacrylic cysteine-selective reagents that may vastly improve the effectiveness of targeted drug delivery while cutting the problems of low efficacy and side-toxicity associated with current methods.



The usual methods of antibody-drug bioconjugation are based on maleimide chemistry. But the resulting conjugates often undergo thiol-exchange reactions while in circulation, which leads to the drug being released before it reaches its target. Gonçalo: "If this happens, the drug is released prematurely which not only limits the efficacy of the treatment but also leads to side-toxicity".

The team located in Cambridge and Portugal use very small amounts of carbonylacrylic derivatives bearing a drug or fluorophore that reacts irreversibly with cysteine residues to produce chemically defined protein and antibody conjugates.

Therapeutic protein/antibody-drug conjugates built using carbonylacrylic derivatives that selectively modify cysteine residues are highly stable in plasma. Gonçalo: "By making antibody-drug conjugates more stable in the circulation we know the drug is only going to be delivered in the site of disease." The work raises important questions and possibilities regarding the delivery of cytotoxic drugs, particularly during cancer treatments or therapy.

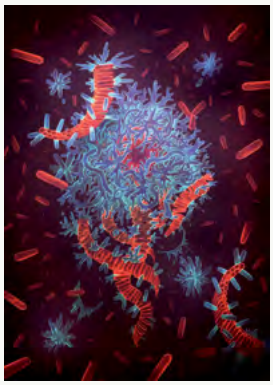
Reference:
Barbara Bernardim et al., *'Stoichiometric and irreversible cysteine-selective protein modification using carbonylacrylic reagents'* Nature Communications October 2016 | DOI: 10.1038/ncomms13128

IMAGE ABOVE: **A stable, precisely modified protein conjugate. Courtesy of Ella Marushchenko**

Physical link in neurodegenerative chemistry

Knowles Group

A team of researchers led by Dr Andela Šarić and Prof Tuomas Knowles have shown that the toxic build up of 'plaques' in the brains of Alzheimer's patients is governed by a simple physical mechanism.



Healthy protein builds up on the surface of protein fibrils, called amyloids. When the deposit reaches a certain amount it triggers fibril self-replication. Once this process has occurred the rate at which new protein fibrils are produced explodes, and results in deterioration in brain function.

However, the study suggests that by controlling the amount of healthy protein making contact with existing fibrils the spread of the pathological protein aggregation could be limited and the disease contained.

A longer version of this article first appeared on the Research website, University of Cambridge.

READ MORE
www.cam.ac.uk/research/news/slow-slow-quick-quick-slow-scientists-discover-how-proteins-in-the-brain-build-up-rapidly-in

Reference
Šarić, *A et al., Physical determinants of the self-replication of protein fibrils. Nature Physics; 18 July 2016; DOI: 10.1038/NPHYS3828*

IMAGE ABOVE: Artist's rendering of self-replication of protein fibrils. Courtesy of Ivan Barun, MD

4-stranded DNA helix points to possible new cancer treatments

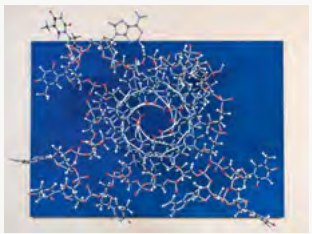
Balasubramanian Group

Researchers in the Balasubramanian Group have identified the role that a four-stranded version of DNA may play in the progression of cancer, and suggest that it may be used to develop new targeted cancer therapies.

In work funded by Cancer Research UK and EMBO, the researchers found that quadruple helix structures occur in the regions of DNA that control genes, particularly cancer genes, suggesting that they may play a role in switching genes on or off. The results, reported in the journal *Nature Genetics*, could also have implications for cancer diagnostics and the development of new targeted treatments.

The structures, with four rather than two (double) helixes are often referred to as G-quadruplexes, as they form in regions of DNA that are rich in guanine, usually abbreviated to 'G'.

"We found that G-quadruplexes appear in regions of the genome where proteins such as transcription factors control cell fate and function," said Dr Robert Hänsel-Hertsch, the paper's lead author. "The finding that these structures may help regulate the way that information is encoded and decoded in the genome will change the way we think this process works."



Professor Shankar Balasubramanian, group leader and the paper's senior author said: "There have been a number of different connections made between these structures and cancer, but these have been largely hypothetical. What we've found is that even in non-cancer cells, these structures seem to come and go in a way that's linked to genes being switched on or off."

A longer version of this article first appeared on the Research website, University of Cambridge.

READ MORE:
www.cam.ac.uk/research/news/quadruple-helix-form-of-dna-may-aid-in-the-development-of-targeted-cancer-therapies

Reference:
Robert Hänsel-Hertsch et al., *'G-quadruplex structures mark human regulatory chromatin.' Nature Genetics (2016). DOI: 10.1038/ng.3662*

IMAGE ABOVE: G-quadruplex structure.

