UNIVERSITY OF CAMBRIDGE

Chemistry at Cambridge Magazine

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Giving a new name to our oldest Chair

chem@cam

Building for the future: the Chemistry of Health.

Building on the past: 60 years in Lensfield Road.

"I'd like to meet the donors funding my PhD."

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Welcome

Welcome to the Winter 2018 edition of Chem@Cam. This is my first opportunity to write to you as Head of Department. I took over the baton from my predecessor John Pyle in October and people are still stopping me in the corridor, and around Cambridge, to ask how it's going.

While this is mainly supportive, sometimes it seems to carry the unspoken question, 'Why would you want to do this?' My answer is, it's an important role and a way in which – from my experience of working with John as one of his deputies and being Director of Teaching here for many years – I feel I can serve the Department.

It is a privilege to be the head of such a prestigious institution. The Department is an incredibly busy place: in the building's foyer, corridors and café, there is a constant flow of people going about their business. That's a reflection of how busy we are with our research and teaching, and in this edition you will be able to read about some of our latest developments in these areas.

A particular highlight has been the opening of the new Chemistry of Health building this autumn. (*See the feature on page 9.*) This project has been many years in the making, and it has been wonderful to see it all come together to deliver a world-class new facility. The building includes incubator space that can be rented by spin-out companies and other enterprises – the first time we've had specific space available for such activities. Even as the building opened, our first commercial tenants moved in. This means that as well as fostering translational research, the new building will not be a net drain on resources.

In addition to government funding, the building benefited from philanthropic gifts. Philanthropy is very important to us: without it, we cannot achieve our goals. On page eight, you can read about the generous gift from Dr Yusuf Hamied that will endow our oldest and most prestigious chair – now to be known as the Yusuf Hamied 1702 Chair of Chemistry, in recognition of his generosity.

You can also read *(page 16)* about the first recipient of the Lord Lewis Research Studentship and find out how the donations given in memory of Jack Lewis are making a real difference to this young researcher.

I hope you enjoy this edition of Chem@Cam. Do keep in touch: we are always interested to hear your news and views.

James

James Keeler
Head of Department

Cover photograph of the cabinet made for Giovanni Vigani after his 1702 inauguration as Professor of Chemistry: John Holman, University of Cambridge.

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Calling chemists' bluff

There was a lot of laughter. There were terrible jokes: "I like to drink wine on a case-by-case basis." And the teams had names like 'In It To Wine It' and 'The Imposters'. Yes, our annual Alumni 'Call My Bluff' Wine Tasting was back again.

At this September event, held at the start of the University Alumni Festival, participants enjoy a range of wines, the company of fellow alumni, and hearing about some of the latest research going on in the department. One participant told us: "This event was great; it's why I love to return to Cambridge."

Alumni sipped white, red, rosé and dessert wines while our three bluffers described the chemical attributes of each one. But there was a catch: only one of them was telling the truth. It was up to our guests to decide which explanation was right. Were they drinking a Medoc or a Malbec? Portugese Moscatal or American Black Muscat?

This year's bluffers included alumnus James Harrison, who completed his MPhil in Dave King's surface science research group in 1996 and is now Executive Chairman of Cycle Pharmaceuticals. He fooled a lot of us, perhaps because of his confident delivery: "Like me, this wine has a certain joie de vivre!"

But both he and our Deputy Head of Department Nick Bampos were bluffing more often than not. The most truthful panellist was Research Fellow Jenny Zhang. Jenny designs new catalytic systems to convert sunlight into solar fuels and wore a pair of modified goggles with colour filters on each eye "to cancel out any possible colour bias so I can have the clearest possible tasting notes". They certainly seemed to help her divine what the wines really were. (Though having the script in front of her might have helped too...)

As the event came to an end, our alumni drained their glasses and gave us their feedback. What was the least satisfactory part of the evening? "My own knowledge of wine," responded one with regret. And the best part? "The cameraderie" and "Seeing others I had been at Cambridge with," said others.

We're glad our alumni had a good time. And we're already looking forward to next year...

- *See the full gallery of event photos on our alumni webpages at https:www.ch.cam.ac.uk/alumni*

Showcasing students' work

"Doing this has really pushed me out of my comfort zone. But that's been good for me as science communication is very important."

So said PhD student Kellie Binder as she prepared to stand up in front of a packed lecture theatre and talk about her research during Chemistry Showcase Week.

This is a week when, to enhance their science communication skills, our postgraduate students must present their research to us all. Second-year PhD students give a poster presentation and third-year students give a 15-minute talk in a lecture theatre. They are scored by academics and postdocs from across the department (though not by anyone from their own research group) using a set of relevant criteria, and prizes are awarded to the best communicators.

Dr Deborah Longbottom, Head of Graduate Education, says: "Our students benefit hugely from this opportunity to present their research to those both inside and outside their research groups. Being able to communicate your research clearly and effectively to other scientists and to the public is an important part of being a scientist."

And Showcase Week also benefits others in the department. This is a large department and research here is divided across five Research Interest Groups: Biological, Theory, Physical Chemistry, Synthetic Chemistry and Materials Chemistry. As our outgoing Head of Department Professor John Pyle said: "It's valuable for all of us to see what our research groups are doing and appreciate the diversity and quality of science being done across our department."

Showcase Week was first introduced into our PhD programme last year, partly at the request of the students themselves who wanted to practise skills that would be relevant for their careers. As Kellie said during the week: "I've found it hard to condense research that I've spent years working on into a talk of just 15 minutes – my first run-through lasted an hour and a half! But it's a very good skill to develop."

- *Congratulations to the talks winners: Sean Chia, Amy King , Tom Scheidt, Jennifer Nelson, Nelson Lam, Andreas Wagner, Kellie Binder and Jake Greenfield.*

- *Congratulations to the poster winners: Lavinia Dunsmore, Thomas Sayer, Belinda Fonseka , Steffen Emge and Katherine King.*

Second-year PhD candidate Eszter presenting her research poster.

Alumni events

Celebrating Women in Chemistry
10:30 - 16:00
Friday 8 February 2019
Department of Chemistry

All alumni are invited to join us on Friday 8th February 2019 as we celebrate Women in Chemistry.

This is an event we are holding to mark the UN International Day of Women and Girls in Science, which was created to help achieve full and equal access and participation in science for women and girls.

When women like Effie Cooke (*seen below*) studied Chemistry at Girton in the 1890s, opportunities were much more limited for them than for men. Though Effie came from a progressive family (her sister trained in medicine) and taught for a while after leaving Cambridge, she was not expected to have any employment once she was married.

Of course, we have made advances since then and female graduates now pursue highly successful careers in science and science-related areas. We will be hearing from some of them at our event and celebrating their achievements.

But we still have further to go in achieving parity. So we will also be asking our alumni to share their experiences of what has helped and hindered them in their careers, and ideas about addressing the barriers to equality that still exist.

Chemistry student Effie Cooke, front left, at Girton in 1895. Photo courtesy of her great-niece, RoseMary Musgrave.

Speakers at our event will include:

- Wendy Brown, Chair of the University of Sussex Chemistry Department
- Sally Curran, Senior Patent Attorney at AstraZeneca and Judge Business School Mentor for Accelerate Cambridge
- Zöe Clyde-Watson, Patent Attorney at D Young & Co
- Alison Davies, Operational Meteorologist with the Met Office
- Melinda Duer, the first woman lecturer appointed in the department *(see correspondence on this issue on page 20)* and now Professor of Biological and Biomedical Chemistry here
- Helen Fraser, Senior Lecturer in Astronomy for the Open University
- Alison Stoddart, Chief Editor of Nature Reviews Materials

We will also be joined by Kellie Binder, who will speak about her experiences as a current postgraduate student and her outreach work with local schools.

This alumni event runs from 10:30 to 16:00 and includes coffee and tea on arrival, lunch, and opportunities to network with department researchers and other alumni.

The afternoon session will focus particularly on issues relevant to female postgraduate students and postdoctoral researchers.

The event is free to attend but spaces are limited, so please register early to ensure your spot.

Book tickets at: https://celebratingwomeninchemistry.eventbrite.co.uk

Annual Chemistry Open Day
Saturday 16 March 2019
Department of Chemistry

As every year, we'll be opening our doors in March 2019 during the University of Cambridge Science Festival for our ever-popular Chemistry Open Day. Alumni and their families are very welcome to come along and enjoy activities that allow scientists of all ages to explore the fascination of chemistry.

The day includes a series of fun-filled and explosive lectures given by Teaching Fellow Dr Peter Wothers. In March 2019, as part of the International Year of the Periodic Table, Dr Wothers will be investigating the mystery of why several different arrangements all appeared around the same time, culminating in the publication of Mendeleev's famous table 150 years ago. He will show how atomic structure gives rise to a diverse range of chemical properties, from metals that explode in water to elements that enable things to burn. Incorporating some exciting new demonstrations, and with help from the audience, we'll find out why our saucepans should be made out of diamond and where to find bags of separate atoms.