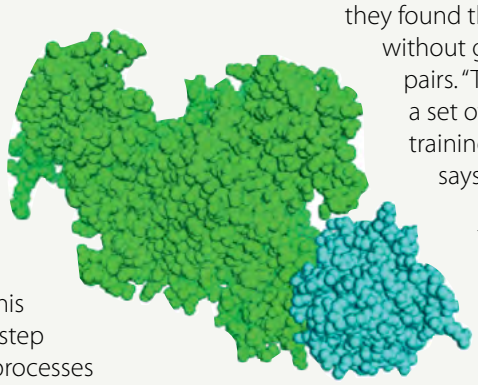
Algorithm for predicting protein pairings

Colwell Group

An algorithm which predicts which proteins inside cells interact with each other sheds light on how proteins work together to complete tasks such as turning food into energy, and will aid our understanding of how living systems work.

"Being able to predict these interactions will help us understand how proteins fit and work together and will aid our understanding of living systems," says theoretical and computational chemist Lucy Colwell, co-senior author of the study with Ned Wingreen of Princeton University.

The ability to generate huge amounts of data from genetic sequencing has developed rapidly in the past decade, but the challenge for researchers is using that sequencing data to better understand living systems. This new research is a significant step forward because biological processes are driven by specific protein-protein interactions.



"We were really surprised that our algorithm was powerful enough to make accurate predictions in the absence of experimentally-derived data," says Lucy.

When proteins interact with each other, they stick together to form protein complexes. In her previous research, Lucy found that if the two interacting proteins were known, sequence data could be used to figure out the structure of these complexes. Once the structure of the complexes is known, researchers can then investigate what is happening chemically.

However, the question of which proteins interact with each other still required expensive, time-consuming experiments.

In the current paper, the researchers used a mathematical algorithm to sift through the possible interaction partners and identify pairs of proteins that interact with each other. The method correctly predicted 93% of protein-protein interactions present in a dataset of more than 40,000 protein sequences for which the pairing is known, without being first provided any examples of correct pairs.

The researchers thought that the algorithm would only work accurately if it first 'learned' what makes a good protein-protein pair by studying pairs that have been discovered in experiments. But they found they could run the algorithm without giving it any such training pairs. "The fact that we didn't need a set of experimentally-derived training data was really surprising," says Lucy.

The algorithm was developed using two well-studied families of proteins, histidine kinases and response regulators from bacteria, and the researchers are now extending the technique to other organisms. "Reactions in living organisms are driven by specific protein interactions," says Lucy. "This approach allows us to identify and probe these interactions, an essential step towards building a picture of how living systems work."

The research was supported in part by the National Institutes of Health, the National Science Foundation and the European Union. A longer version of this article first appeared on the Research website, University of Cambridge.

READ MORE
www.cam.ac.uk/research/news/algorithm-for-predicting-protein-pairings-could-help-show-how-living-systems-work

Reference:
Anne-Florence Bitbol et al., *'Inferring interaction partners from protein sequences.'* Proceedings of the National Academy of Sciences (2016). DOI: 10.1073/pnas.1606762113

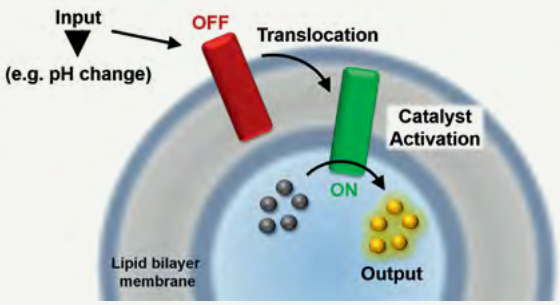
IMAGE, ABOVE:
Interacting proteins.
Courtesy of Dr Lucy Colwell

Controlled membrane translocation

Hunter Group

Signal transduction involves molecules outside a cell signaling to molecules inside the cell that in turn trigger events on the inside. It is an essential feature of biological systems. A small team of researchers in the Hunter Group has created a new and different mechanism for signal transduction by synthesizing molecules that not only transmit a signal across a membrane but also amplify the signal by activating a catalytic reaction on the inside. Group leader Professor Chris Hunter says: "It's an analogue of what happens in nature to trigger many biological process."

In biology proteins do the job of bridging the gap between the inside and the outside of a cell. When these proteins bind to molecules in the external environment, they undergo a structural change, which transmits the chemical signal to the inside of the cell, triggering a cascade of catalytic reactions. The Hunter Group used vesicles, which are synthetic cells with just the lipid membrane, and a synthetic molecule that does the job of the protein. "What's interesting about this work is we can control the molecule's movement across a membrane. When it sees the signal it drops down through to the other side without actually crossing over. We use pH to drive this molecular machine – high pH pushes the molecule in and turns the catalyst on, low pH pulls it out turning the catalyst off," said Chris.



A bit like doing the hokey-cokey – pull it out, push it in, shake the cell around – that's what it's all about. Clearly, as the subject of a recently published paper in Nature Chemistry, there is a bit more to membrane translocation of a synthetic molecule than an old folk song and dance may suggest. And although there are no immediate applications, this fundamental research represents the first example of an artificial system that is able to transduce and amplify chemical signals across a membrane without physical transfer of matter. Lead author Matthew Langton said: "We are excited by the range of possibilities that could arise from being able to remote-control reactions inside synthetic cells. We are now developing systems that can respond and be controlled by a range of input signals such as small molecules and enzymes, which might ultimately find applications in controlled drug delivery and sensing."

Chris summed up: "People have been trying to do things like this with synthetic molecules for some time. Molecular machines are generating a lot of excitement in the scientific community. But complex function is difficult to achieve. Our system is an assembly of relatively simple components that reproduces one of the most sophisticated functions of biomolecules. The simplicity of the design means there will be many potential applications."

IMAGE, ABOVE: Graphic representation showing the behaviour of a synthetic transducer embedded in a lipid bilayer membrane. An input signal (e.g. pH change) leads to the translocation of a molecule embedded in the membrane. In the OFF state (red), the transducer is inactive; when in the ON state (green), the exposure of the transducer to the internal aqueous phase turns over an encapsulated substrate (grey spheres) to generate an output signal (yellow spheres).

Reference:

Matthew J. Langton et al.,*'Controlled membrane translocation provides a mechanism for signal transduction and amplification'* Matthew J. Langton, et al., Nature Chemistry, Dec 2016 DOI: 10.1038/NCHEM.2678

Harnessing the possibilities of the nanoworld

Scientists have long suspected that the way materials behave on the nanoscale – that is when particles have dimensions of about 1–100 nanometres – is different from how they behave on any other scale. A new paper in the journal *Chemical Science* provides concrete proof that this is the case.

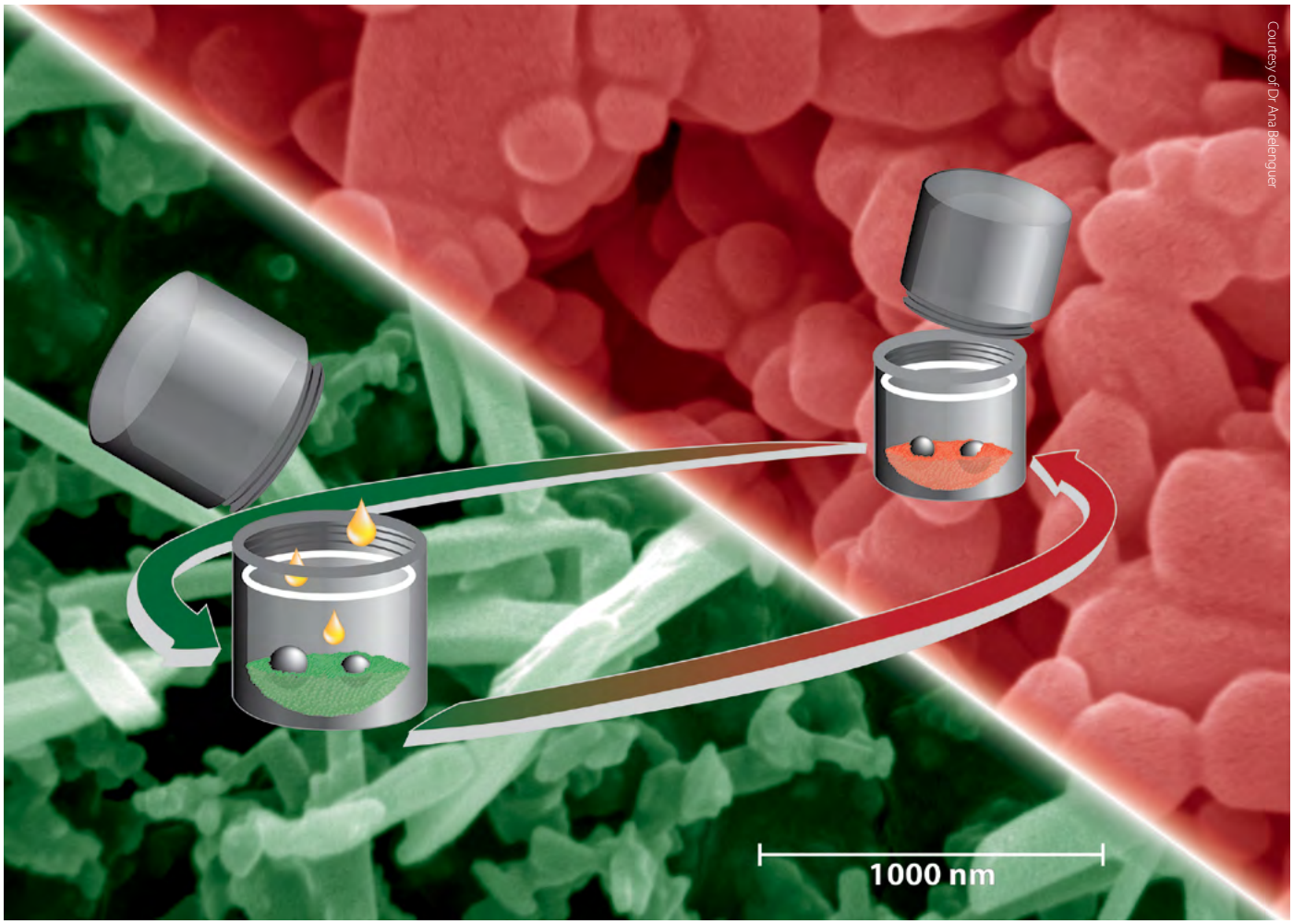
In this paper, the authors have used mechanochemistry – that is milling and grinding – to obtain nanosized particles, small enough that surface effects become significant. In other words, the chemistry of the nanoworld – which structures are the most stable at this scale, and what conditions affect their stability, has been studied for the first time with carefully controlled experiments.