We have been able to reserve a limited number of places for alumni and their guests for these lectures. The lecture times are: 11:00 - 12:00, 13:30 - 14:30 and 16:00 - 17:00.

To book your places, please go to:
https://opendayperiodictable.eventbrite.co.uk
The lectures are always very popular so early booking is advisable. They contain loud bangs and are suitable for ages 7+.

- The Chemistry Open Day is supported by the Walters Kundert Charitable Trust.

Reunion for Pre-1979 Chemistry Alumni
17:00 onwards,
Friday 29 March 2019
St Catharine's College

After this year's successful reunion for pre-1968 alumni, we've opened up next year's reunion to alumni (undergrads, postgrads, MPhils & PhDs) who studied chemistry at the University of Cambridge up to and including 1979. Partners are also very welcome.

In 2019, we'll be celebrating the International Year of the Periodic Table, marking the 150th anniversary of Mendeleev's famous table. At the reunion, alumni will hear from Teaching Fellow and chemistry history enthusiast Dr Peter Wothers about the history of the periodic table *(see article left)*; have a private viewing of an exhibition that includes a rare first edition of Mendeleev's Principles of Chemistry, the first book in which his Periodic Table appeared; and enjoy a drinks reception hosted by the Department of Chemistry. The evening concludes with a three-course dinner.

Alumni will also be able to see other exhibits during the evening, including the lesser-known but rarer 'telluric screw' devised by de Chancourtois seven years earlier, which displays the elements as a continuous spiral around a metal cylinder.

The lecture, which starts at 17:00, is free to attend. The Department will host the drinks reception and provide wine and soft drinks during the meal. The price for the three-course dinner is £49.20.

We hope you will want to join us at this event.
To book your places, please go to:
https://chemreunionlecture.eventbrite.co.uk

A new name for our oldest Chair

Gift by alumnus honours 'close bond' with department

The 1702 Chair of Chemistry at Cambridge – one of the longest-established chemistry chairs in the world – is to be renamed in honour of a distinguished alumnus whose significant donation will support it in future.

The Chair will now be known as the Yusuf Hamied 1702 Chair of Chemistry. It was previously the BP (1702) Chair of Chemistry, the original Chair having been renamed following a generous endowment by BP in 1991. BP is continuing its association with the department, but will redirect its funding to support young academics.

As CEO and Chairman of the socially conscious Indian pharmaceutical company Cipla, Dr Hamied worked to provide low-cost generic antiretroviral drugs to people with HIV and AIDS in developing countries, reducing their cost to under a dollar a day. His actions in saving hundreds of thousands of lives were celebrated in the acclaimed documentary *Fire in the Blood*. In recognition of his socially conscious work, Dr Hamied was awarded the first Department of Chemistry Alumni Medal in 2016 "for services to the community that have brought honour to the Department of Chemistry."

Dr Hamied has already donated generously to the department in many areas, including the creation of the Todd-Hamied Meeting Room. This was named in honour of Lord Todd ("my mentor and guide over the years", says Dr Hamied), who was himself a holder of the 1702 Chair of Chemistry. Thanks to Dr Hamied's support, the department also has the Todd-Hamied Laboratory and the Yusuf Hamied Laboratory for Chemical Synthesis & Catalysis.

Dr Hamied came to Cambridge to study Natural Sciences in 1954 and stayed to complete his PhD with Lord Todd who, he said, "transformed my experience of science". Of his support for the Yusuf Hamied 1702 Chair of Chemistry, Dr Hamied says: "My association with Chemistry at Cambridge dates back to 1954 and ever since there has been a close bonding, which I hope will last for years to come.

"In recent years we have set-up the Todd-Hamied Seminar Room, the Todd-Hamied Laboratory and the Yusuf Hamied Laboratory in the department. Now I am delighted that I am leaving behind a legacy for the future in the creation of the Yusuf Hamied 1702 Chair for Chemistry. Cambridge has always been a leader in chemistry and this chair will contribute further to its leadership role."

BP is continuing its long association with chemistry at Cambridge. Anna-Marie Greenaway, BP Global Director for International University Partnerships, says: "BP has worked closely with the Department of Chemistry for over 30 years and our endowment will now focus on enhancing the diversity and development of young academics within the Department."

Head of Department James Keeler says: "We are extremely thankful to Dr Hamied for his continuing support, and it is truly fitting that his name will henceforth be associated with our most prestigious chair. The repurposing of the BP endowment is also very welcome, as it gives us an important new way to support early-career academics. We are very grateful to BP for making this possible."

Chemistry of Health building 'offers hope'

Our new Chemistry of Health building, which is dedicated to combating neurodegenerative disorders, was officially opened in September.

"Our scientists and this building offer hope," said Vice-Chancellor Professor Stephen J Toope as he opened our new Chemistry of Health building, which is dedicated to combating diseases such as the neurodegenerative disorders Alzheimer's and Parkinson's. "The research carried out here has the potential to affect millions of lives around the world for the better."

The building houses the Centre for Misfolding Diseases, a world-leading research facility focused on the misfolding of proteins in human cells – a phenomenon that causes a number of disorders including Alzheimer's, Parkinson's, Huntington's and motor neurone diseases.

The building has been funded by £17.6 million from Research England's UK Research Partnership Investment Fund, as well as with contributions from Elan Pharmaceuticals and AstraZeneca. Among the philanthropic contributions is a substantial donation from Cambridge alumnus Derek Finlay in memory of his late wife, Una, who suffered from Alzheimer's disease.

A 2015 report suggested that by 2030, there will be 75 million people worldwide living with Alzheimer's disease. While the number of cases of Alzheimer's diseases and other neurodegenerative disorders continues to rise, so too do the costs to society, both economic and emotional. At the opening ceremony, the Vice-Chancellor told guests: "Through collaboration and the sharing of ideas, our research teams will work to find the keys that unlock the mysteries of neurodegenerative disorders, one of the greatest health problems of our age."

The Centre for Misfolding Diseases is co-directed by Professor Sir Christopher Dobson, Professor Tuomas Knowles and Professor Michele Vendruscolo, three world leaders in their fields who have been studying the molecular origins of neurodegenerative diseases. "This building will for the first time bring together a

large number of scientists from different disciplines who are dedicated to establishing the molecular basis of neurodegenerative disorders and to identifying new ways for treating or preventing these debilitating conditions," said Professor Dobson.

"The treatment of neurodegenerative disorders represents a major challenge, requiring both the development of innovative biophysical approaches and their translation into diagnostic and therapeutic tools," said Professor Vendruscolo. "This new building creates favourable conditions to combine these two steps."

The new building is also home to a Chemistry of Health Incubator, which will enable closer collaborations between researchers and industry and host spin-out companies in order to increase the rate at which scientific discoveries are translated into new therapies. The new incubator is the first in Cambridge to be directly integrated into a University department, and will provide the resources and complementary know-how required to ensure that fundamental research is ultimately used to develop new treatments for patients. The first spin-out company to move into the Incubator will be Wren Therapeutics, which is based on a ground-breaking drug discovery method for neurodegenerative disorders developed at the Centre for Misfolding Diseases.

- You can see the building going up in just three minutes in a timelapse video on our YouTube channel at https://youtu.be/dv4Tqo_CccM

Celebrating inspiring researchers

Olalekan Popoola and Sandile Mtetwa

As the UK marked Black History Month in October, two researchers from this department talked about their route to Cambridge, their inspiration and their motivation.

During Black History Month in October, the University of Cambridge highlighted 'The Black Researchers Shaping the Future'. Two of them were scientists here in the Department of Chemistry.

Dr Olalekan Popoola is working on air pollution and its impacts on human health and the environment. He received his bachelor's and master's degrees in Nigeria and as a PhD student here, he worked on developing low-cost air quality sensors and using them in cities including London and Lagos.

Lekan (as he is known) is continuing this research as a postdoc in the Jones Group in the Centre for Atmospheric Science. His research is helping to revolutionise air pollution studies and deliver a cheaper option for monitoring air pollution, especially in low income countries. In developed nations, the approach can complement existing infrastructures used by air pollution monitoring agencies and regulators.

Sandile Mtetwa is a Gates-Cambridge scholar studying for her PhD in the Wheatley research group. She is investigating alternative energy sources that can produce and store hydrogen, and could give her home country of Zimbabwe access to cost effective solar energy.

Sandile says: "In the future, I would like to use my lab work as a foundation to start up practical and implementable energy resource projects. My passion is to reach out to marginalized communities as well as resuscitate some industries that have been negatively impacted by high energy costs."