Professor Jeremy Sanders, who led the work, said: "We're trying to understand crystallisation, the process by which particles, randomly distributed in a solution, can form highly ordered crystal structures, given the right conditions." But different conditions can sometimes yield different crystal structures. These are known as polymorphs, and they're important in many branches of science including medicine; for instance a drug can behave differently depending on which polymorph crystallises in the body.

"It's very exciting in 'retirement' to find myself working in this totally new area which turns out to be so important."

By changing the milling conditions, for example by adding a small amount of solvent, the authors have been able to control which polymorph is the most stable. Jeremy said: "It is exciting that these simple experiments, when carried out with great care, can unexpectedly open a new door to understanding the fundamental question of how surface effects can control the stability of nanocrystals."

Joel Bernstein, Global Distinguished Professor of Chemistry at NYU Abu Dhabi, and an expert



Courtesy of Dr Ana Belenguer

The graphic shows that you can go from green nanocrystals to red by adding a few drops of solvent and grinding, and back to green by grinding without solvent because solvation of the surface changes the stability of tiny crystals.

in crystal growth and structure, explains: "The authors have elegantly shown how to experimentally measure and simulate situations where you have two possible nuclei, say A and B, and determine that A is more stable. And they can also show what conditions are necessary in order for these stabilities to invert. This is news, because you can't make those predictions using classical thermodynamics, and nor is this the quantum effect. By doing these experiments, the authors have started to gain an understanding of how things behave on this size regime, and how we can predict and thus control it."

One of the key words of chemical synthesis is 'control'. Chemists are always trying to control the properties of materials, whether that's to make a better dye or plastic, or a drug that's more effective in the body. So if we can learn to control how molecules come together in a solution to form solids, we can gain a great deal. This work is a significant first step in gaining that control.

This is excerpted from a longer article published *on the Royal Society of Chemistry* website and on the University of Cambridge research news webpages.

READ MORE
www.cam.ac.uk/research/news/harnessing-the-possibilities-of-the-nanoworld

Reference:
A. M. Belenguer et al., *'Solvation and surface effects on polymorph stabilities at the nanoscale.'* Chemical Science (2016). DOI: 10.1039/c6sc03457h

Tanya Hutter

Women in Chemistry

Tanya Hutter completed her PhD in 2013 under the supervision of Professor Stephen Elliott. Three years on, Dr Hutter is a Henslow Research Fellow at Darwin College, a postdoctoral researcher in the department, and director and co-founder of her own company, SensorHut. Tanya recently returned to work after having her second child, at the head of a major clinical sensor development project. Tanya is this issue's Woman in Chemistry.

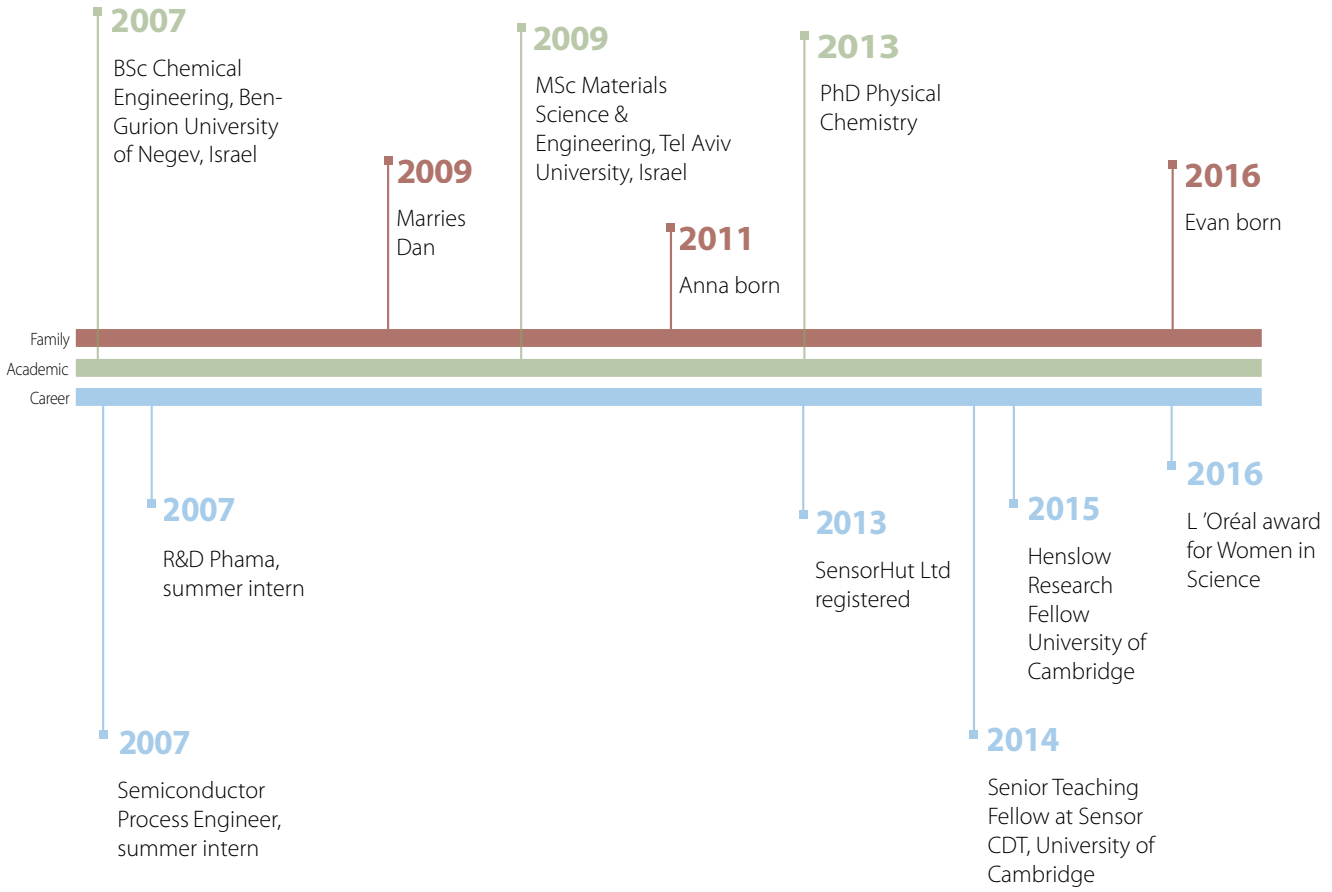
Tanya Hutter arrived in Cambridge, with a BSc in chemical engineering from Ben-Gurion University and an MSc in Materials Science & Engineering from Tel Aviv University, specialising in optical sensing, during which time she published four papers, filed one patent and graduated top in her class with distinction. "Succeeding in my Masters gave me the confidence to continue in academic research, because two years earlier I could not have imagined doing a PhD or studying in Cambridge. Securing a competitive scholarship from Trinity College allowed me to come to Cambridge for a PhD, and when I arrived I was overwhelmed and excited by the prospect of being able to work on a variety of different subjects such as optical waveguides, plasmonics, nanotechnology, microfluidics and chemical sensors – it all seemed like so much fun," said Tanya.

Tanya joined Professor Stephen Elliott's group in 2009 but took six months out of her research to have her first child, Anna. By the end of her PhD (which was completed in the designated three year period) Tanya published an astonishing 14 papers and conceived the concept for SensorHut.

"I was really excited by the ideas that were beginning to develop in the back of my mind about SensorHut, but I did not want my PhD research to be distracted until the thesis was done and dusted". With the PhD complete and support from her husband Dan, Tanya turned her attention to the start-up. "I decided to remain in Cambridge to develop my research, collaborate with colleagues, explore the business potential of my start-up idea, and provide a stable and supportive environment for my young daughter. I also joined the Accelerate Cambridge programme at the Judge Business School where I gained the skills in commercialisation and business development."

SensorHut was founded in late 2013 in order to commercialise a new chemical sensing technique based on the principles of optical absorption. The company's aim is to provide more accurate measurement of volatile organic compounds in applications ranging from the monitoring of industrial processes to medical diagnostics.