Both researchers have found Cambridge to be an inspiring and supportive environment. Lekan says: "Cambridge offers excellent research facilities and mentorship for both students and research staff. In addition, the University fosters international collaborations both with academic and industrial partners."

Sandile says: "Walking in the footsteps of Isaac Newton, Alan Turing and Stephen Hawking gives me confidence to pursue a PhD here. I also have a very supportive network that includes my supervisor, academic mentor, fellow research group mates, and endless resources to help me through the challenges in my research." Sandile also has access to a rich network of other Gates-Cambridge scholars.

"Black History Month is an important opportunity to engage and inspire aspiring talents from my community with the opportunities available to them, " says Lekan.

"For me," says Sandile, "Black History Month at Cambridge is a reminder that we too are Cambridge. I've been inspired to learn about alumni like myself, in particular the international businesswoman Winnie Muriithi, who completed her PhD in Chemistry here."

Sunlight turns plastics into fuel

Reisner Group

Taylor Uekert and her colleagues in the Reisner lab have developed a sunlight-driven method to convert plastic waste into fuel and useful chemicals.

In a paper published in Energy & Environmental Science, the scientists demonstrate a new process using sunlight, water and a precious-metal-free photocatalyst to convert waste plastic into a renewable fuel source.

Plastic eventually begins to break down when it is immersed in water and exposed to sunlight, but this process can take hundreds of years. The researchers were able to speed up this reaction by using a photocatalyst that harnesses the energy in sunlight. The process, known as photoreforming, can break down water to pure hydrogen fuel and plastic to useful small molecules within hours.

Photoreforming of simple alcohols to produce hydrogen has been researched extensively, but this process is too costly for industrial hydrogen production. Instead, the team used waste plastics as an abundant and inexpensive alternative to alcohols. The problem is that plastics are more challenging to reform because of their complex structures, low water solubilities and poor biodegradability.

To reform the plastics, researchers developed a photocatalyst made of inexpensive cadmium sulphide quantum dots mixed into an alkaline water solution. The dots are no bigger than five nanometers in diameter – 100,000 times smaller than the diameter of a human hair – which gives them an enormous amount of surface area, making the catalyst extremely efficient.

The resulting catalyst solution was applied to three commonly-used plastics: polylactic acid (PLA), polytheylene terephthalate (PET), and polyurethane (PUR). The researchers then irradiated the plastic mixture with sunlight, allowing the catalyst to reduce water from the solution to hydrogen and simultaneously oxidise the plastic to small organic molecules. The entire process can be done at ambient (room) temperature, which contributes to its cost-effectiveness.

Professor Reisner stated: "Waste plastic contains a large amount of stored energy that is currently being thrown away. Our work shows that we can use plentiful resources like waste plastics and sunlight to create hydrogen fuel and organic chemicals in a sustainable way. We will continue to investigate ways to improve our process by studying a wider range of polymer substrates and photocatalysts, and will evaluate its economic viability in the near future."

Taylor Uekert *(pictured left)*, PhD student and first author of the article, added: "Plastic waste is a global issue: over half of all plastics produced since 1950 have been thrown away, and recycling is still difficult or economically unviable for some types of plastic. What if we could find a way to use those resources so that they are no longer polluting our planet? That was the question that inspired this work, and we're really excited to show that we can in fact transform plastic waste into something useful (hydrogen) using only a renewable energy source (sunlight)."

Taylor Uekert, Moritz F. Kuehnel, David W. Wakerley and Erwin Reisner. *Plastic waste as a feedstock for solar-driven H2 generation*, Royal Society of Chemistry Energy & Environmental Science (2018), Doi 10.1039/c8ee01408f.

Our Diamond Jubilee:

Sixty years in 'The Chemical Laboratories'

'The Buildings of the University Chemical Laboratories' were officially opened by Princess Margaret on 6th November 1958. We asked our alumni for their memories of working in the building since then; here are some of their responses. Reading them, we are glad to say working conditions here are much better now than they used to be...

Brian Tyler moved into the physical chemistry section of Lensfield Road in 1958 during his PhD with Sandy Ashmore. "I shared a lab with another of Sandy's students, Mike Burnett, which was entertaining. He seldom came in before 10 am, by which time I had made a pot of percolated coffee (our only use of a bunsen burner). He smoked a pipe. Wandering over to chat by my desk, he would shake out a match and discard it into my waste bin. Often this would be followed by a ball of flame from the ether-soaked cotton wool I had used to clean the Apiezon grease off one of my vacuum taps. No harm was done."

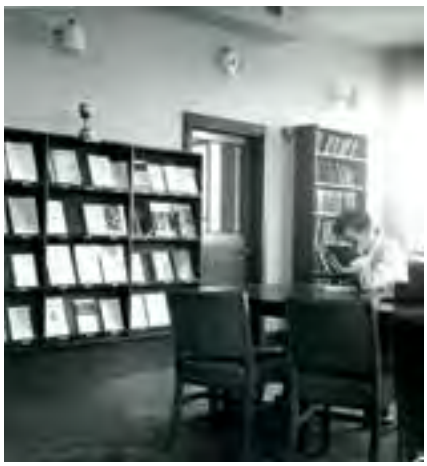
Anne Butland (now Lyon) came to read Natural Sciences in 1967 and stayed on to do a PhD in Chemistry. "The organic chemistry labs were very smelly, with a limited number of fume cupboards along the edge and most experiments carried out on the open bench. When the theoretical chemistry students walked through lab 122, they used to screw up their faces and hold their noses."

Philip Evans also came to read Natural Sciences in 1967. "I was elected onto a new chemistry staff/student group. A student gripe, as Part II came into view, was that we could not use the main chemistry library after hours. We could in theory, but the main doors were locked after office hours and only post-grads had keys. So we had to hang around outside until someone with a key arrived and go in with them, and do the same get out. A formal request from the group was ultimately agreed so that those who wanted a key were granted one. If anyone asks my sons now, "Was your Dad a student revolutionary in the 1960s?", they reply: "Yes, he campaigned to keep the chemistry library open!"

Stephen Palmstrom studied here for a PhD from 1970-73. "One of my memories is that of the freezers with a number of unlabelled bottles that were left well alone lest they exploded."

Mark Hanning-Lee was a Natural Sciences undergraduate here, 1982-85. "The air handlers did not work, so the fume hoods reduced the air pressure in the building below ambient pressure. The pressure difference made it difficult for some people to open the doors at the main undergraduate entrance – especially for smaller undergraduates."

- *See more memories of Lensfield Road in our Alumni web pages: www.ch.cam.ac.uk/alumni/60-years-lensfield-road*



Top left: builders on the centre section of the roof in 1954; below left, the new library and ground floor teaching laboratory. Top right: the Lensfield Road building under construction, and below right, finally finished.

Planning a Laboratory

In *The Cambridge Review* of 16 October 1954, architect John Murray Easton described how the project came to be – and some of the stumbling blocks it encountered.

Post-war steel rationing
"If at all possible the large teaching laboratories on the Lensfield site – 45 to 47 ft. in width – were to be free from columns. At a time when steel was jealously rationed and the wire necessary for pre-stressed concrete unobtainable, this was a tall order, and much thought was needed for its fulfillment. Studies were made of all possible methods of spanning the voids, the comparative weights of steel required, and the advantages or drawbacks of each.

A picture in an American magazine provided the answer. It showed a building whose floors were supported by a continuous ridge-and-furrow arrangement of light steel sections. This was found to be very economical of steel. The Consulting Engineer was able to go to Detroit and consult the designers and examine the structure itself."

Avoiding 'damage by burns or poison gas'
"A 'pilot' laboratory was constructed and equipped. Different types of windows, benches, taps, sinks, fume-chambers, floor and wall finishes were installed, subjected to relentless criticism, and altered until some degree of acceptance was achieved. A ventilation sysem was provided and mock accidents were staged to see whether even the most accident-prone student or lab hand might be expected to escape serious damage by burns or poison gas."

Underground bicycle park
"One hopes that the new building – which provides an underground bicycle park which not even the most accomplished undergraduate may wholly be able to avoid using – may facilitate the study of chemistry – organic, inorganic, physical and theoretical."

(*Editor's note: We'd love to hear from anyone who can tell us what happened to the underground bike park.)*

"I remember, shortly before Princess Margaret arrived to open the building, the Lord Lieutenant rushing around in panic, looking for a screwdriver. The ceremonial spur had just fallen off one of his boots..."
Professor Emeritus Brian Thrush

Heather Greer

Women in Chemistry

Our long-awaited new Transmission Electron Microscope arrived here (in 17 separate crates) in July. And now our Electron Microscopy Technical Officer Dr Heather Greer is delighted. Or rather, she would be – she says – if only the emails would stop and she could just spend all day using it...