Tanya's new project in the department has secured transitional funding from NIHR (National Institute for Health Research), with the aim of developing a real-time online sensor which can measure molecular changes of acute head injury patients. "I really enjoy doing science and the idea of translating fundamental research into products that improve the lives of users. In my current research



I am exploring the overlap between the fields of microfluidics, optics, materials and surface chemistry. Being based in a chemistry department doesn't mean that I only do chemistry - this is what's great about multidisciplinary science. I am particularly excited when someone comes to me with a challenging problem that can only be addressed by exploiting a number of disciplines. I want to bridge the gap between commerce and academia."

Motherhood

Balancing the demands of motherhood with a successful career has not been straightforward, and the challenges Tanya has experience are not uncommon amongst early career female researchers. However, being one of five recipients (from hundreds of applicants) for the prestigious L 'Oréal-UNESCO for Women in Science Award in 2016 gave Tanya much needed support at a key time in her career when she had her second child. "I cannot thank L 'Oréal enough. Not only did the award recognise my scientific achievements, but the prize helped with childcare and my return from maternity leave."

Tanya has been grateful for the support of family and friends during her research career, but she did encounter some people in Cambridge who were surprised by the timing and the impact of motherhood on her career. "On reflection I wish I'd had both my children during my PhD as the structures are better developed to intermit and successfully complete a research project in a timely manner. In my current role I am juggling several collaborative projects, which rely on my specialist input, so the option of taking a break is not straightforward. My concern is that taking time out of my research may compromise everything I have worked so hard to achieve."

"I am determined to enjoy motherhood and at the same time progress my career. Some may say that this is a tough ask, but I have worked hard and invested a great deal of energy and thought into everything I do. The department's Athena SWAN Silver Award is tackling many of the obstacles encountered by early career female scientist, but there is still a great deal to be done to overcome the perception that in a competitive academic environment the demands of parenthood are not adequately accommodated. I have done all I can to be as productive and innovative as anyone at this stage in my career, so while I probably won't know the effects of motherhood on my career for years to come, I am determined to have my cake and eat it."

As I see it...

Julian Huppert – Brexit and academic research

Julian Huppert is a Liberal Democrat politician and former Member of Parliament for Cambridge. Dr Huppert is also a chemistry alumnus (Balasubramanian Group). Following the UK's vote to leave the EU, Julian has been reselected to stand as a parliamentary candidate in the next general election saying he wants to stand on a strongly pro-EU platform. We asked for his opinion on Brexit and academic research at Cambridge. These are Julian's own views.

I've been involved in the campaign against Brexit for many years, because I could see the huge harm it would do to the country. Frankly even if the side I supported, the 'remain' side, had won I think it would have been bad for the country. Just having the referendum was a mistake; it has sowed division. One of the threads of the campaign that I led was with Scientists for EU and they were broadly united in wanting the UK to remain.

I was utterly depressed about the result. To see the UK turning its back on internationalism is very hard. And of course science is a fundamentally internationalist area. It simply doesn't make sense to be nationalist about how you do science and who you work with. It's a silly concept.

Legally nothing has changed yet, we're still part of the EU but we've sent a strong message that we're closed to foreigners; we're not interested in having them here. That does not make sense in a scientific context. And that is already causing harm.

People are obviously wary about going public with many of the details but I'm aware of research grants that people have been pushed out of, I'm aware of academics who have turned down places, I'm aware of businesses that have had contracts cancelled or bids ended, I'm aware of students who have not been coming here to take up places. All of these things are very real and we haven't even left yet.

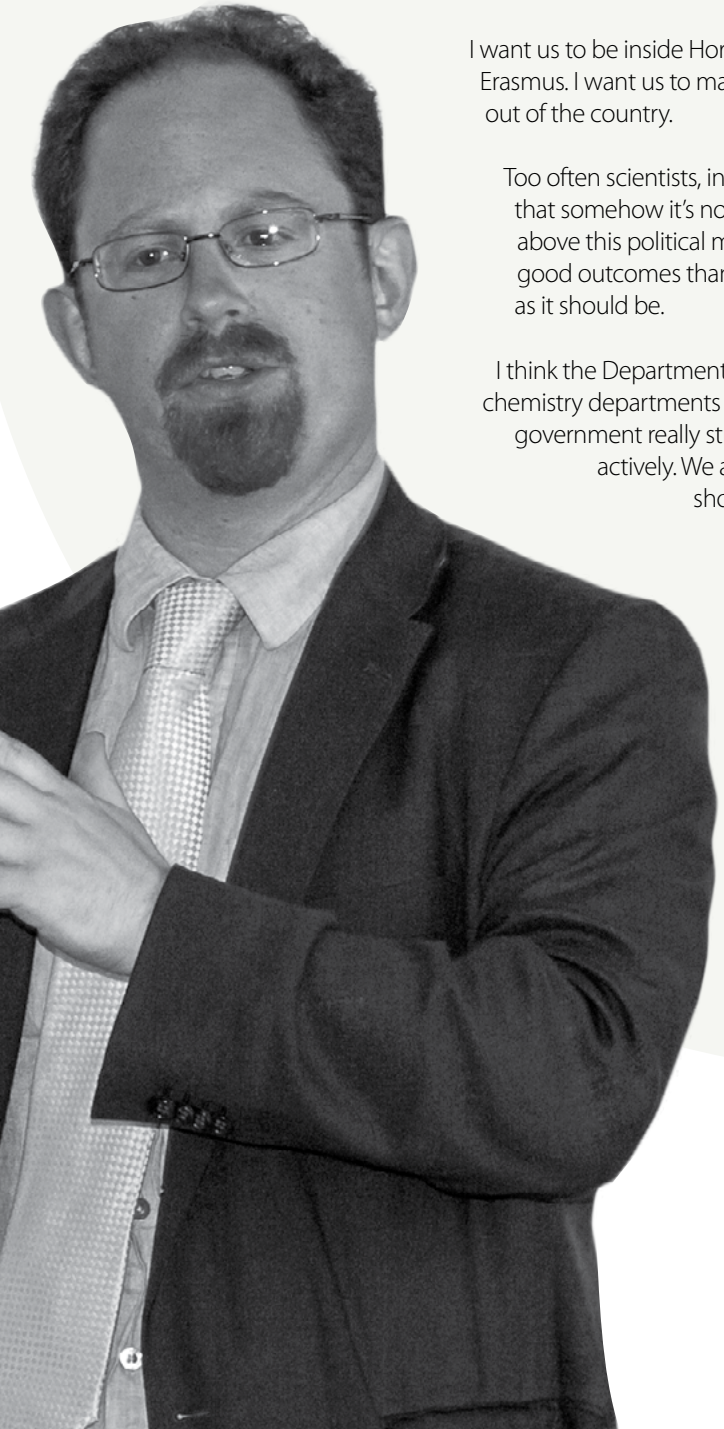
If the stories are true it will be the end of March 2017 that Theresa May invokes article 50 of the Lisbon Treaty. That means we leave in two years, which means our first day outside the EU would be 1 April 2019. April Fool's day may be an appropriate day to discover what it's like outside the EU! But we simply won't know until the end of the negotiation process.

In academia there is huge uncertainty about anything to do with Horizon 2020 European funding. We've had some limited reassurances for now but nothing like enough. And it is causing a number of European consortia to say actually we don't want a British person involved because putting a research grant together is risky enough, we don't want to add more risk.

"We note this result with disappointment. My position on this issue is well known, but 52 per cent of voters in the referendum disagreed. We will work with our partners in business, research and academia, as well as our European partners and the government, to understand the implications of this outcome."

Professor Sir Leszek Borysiewicz

For more recent statements: www.cam.ac.uk/notices/news/statement-from-the-vice-chancellor-of-the-university-of-cambridge-on-the-result-of-the-eu-referendum



I want us to be inside Horizon 2020, inside all the research arrangements, inside Erasmus. I want us to make sure scientists and students can easily come in and out of the country.

Too often scientists, in general, have avoided politics because there's a sense that somehow it's not quite our thing, that science is pure and neutral and above this political maelstrom. I think that's one of the reasons we get less good outcomes than we should do, and why evidence isn't taken as seriously as it should be.

I think the Department of Chemistry, along with the University and other chemistry departments around the country, need to make the case to government really strongly for what we need and that needs to be done very actively. We also need to broadcast internationalism. The department should speak out to the international audience. Let them know that we are still open; we're still international. This is a world leading chemistry department and yes it's in Cambridge, yes it's in England, yes it's in Britain but it's also part of Europe and the world.

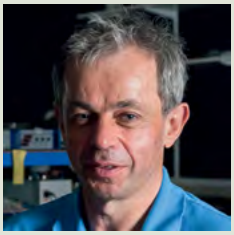
Horizon 2020 is the biggest EU research and innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020). The Erasmus Programme (European Region Action Scheme for the Mobility of University Students) is an exchange programme that provides funds for undergraduates to travel to EU countries to study as part of their degree.

Noticeboard

Recognitions and awards

Professor Sir John Meurig Thomas has been awarded the Royal Medal

Professor Jonathan R Nitschke has won the Japan Society of Coordination Chemistry International Award for Creative Work