How did you get into this field?
I was only ever interested in science and maths and always wanted a career in science. At school, I thought about being a radiographer or a pharmacist. And when I was at university (St Andrews) studying chemistry and maths, I assumed I would go into industry – probably oil, as my family had moved from Northern Ireland to Scotland and we were living between Aberdeen and Dundee.

I started working in microscopy during my final year project for my undergraduate degree. It was my first real taste of research and I found I liked it. So I decided to do a PhD on non-classical crystal growth mechanisms because I wanted to carry on working in electron microscopy. I stayed on for three years' postdoctoral research and by then, as well as working on my own projects, I was also running a lot of samples on the Transmission Electron Microscope (TEM) for others in the department and collaborators. I found myself preferring the diversity of everyone else's samples to my own. That made me realise the perfect job for me was to manage my own research facility where I would see the whole range of samples coming in and learn why people were running them.

What brought you here?
I started looking for jobs in this field and found the role here in Cambridge. And I really enjoy it. I manage the lab and train the users, making sure they are getting everything the instruments are capable of and that they understand the data that comes out.

Most users start by scanning the surface of their sample with the Scanning Electron Microscope (SEM), manipulating the energy of the electron beam depending

on what they want to see – be it particle size, morphology or z-contrast if it's a multi-phase sample. There's also an EDX (energy dispersive x-ray spectroscopy) detector to find chemical maps and spectra. If the SEM doesn't provide the resolution or information our researchers need, then for much smaller materials, such as those working at 50 nanometres or less, we can use the TEM to push the resolution so we can see atomic images.

Are there other Transmission Electron Microscopes within the University?
Yes, but very few of them are multi-purpose. Our new TEM provides the resolution and sensitivity to characterise hard and soft materials so, as well as impressive atomic imaging capabilities, it is also equipped with EDX, tomography and Electron Energy Loss Spectroscopy – which our battery researchers are very excited about using in order to detect and map Lithium.That's something we couldn't previously do. And our cryo holder will be in large demand by researchers looking to view their nanomaterials in frozen hydrated state.

There's a great electron microscopy community here. There are about 40 electron microscopes in Cambridge University and the staff managing the labs meet up from time to time, hold seminars and hear about the different experiments we're all doing. We support each other. Though there's some friendly rivalry too...

What's the best part of your job?
When I arrived here, a little over two years ago, the SEM was older than me (!) and the TEM had good and bad days, to put it kindly. Both instruments desperately needed replacing. I led the purchase on both of them, so we now have state-of-the-art equipment to use and the lab looks completely different from the way it did when I arrived. That gives me a real sense of achievement.

And the worst part?
All the emails. I'd far rather just be on the instruments all day and not have to deal with any emails at all.

How did you find buying the microscopes?
A baptism of fire! The department had the money to purchase a new SEM, so one of my very first jobs here was to start negotiations with prospective suppliers, see product demonstrations and then choose which instrument we would buy. I had only just arrived and was still meeting all the research groups, trying to understand from each what their speciality was and what their needs were. Suddenly it was my responsibility to buy an instrument that would make them *all* happy.

Buying the TEM, which we were able to do thanks to a generous multi-user facility grant from the EPSRC, was easier for me as it was my second time around. But the amount of money and responsibility involved was scary. It gave me quite a few sleepless nights.

And now it's here?
It arrived in 17 crates and took 11 weeks to install. But now it's finally up and running and we've been trained on it, it feels like my baby. I am very protective of it.

Do you enjoy training people to use it?
Yes. I see a range of people, from those who know very little about electron microscopy to those who have a real passion for using it. They challenge you and that's good. I'm always up for a challenge.

Most of your peers in the university are male. Has being a woman ever impeded you in your career?
No. Though there are a few other female facility managers, the majority are men. But that's never been an issue. I think we all are treated equally and I've never had an advantage or disadvantage because of it.

Why do you describe yourself as 'the black sheep' of your family?
It's not literally true, obviously! But no-one else in my family works in science. They are all in farming and my twin sister is a police officer. I don't think my relatives really know what I do, beyond the fact that it involves some kind of microscope...

The researcher grateful for the help of strangers

His family gave him lessons in hard work and his teachers encouraged his interest in chemistry. But it is the generosity of strangers that is supporting him through his PhD. Aurimas Narkevicius, the first recipient of the Lord Lewis Research Studentship, explains why he'd like to meet them.

Aurimas Narkevicius was born in the small brewing town of Biržai in Lithuania shortly after the country gained independence from the Soviet Union. As a child, he spent every other weekend helping out on his grandmother's farm. "We would be harvesting potatoes in autumn and chopping timber in winter. It was hard physical labour and I didn't really enjoy it. So my dad said to me, 'If you don't want to do this, the only other option is to study and go to university'. "

Today, that's exactly what he's doing. Aurimas, a former winner of Lithuania's national Chemistry Olympiad, is the first holder of the Lord Lewis Research Studentship in Chemistry here. With its support, he is studying for his PhD in the Vignolini Group, investigating bio-inspired materials. He and his colleagues look to nature for ideas about how we could improve the structure and properties of man-made materials. In his case, Aurimas is quite literally trying to crack a secret: why crab shell is so hard to break and what we could learn from that.

Cracking the secrets of crab shell

"Crab shell is a composite material with a structure made up of layers that rotate as they go down – a bit like steps in a spiral staircase," he explains. "Because of its structure, it is highly resistant to stress: when you apply pressure, it dissipates in all directions. That's why it's so hard to crack. One of its principal components is chitin and in the laboratory, I am using a nanomaterial extracted from chitin – chitin nanocrystals – to see if, by using them, we could reproduce a functional material like that in crab shell."

As chitin is non-toxic and biodegradable, it is already used in applications from surgical thread to binders for dyes. "But it's underexplored and not very well understood," he says, "and I'm interested in how such a basic starting material could lead on to some really interesting substances. "

"Harvesting potatoes was hard work. My dad said, 'If you don't want to do this, study and go to university'. "

Aurimas is enjoying his research so much that he is already talking about making a career in academia. And that is something the late Lord Lewis would have been delighted to hear. PhD students are the future of the academic profession and the decline in PhD funding has led to the loss of many talented individuals. To help address this, the department and Robinson College joined together after Lord Lewis's death in 2014 to create this Studentship in memory of the inspiring scientist who spent 25 years in the department and was also the first Warden of Robinson College.

Many Chemistry alumni have given donations both large and small to the fund, and Aurimas is the first to reap its benefits. He says, "I am really grateful to all those who donated to it because without them, I wouldn't be able to do a PhD. That's for sure."

Manual labour – or university studies

Aurimas's father himself did not have the opportunity for higher education. Growing up in a village in Lithuania when it was still under Soviet control, "it wasn't very common for people like him to go to university," Aurimas says. "So he went to technical school and got an engineering qualification. But if things were different I think he would

have liked to go to university and I think he would have been more than capable."

Perhaps that's why, when Aurimas began to show marked academic talent, his parents gave him so much support. His father drove Aurimas hundreds of kilometres to take the entrance exams for Kaunas University of Technology Gymnasium – a pioneering, university-supported high school for gifted children. There Aurimas was encouraged by a chemistry teacher who offered additional classes after school and coached him for the country's Chemistry Olympiads. And after Aurimas finished his studies there and was accepted to Cambridge to read Natural Sciences, his parents continued to support him as much as they could.

Financial support

Though Aurimas took out a student loan to cover the fees, and received a Cambridge *[formerly Newton]* Trust Bursary that paid for his college room, he still needed their help to fund his living costs. "I would do internships in the summer and the money I saved from them would carry me through the next couple of months. But even so, it was not that easy for my parents to afford. Though I was financially supported by Churchill College, which helped a lot, I was still using up about a third of my parents' monthly salary."

His parents, as they had done his whole life, took additional jobs in the evenings to make some more money. And on top of that, his father was still helping out on the family farm. But this was a good life lesson, Aurimas says, and one that means he doesn't shy away from long hours in the lab. "To succeed in science, it's important to be persistent and to have a good work ethos. I learned that from my dad. He's the person I look up to most."

In fact, if you ask Aurimas if his parents are proud of him, he turns the question round. "I'm proud of them because without them, I wouldn't be here. They worked hard to help me get to Cambridge and to stay here."

He is equally grateful for the support from those whose donations are funding him through his PhD and giving him membership of Robinson College. "But I've had no opportunity for personal contact with the donors," Aurimas says. "I'd actually like to meet them and have a conversation with them to find out their connection to Lord Lewis and why they donated. And I hope they would think their donation was worthwhile."