David Klenerman has been awarded a Royal Society Research Professorship

Appointments and promotions

Andreas Bender becomes a Reader in Molecular Informatics

Markus Kalberer becomes Professor in Atmospheric Science

Obituaries

Jim Watson, former 2nd floor technician, 11 November

Professor Ian Smith, FRS, world-leading kineticist, 8 November

Eric Smith, former head of photography, 25 September

Professor Roger Tsien, Nobel Prize winner, 24 August

Upcoming events

Melville Lectures
6 –11 February 2017

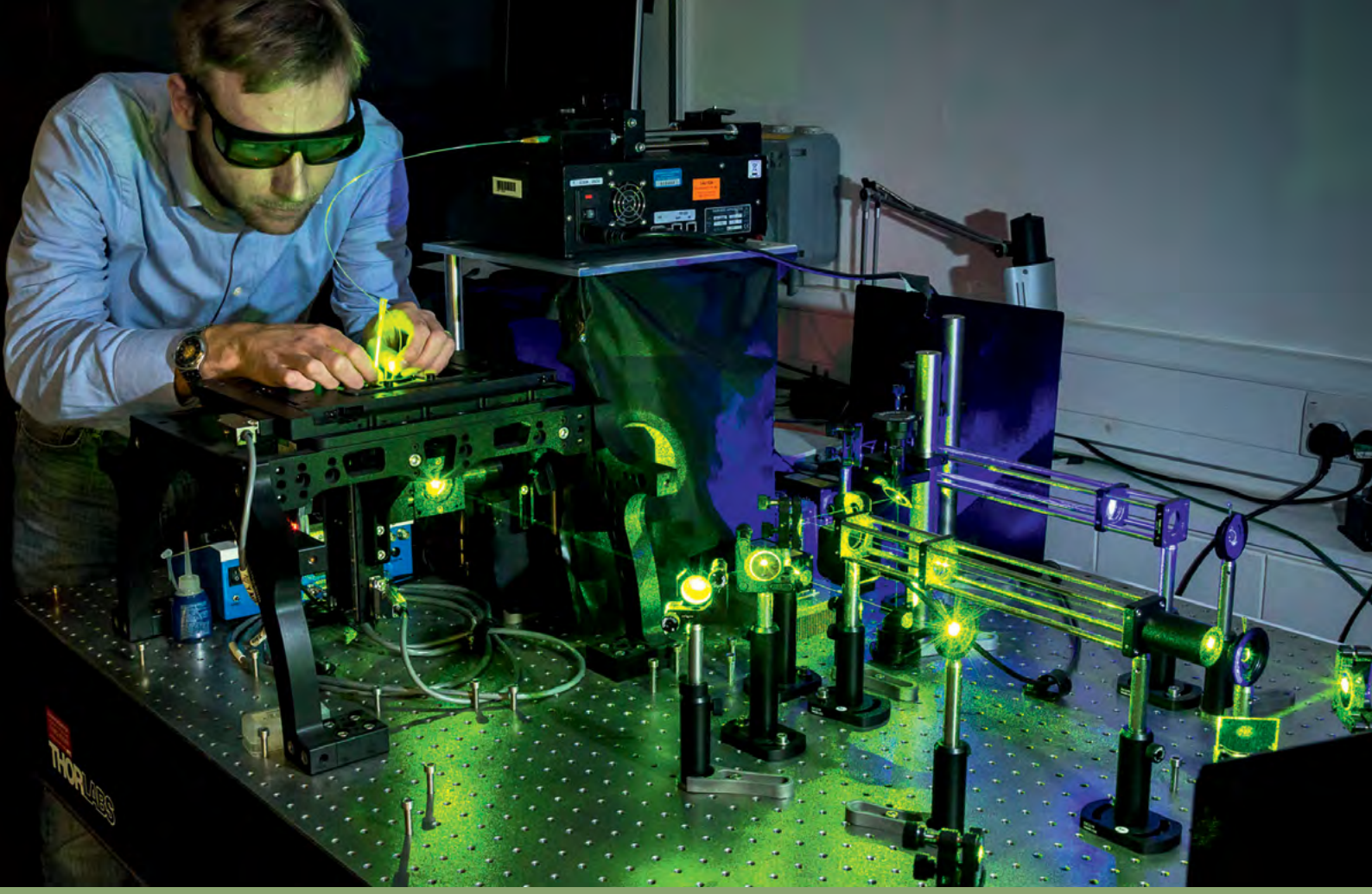
Chemistry Open Day
18 March 2017

Lewis Lectures
24 –28 April 2017

Salters' Festival
23 March 2017

Sutton Trust Summer School
14 –18 August 2017

A school group enjoying Chemistry Open Day 2016



How you can contribute

As demonstrated by the Newman Foundation gift to establish a microfabrication laboratory, funding these days must come from a wide range of sources. Private individuals, government and industry have all helped the department maintain its research edge and will continue to be critical to our success.

If you are interested in playing a part in supporting research in the department, 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.

***Adoration of the Magi*, Italy, Venice, c.1567-1572**
ARTIST: Giovan Battista da Udine

The initial O comes from a set of choir books made for the basilica of San Marco in Venice in the 1560s and 1570s. The blue colour on the initial is created using smalt and suggests close contacts between medieval illuminators and glassmakers.

Marlay cutting It. 40
Bequeathed by Charles Brinsley Marlay in 1912

Image courtesy of The Fitzwilliam Museum