Head of Department Dr James Keeler congratulated Aurimas on his success and commented: "The Lord Lewis Studentship is an excellent example of the benefits that result when the department and colleges work together. In this case we have helped out an exceptional student who might otherwise not have been able to study here."

- If you or someone you know would like to support the Lord Lewis Research Studentship in Chemistry, please visit the Robinson College website at www.robinson.cam.ac.uk/alumni/bursaries-scholarships/lord-lewis-research-studentship-chemistry
- If you would like to find out more about setting up a joint Studentship in Chemistry at your own college, please contact: chemhod@hermes.cam.ac.uk

"I am really grateful to those who donated because without them, I wouldn't be able to do a PhD."

From the archive

Century-old picture of lab assistants sparks memories

This photograph of 'laboratory assistants' taken around 1913 resurfaced recently, putting a human face on some departmental history. Among the young lads pictured is Fred Smith, thought to have been 16 or 17 at the time the picture was taken. After the outbreak of World War I, he joined the army and saw active service as a sniper, but was fortunate enough to survive. He returned to work here after the war. Chief Technical Assistant Walter Lister, centre, started work here as a 'wash-up boy' in 1903 and stayed until the 'Chemical Laboratories moved to Lensfield Road. Below is part of an interview he gave in 1956.

Where and when did you start work?
In the University's Chemical Laboratories on a Thursday morning in April 1903. I was 13 and my father had taken me there for an interview when he heard there was a job for a wash-up boy. I had to do some writing and sums for a test. Later my father told me 'You start work tomorrow'. I have often thought of that start when parents bring their boys to me and the parents say to them 'Do you think you'd like to do the job?'

Do you remember your first pay day?
Professor G. D. Liveing said to me, when Saturday came, 'As you have worked half-a-week, you get half-a-week's pay' and he handed me 2s.

Where did you learn Chemistry?
Like the other boys employed in the laboratories, I had to attend evening classes in Chemistry. Then at 17, I was given the job of organising classes for students and my duties grew until I was appointed Chief Steward in 1922. For the last 30 years, I have taught laboratory technique. Many famous men in the world have passed my way during their course of study.

There were less than 200 students in the Labs when I started. We increased up to 1,200 after 1914. By that time, all the colleges had given up their Chemistry labs, even Girton and Newnham. Downing was the last college to have its own department.

How have things changed since your early days?
There are four times as many girl students as there were before. And all students in the Labs work harder than they used to.

Scientific knowledge has so increased that a student has got to work harder and longer to get the necessary amount of learning in a given time. It used to be games for them every afternoon, but now it's mainly Saturdays for games.

"No silly answers, please..."

The Supervisors' Tripos Paper – a Rag Week stunt in 1977 – turned the table on undergraduate students' supervisors. This mock exam paper contained questions about the rotational energy levels of a bicycle wheel, the change in entropy on consumption of a packet of Opal Fruits, and the IQ of the examiners. "No silly answers, please," wrote one question-setter. Faint hopes! The answers were very silly indeed and were sold to raise money for charity. We reproduce some of them below.

Section 1: Physical Chemistry

Define the words enzyme, energy, entropy and entomology. Then energetically estimate the change in entropy on consumption of a packet of Opal Fruits.

Professor Alan Battersby

'Enzyme': The justification for the existence of of Professor Battersby and Dr Staunton.

Dr Dudley Williams

'Energy': This topic has not yet been discussed on my lecture course, since the lecturer has been instructed by a government department to 'save it'.

Professor Ralph Raphael (then Head of Department)

'Entropy': The act of gorging oneself on a chicken dinner. (From the French *'trop'*, 'too much'.)

Dr A Bruce Holmes

One packet of Opal Fruits in 30 students' mouths for one hour of a Part II lecture produces enough energy to turn down the departmental heating system 2˚C.

Section 2: Inorganic Chemistry

Give a brief outline of how, starting with readily available materials such as graphite, nitrogen, oxygen, water, etc, you would synthesize samples of (a) Scotch whiskey, (b) Sodium amalgam.

Professor Raphael

(a) I am afraid I must comment on the deficiencies of the examiners who spell 'Scotch whiskey' with an 'e', whereas any literate drinker knows that 'whiskey' refers exclusively to the Irish version.

Dr R Murphy

(b) I can't think why you asked this question. So, true to traditional examination format, I'm going to ignore the question you asked and answer one of my own choosing.

Section 4: Theoretical Chemistry

Derive the wave function of the hydrogen molecule without using any Greek letters. Hence, derive the wave function and account for the chemical properties of D.N.A.

'A story for all age groups, by Dr S G Warren

'Do you know what this is?'

'No,' said Piglet.

'It's D.N.A.'

'Ah,' said Piglet.

'Not R.N.A. *D.N.A.*' said Eeyore severely.

'But Eeyore,' said Piglet nervously, 'Hydrogen is very small and simple, like me. But D.N.A. is big and complicated. So...'

'I'm telling you Piglet,' said Eeyore, 'people come and go in this laboratory and they say "It's only Eeyore so it doesn't count!" But do they know anything about D.N.A.? They don't. It's just a few mathematical symbols to them. But to the Theoretical Chemists – mark this, little Piglet – to Theoretical Chemists, it's great and glorious D.N.A. Not just something Organic Chemists can come and *breathe* on.'

Piglet stepped back nervously ...

"Heavens! Has somebody still got a copy?" said Jill (now Dr Jill) Barber when Chem@Cam contacted her about the joke exam, which was discovered recently during an office clear-out. Jill was one of the final-year undergraduates who put it together with a group of others including Peter Jenner, Paul Burn Murdoch, Colin Leach, Claire Varley, James Froomberg and Mark Manning. As well as setting the questions, the students gave awards to the participating supervisors. They included '2 sliding doors and a conveyor belt' (awarded to Mr J I Grayson), and the NSPCC Award for Kindness to Computers, which was given to Dr (subsequently Professor) Anthony Stone. Professor Alan Battersby was declared to have failed, though doubtless he was cheered to be 'recommended for Professorship at Oxford...'

Write to us

We are always delighted to receive your emails and letters.

Email your comments to: news@ch.cam.ac.uk

**Post your letters to: Chem@Cam,
Room 142, Department of Chemistry,
Lensfield Road,
Cambridge CB2 1EW**

Correspondence

First female lecturer?

From Jeremy Freeman (Peterhouse, 1954-57)
I was surprised to read in the Spring 2018 issue that after completing her PhD here in 1988, Melinda Duer was 'the first woman to be appointed to a lectureship in the department'. We certainly had women lecturers before that. I was a third-year chemistry student (specialising in Physical Chemistry) in 1956-7 and in the Michaelmas term, we had four lectures on molecular structure by magnetic methods given by Mrs Agar. I think she was the wife of Dr Agar, who lectured in thermodynamics and electrochemistry – then very much a Cinderella subject, though it sprang to life again in the 1960s. I think it was he who remarked that the Debye-Hückel theory applied to 'slightly dirty water'.

Mrs Agar's lectures followed four by Dr Menter. These should have been really exciting, as he had recently obtained some of the first direct images of crystal lattices. But his inimitably boring delivery earned him the title 'The Dementer'.

Delia Agar, second row, right. John Agar, front row, left.

Editor: *Jeremy is correct that Mrs Delia Agar* was *the wife of John Agar. But though she was for many years a College Lecturer and Fellow at Newnham and she did give lectures in the department, she never had a University post. Neither did a more recent female lecturer, Catherine Housecroft, a Royal Society Research Fellow. Melinda Duer was indeed the first.*

On Ronald Norrish and Nobel Prizes

From Professor John Ogilvie (M. A., Ph. D. Cantab.)
In issue 56 of Chem@Cam (Winter 2017) Professor R. G. W. Norrish was described as 'Sir Ronald Norrish'. This is inaccurate: he was known to have declined any such knighthood. I was reasonably well acquainted with him, as Professor Norrish's Assistant in Research before his retirement in 1965, and as we were both Fellows of Emmanuel College – he Professorial and I Research.

After B.Sc. (combined honours in physics and chemistry) and M.Sc. (chemistry) degrees from the University of British Columbia, I had arrived in Cambridge in August 1961 in time to attend the Summer School on Rapid Reactions and became a research student under Professor Norrish in October. My project was designed to record infrared spectra of free radicals isolated in inert dispersants at 4 K that had proved difficult to detect in the gaseous phase. Some 20 months thereafter I was elected to that Research Fellowship and in another few months I was appointed to the Faculty of Physics and Chemistry in the Department of Physical Chemistry. When I began my research project, Professor Norrish assigned Tom Fletcher, the senior technician in the department, to serve as my assistant; he provided invaluable

assistance throughout my research in that department. One day in about spring 1965 (i.e. long before the fuss about a Nobel Prize for flash photolysis), Mr. Fletcher mentioned in passing that the idea of flash photolysis had been given to George Porter, nearly two decades earlier, by a technician. It seems that Mr. Porter, as he then was, was experiencing great difficulty in obtaining a sufficient concentration or quantity of free radicals to be detectable in an absorption spectrum through simply increasing the intensity of radiation from continuous lamps. According to Mr. Fletcher, the technician reportedly suggested 'Why not try a flash of light?' Mr. Fletcher did not name the technician, but recent correspondence with Professor Brian Thrush indicates it was likely to have been 'Dick Luff', who subsequently transferred to another department long before I arrived on the scene.

In a sense it is ironic that such a mechanism might have prevailed for the initiation of a major advance in the study of rapid reactions. Shortly before his retirement in September 1965, Professor Norrish disposed of many files accumulated over the years, including those related to his wartime projects, for which purpose I was directly involved as his Assistant in Research. One such project, of which I became aware through handling those old documents, was the suppression of gun flash.

As it happens, Professor Porter served as the external examiner of my doctoral thesis. The internal examiner would traditionally have been my supervisor, Professor Norrish, but he had just retired. So instead it was Dr. Howard Purnell (later President of the Royal Society of Chemistry, 1994 - 1996.) Because of various commitments of both examiners, the examination was conducted in the office of the Director of the Royal Institution in London, the post to which Professor Porter had just been appointed.

Enzymes: proteins or sugar?

From John C Anderson (1956-62)
I was intrigued by a statement in the interview with Professor Melinda Duer in the Spring 2018 issue that she 'identified the sugar that directed bone calcification as Poly (ADP-ribose) polymerase'. When I retired from University teaching in 2007, it was held that all enzymes are proteins. Have things moved on with the discovery that the above enzyme is a sugar, or is this an unfortunate error?

Editor: *Sadly, it is the latter. The sugar is poly(ADP ribose) and it's synthesised by poly(ADP ribose) polymerase enzymes, which are indeed proteins.*

John Pople, back centre, in 1948. Front left, Dr Menter.

The chemistry of melody

Editor's note: In his letter to us, Professor Ogilvie also reminded us that in writing about the award of the 1967 Nobel Prize to Ronald Norrish and Lord Porter, we should have acknowledged that they shared the prize with Manfred Eigen for his research on rapid reactions in solution. "And unlike Professor Norrish," Professor Ogilvie adds, "who was not known to have any remarkable activity outside chemistry, Professor Eigen recorded two piano concerti of Mozart as soloist."

Research reveals that Eigen – a gifted pianist – once recorded Mozart's Piano Concerto no. 17 with the conductor David Epstein and the New Orchestra of Boston. The slow movement was played at Epstein's funeral where Eigen's performance was much appreciated. Other Chemistry Nobel Laureates have also demonstrated an ear for music. Jean-Marie Lehn is an excellent organist and pianist and used to give professional-standard recitals at chemistry conferences. And John Pople too had musical ambitions. An alumnus of this department, he won the Nobel Prize for Chemistry in 1998 when it was divided equally between Pople "for his development of computational methods in quantum chemistry" and Walter Kohn "for his development of the density-functional theory".

In his biography on the Nobel Prize.org website, Pople talks about returning to Cambridge in 1947 from a stint in industry and attempting to learn to play the piano. "I rented an instrument for the attic in which I lived in the most remote part of Trinity College," he writes. "The neighbouring room was occupied by the philosopher Ludwig Wittgenstein, who had retired to live in primitive and undisturbed conditions in the same attic area. There is some evidence that my musical efforts distracted him so much that he left Cambridge shortly thereafter..."

Pople's piano practice was not all bad news, however. After he sought out a professional teacher, Joy Bowers, she and Pople got on so well, they subsequently married.

Head in the Cloud...

Ley Group

Postdoc Daniel Fitzpatrick is harnessing the power of the Cloud for both his research into how new technologies can revamp synthesis and his start-up chemical management business.

Writing a software package in his spare time to help his colleagues in the Ley Group manage their chemicals more efficiently, Daniel Fitzpatrick had no idea where his project would lead. The first-year PhD student simply wanted to make it quicker and easier for himself and his colleagues to locate the compounds they wanted among the 8,000 containers spread across the Ley Group's two labs.

The group already had an inventory system, but the software running it was about to expire. "Nothing else on the market really met our needs," Daniel says, "so I developed new software at home. All our chemicals were spread across a large area and two labs: we needed an effective way of monitoring them so we weren't spending two days hunting for a particular compound, and so we could do our regulatory reporting more efficiently. I sat down to create such a system."

He trialled his fledgling ChemInventory software in the Ley Group and used the feedback from colleagues to improve it. The response was enthusiastic and word spread. Soon, other research groups in the Department were asking to use it. "When it got to the stage where postdocs were moving on to other institutions and asking to take the software with them," Daniel says, "it started to snowball. I thought it would be a good idea to set up a company to handle it."

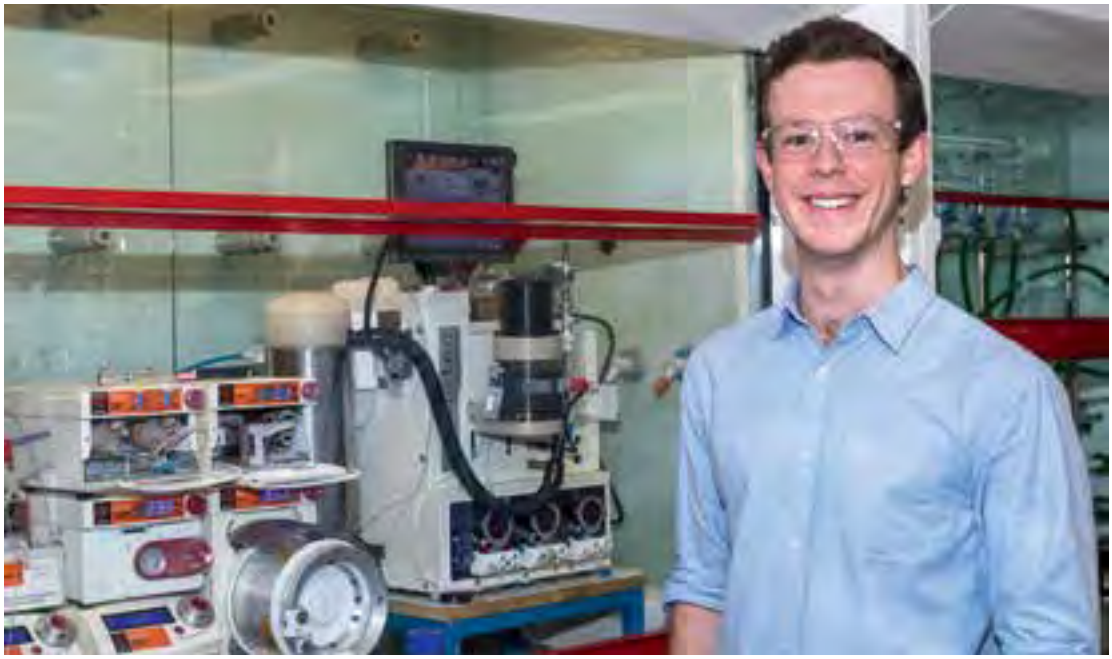
Today ChemInventory software is being used in 2,800 institutions across 96 countries, including in several multinational publicly-listed firms.

And the innovation impressed *Chemical & Engineering News (C&EN)* so much that they named him one of their 2016 'Talented Twelve'. "I had no idea ChemInventory would get so big," says Daniel.

Since finishing his PhD last year (which won him an Outstanding Thesis Prize in the Department), he has stayed on to conduct postdoctoral research part-time. He spends half his week here and dedicates the other half to ChemInventory. There is a strong connection between his research and his business. Daniel has an overarching interest in processes and how new tools, technologies and computer systems can improve them. He wants to "develop new processes for executing value-added change", whether it's for making lab work more efficient and sustainable or for automating self-optimising chemical reactions.

That was the subject of his PhD and he is continuing that work now: *Angewandte Chemie International Edition* recently published a paper by Daniel, Steve Ley and two collaborators. It describes how they harnessed the power of the Cloud to produce pharmaceutical compounds remotely, with a researcher in Los Angeles setting up, monitoring and controlling self-optimization reactions using equipment based here in Cambridge and servers located in Tokyo. (Little wonder that when *C&EN* wrote about Daniel, they described him as a 'Reaction Hacker'...)

Daniel's interest in this area began at the University of Auckland in his native New Zealand. He had applied to study engineering



and law but when the engineering department saw his grades, they invited him onto an accelerated programme that fast-tracked him into the second year of an engineering degree. Of the options on offer there, chemical engineering interested him most.

He then came to Cambridge for his PhD, he explains, "to try and link chemical engineering with chemistry. The Ley Group is an organic synthesis group and within it, most researchers work on developing new chemical reactions. What I do is to look more at tools and techniques associated with synthesis, to find out how we can use them to synthesise molecules more efficiently." He initially found joining a synthesis research group "a baptism by fire! I hadn't done any synthetic work before and spent my first year asking a lot of basic questions and learning a huge amount."

Then he moved on to investigating how to integrate computer systems with the synthesis projects the group was conducting, looking for ways to automate and optimise the chemical reaction processes, so that they could run on their own. "This has the capability to greatly assist with drug development and synthesis and liberate researchers to spend time on more productive pursuits," he says in the paper in *Angewandte Chemie*. Or as Professor Steve Ley put it to *C&EN*, Daniel's new software and hardware control systems "have the potential to completely revamp the way work is carried out in an R&D laboratory."

Daniel, whose PhD studies here were supported by a Woolf Fisher Scholarship, will stay for one more year. Then when his visa expires he will be moving on. He is not quite sure where, but a business path looks likely. Following on from ChemInventory, he is already developing more software for use in research labs – this time an electronic lab notebook that would enable researchers quickly and easily to search through all the experiments on a particular chemical structure previously conducted there.

But as he points out, given that his office is entirely virtual, with a laptop and internet connection he can work anywhere in the world. "Maybe even on a beach in Bali..." he says hopefully.

Daniel E Fitzpatrick, Timothé Maujean, Amanda C Evans & Steven V Ley. *Across-the-World Automated Optimization and Continuous-Flow Synthesis of Pharmaceutical Agents Operating Through a Cloud-Based Server*, Angew. Chem. Int. Ed. 2018. DOI: 10.1002/anie.201809080.

http://talented12.cenmag.org/daniel-fitzpatrick/

‘Against the odds’ discovery creates new tool for adding functions to proteins

Gaunt Group

Using a chemical reaction that “really shouldn’t work” on an under-explored amino acid, researchers here developed a new system for adding functions to proteins that could be used to deliver drugs to targeted cells.

Their new process works by linking a new functional group to an amino acid called methionine in the protein. And as only one other effective method using methionine has been reported so far, the scientists reported in *Nature* that it could considerably expand the toolbox available to synthetic chemists working to modify the structure and function of proteins.

The research was carried out by Professor Matthew Gaunt working with former postdocs Michael Taylor and Marcos Suero, and current PhD student Jennifer Nelson *(pictured right)*. They said in their paper that manipulating the structure and function of proteins in this way “has become essential to the continued advancement of medicine, molecular biology and chemical biology”. But, they add, the number of suitable chemical transformations that can do this effectively is limited. This is because the chemical reactions required have to be very fast, targeted at a single precise location on the protein, take place in biologically ambient conditions and be perfectly reliable, producing the same transformed mature protein product every time.

Many bioconjugation methods – i.e. ways of linking functions to proteins by forming a stable covalent link between two biomolecules – have been developed to date using the reactive amino acids cysteine and lysine. But in their search for new platforms and strategies for synthesising molecules, the chemists on this project opted to study a less commonly-used amino acid: methionine.

“Targeting cysteine and lysine has yielded many different methods to modify proteins,” Matt explains. “But nature is so vast, there’s no way that just two systems are going to solve all the problems. We knew that if we could find a third system to add to the toolbox, it would be very beneficial.” They set about looking for chemical strategies to link molecules to methionine, specifically using hypervalent iodine compounds.

“These are very reactive electrophiles and we were interested in seeing if variants of these molecules could engage the sulfur atom in methionine, which is a weak nucleophile,” Matt says. And they faced some very significant challenges. “The chemical reaction to do this had to work in water, because proteins really only dissolve in water, and had to be incredibly fast to work. But it does,” Matt adds.

“And what is most surprising is how selective it is. This is one of the most reactive electrophiles, it’s got so many reactive functionalities that it should be completely unselective. Even we were a bit sceptical that it would work. But for reasons we don’t yet fully understand, it is selective for methionine.”

Jennifer Nelson, who carried out some of the research as part of her AstraZeneca-sponsored PhD, says: “We developed ways for making this a viable

process through a series of experiments in which we tried to work out how we could tune the reagent and make it more or less reactive, how to make it more stable and more water-soluble. And we ultimately fashioned a process that enabled us to label methionine selectively in a number of different systems."

And having discovered that they could target methionine in this way, they then wanted to see if they could take their work a step further – potentially to add more functional diversity or even open up the possibility of carrying out chemical changes to methionine not just in the isolation of a science lab test-tube but inside a living cell. "As well as the functional payload we installed – which could be an imaging marker, or a drug – we also wanted to experiment with the unique functional group that we installed. This is an electrophilic diazo group, which provides a platform for finding new 'on-protein' transformations," Matt explains.

The further chemical reactions they carried out on the functional group, including stimulating it with visible light, using a photocatalyst, also brought exciting results, which could add further diversity and stability to the compound.

The researchers say in their paper, "The merger of these two approaches provides a versatile platform for the development of distinct transformations that deliver information-rich protein conjugates directly from the native biomacromolecules." They are now looking for collaborations with scientists working in chemical biology to help them take their research further.)

Michael J Taylor, Jennifer E Nelson, Marcos G Suero & Matthew Gaunt. *A protein functionalization platform based on selective reactions at methionine residues,* Nature (2018). DOI: 10.1038/s41586-018-0608-y.

Dual strategy reveals secrets of collagen structure

Duer Group

Researchers in Professor Melinda Duer's group have used an enhanced NMR technique combined with improved isotope labelling to identify for the first time chemicals that are vital for assembling and maintaining the structure of connective tissues such as bone and cartilage.

Working with researchers in Berlin, the team used an emerging NMR technique called Dynamic Nuclear Polarization (DNP), which enhances the sensitivity of NMR to even very low abundance chemical species in tissue. They used the technique to analyse mouse tissues labelled with the NMR active stable isotope carbon-13 (provided by collaborators from King's College London and the Babraham Institute) which increases the sensitivity of the analysis even further. This dual strategy enabled the group to detect very low concentration molecules which have been implicated as critical to collagen structure but never before observed in whole tissue by any technique.

The Duer group investigates the detailed structure of chemical species in the human body and their roles in assembling and maintaining collagen. "Collagen is the basic building block of all connective tissues in the body, including bone, cartilage, skin, blood vessels and tendons," says Dr David Reid, who played a key role in the study. "These findings could suggest new therapies for connective tissue diseases such as osteoarthritis and diabetes, and metastatic cancers."

- Image by Barth van Rossum, freelance scientific illustrator and scientist in structural biology at FMP Berlin.

Wing Ying Chow, Rui Li, Ieva Goldberga, David G. Reid, Rakesh Rajan, Jonathan Clark, Hartmut Oschkinat, Melinda J. Duer,Robert Hayward and Catherine M. Shanahan. *Essential but sparse collagen hydroxylysyl post-translational modifications detected by DNP NMR*, Chem.Commun., 18 Nov 2018, 54, 12570.

Dr James Keeler

Growing up on a farm sparked his interest in "fiddling around with things to see how they worked" and an inspiring teacher focused that interest on chemistry. Subsequently, James Keeler became a teacher himself, coming to Cambridge first as a lecturer and then as Director of Teaching. In October, he took over as Head of Department. Here he shares his thoughts on teaching students, studying spectroscopy... and Star Wars.

What are your earliest memories?
Growing up on the family farm: messing around in the buildings, climbing on the roofs, helping out with the animals. And wonderful harvest teas brought out to the prickly stubble fields by my mother.

Farmers are practical people and have to be able to turn their hands to anything. I think seeing my father and grandfather at work on the farm impressed on me that you could do anything if you put your mind to it.

Why chemistry?
At school I was entranced by the prep room next to the chemistry lab: all those brown bottles with mysterious names, different colours and smells. I liked taking the lids off and having a good look – and a cautious sniff, if I dared! I remember wondering what made the contents of the bottles so different.

And as so often, I was inspired by a teacher. Our chemistry master took a real interest in his pupils and when he saw I had an enthusiasm for the subject, he encouraged me. That made a big difference.

What took you to Oxford?
A couple of previous pupils from my modest school had studied chemistry at Oxford. I went there too as an undergraduate *[where, though he doesn't say so, he won the Gibbs Prize for best performance in the third-year exams]* and stayed on to do a DPhil in NMR spectroscopy with Ray Freeman.

Ray was a fantastic supervisor and had assembled round him a great research group. When I joined it, I'm ashamed to say I had no idea what a big name he was in the NMR world, nor how fast the subject was moving – and it was a time when NMR was developing very quickly. I was lucky to be in the right place at the right time.

What brought you to Cambridge?
NMR was strong at Cambridge in the early 1980s, with Jeremy Sanders and Dudley Williams leading the way. It was Jeremy's idea that the Department should recruit someone with a background in more technical/theoretical NMR. I fitted the bill exactly and was lucky enough to be appointed. That was 34 years ago, I'm horrified to say...

How did you find lecturing?
I've always enjoyed it. When I first came here, Stuart Warren, Ian Fleming, Ruth Lynden-Bell and others gave outstanding lectures (the like of which, I fear, I had not experienced at Oxford). So I had excellent role models to aspire to.

Ever had any lecture disasters?
Oh, yes! You can find your words drying up mid-lecture, or hear yourself getting them back-to-front. But if I make a mistake I always fess up, go back and start again. If you try and hide it, your audience always knows.

Tell us something about yourself people wouldn't know?
I love Mozart operas. And a colleague from Oxford, who was a classical music and Proms enthusiast, sparked my interest in Mahler. There's nothing to beat the finale of his Symphony No 2, 'The Resurrection', performed in the

"I was entranced by all those bottles of chemicals with mysterious names and different colours and smells. I liked taking the lid off and having a good look – and a sniff, if I dared!"

Albert Hall with a huge orchestra and choir, and the organ at full blast too. It's an extraordinarily moving piece. It would be on my Desert Island playlist – along with The Mamas & The Papas.

How has the department changed since you came here?
It's a lot bigger. I suspect there are at least twice as many people on the research side now, though that's partly because synthetic chemistry and related areas are very labour-intensive: to be internationally competitive, you need a lot of people and capacity.

Also, standards have got higher over the years. What people might have done on an open bench 30 years ago would be unthinkable now. In the old days, each corridor in the lab had its own characteristic smell! Now if I smell anything chemical, I'm on the hunt to find if something has been dropped or some containment has failed.

You became Director of Teaching..?
When the Government started to assess the quality of undergraduate teaching at university for the first time. It encouraged us to think more about teaching – how we could raise its profile, organise it more efficiently and give it more structure. That was when the post was created, and I was the first person to hold it. And the external scrutiny of teaching has only increased since then. We take our responsibilities in this very seriously: we're keenly aware of the need to deliver a really high standard of lecturing and teaching.

What's the best part of your job?
As teachers, we guide students' learning and understanding and, if we're lucky, that can make a real impact on them and what they do. Sometimes I meet students who still remember things I told them 20 years ago. When I hear stories like that, it makes it all worthwhile.

Do you regret not having more time for research?
When I was first here, I enjoyed my research. *[James's interests are in the area of high-resolution nuclear magnetic resonance, particularly developing and applying new techniques. In 2017, he won the Shoolery Award, which recognises important contributions to small molecule NMR spectroscopy.]* But over time my interests shifted and I found teaching and writing more engaging.

What are your thoughts on becoming Head of Department?
I've been a Deputy Head for the last three years, alongside Nick Bampos, working closely with [former Head] John Pyle. So I think I have a sense of the issues. The key thing is to provide an environment where everybody – from academics, students and postdocs to support and administrative staff – feels that what they do is valued and that they can really contribute. I think, on the whole, we do achieve this. But there are significant challenges ahead.

Such as?
Managing space so that people don't feel constrained and everyone thinks they're getting a fair crack of the whip. Finding additional resources is also going to be an issue: the University has a structural deficit, so the finances are going to be more difficult and we'll be under pressure to bring in more external funding. Recruitment, especially at the senior level, is also increasingly difficult. Attracting senior-level academics for our named chairs is difficult when we are competing with other universities, like those in North America, who can pay way beyond what Cambridge can afford.

Who would you like to play you in the film of your life?
It would have to be Alec Guinness. I was a first-year undergraduate when the first Star Wars film came out – and I'm still obsessed. We lived out in the Norfolk countryside, so I'd only ever been to the cinema twice before. It seems tame now, but at the time Star Wars was astounding. It made a long-lasting impression on me. But the current generation of students don't get my allusions to the film's plot and characters any more. Sadly.

So do you own a light sabre?
No, though I can reel off quite a lot of the dialogue from the films without too much effort. But I am wondering if I should model my management style on that of Emperor Palpatine...

‘As I see it...’

Once he was unsure he’d get to university because of financial constraints; now David Izuogo is doing a PhD in computational chemistry here. He’s been fortunate, he says, and that’s why he wants to give back.

“There is wealth in Nigeria – but it is concentrated in the hands of a small number of people. Many people’s wages are low: the minimum wage is around £46 per month. So most qualified graduate students cannot afford the £60 fee to apply to Cambridge.”

David Izuogu, a second-year PhD candidate in Dr Alex Thom’s theoretical research group, knows all about financial hardship in Nigeria. Money problems in his own family meant that for him, even finishing high school was a struggle. So when he wanted to study Pure and Industrial Chemistry at the University of Nigeria, Nsukka, he had to turn entrepreneur to support himself. He wrote chemistry manuals and ran coaching sessions for fellow students. “It wasn’t easy combining my studies and producing these solution manuals while topping my class at the time,” he says. But he did. And his academic achievements were recognised when he won Japanese government funding to study at Hokkaido University.

Life-changing scholarship

This was a turning point for him. “Being able to travel abroad for my studies changed my life and inspired me to think beyond the present,” he says. He stayed on in Japan for his master’s degree and then applied for funding for a PhD here in Cambridge. He was successful, securing support from the Cambridge-Africa programme, Cambridge Trust and the Islamic Development Bank.

David knows he is very lucky and that there are plenty of other equally gifted African students who are so daunted by the obstacles facing them that they will not apply here. So he is using his story to encourage others to follow him. “I want to be the bridge for them and motivate them to reach their aspirations,” he says.

Through a foundation he has set up – the “Africa Of Our Dream Initiative” – David returned to Nigeria in September to run an outreach programme encouraging more secondary school and university students to aspire to high-quality education. In this he was supported by the Cambridge Trust, Gates Cambridge, the Cambridge-Africa programme, the Graduate Admissions Office and the Department of Chemistry. He spoke to thousands of students about the issues facing them, such as a lack of funding and mentorship as well as the costs of the application and required language tests. He gave them as much information as he could and encouraged them to persevere. And he is personally paying the application fee for two students he met in Nigeria to apply here.

David himself once thought that “I would never see the four walls of a university”. So now he is really embracing his PhD programme, “using computational techniques to investigate materials that hold a promise for the future of technology – quantum computing.” In Japan he conducted experimental research, looking for potential molecular designs for single-molecule magnets. Such magnets hold tantalising promise: they could be used for applications in information processing, quantum computing and spintronics. But new approaches are needed to overcome the existing limitations on producing them. So he has switched to computational techniques to help rationally design molecules with the desired properties.

Commercialising research in Nigeria

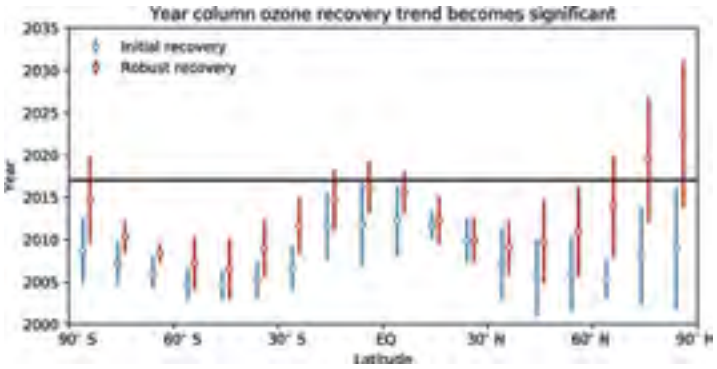
He wants to encourage more of his compatriots to raise their aspirations and follow him. David is also trying to use his time in Cambridge to set up Cambridge-Nigeria research collaborations. Later, after his PhD, he wants to return to the country to lead a team focusing on the commercialisation of cutting-edge research. This is currently lacking there, he says. “That’s partly why I opted for computational chemistry. It’s a field that allows you to interface with most other areas of science to bring about technologies that could redefine our future. Africa is the future,” he adds, “and we should be prepared to embrace it.”

Detecting signs of ozone recovery

Centre for Atmospheric Science

Researchers in our Centre for Atmospheric Science have used coupled chemistry-climate model simulations to confirm that the world is making 'progress on the road to ozone recovery'.

The Montreal Protocol was implemented worldwide in 1987 to protect the stratospheric ozone layer from the harmful effects of man-made ozone-depleting substances. Three decades later, researchers here conducted a study to explore the impacts of the Montreal Protocol on 'total column' ozone values (i.e. the total amount of atmospheric ozone in a column from the surface to the edge of the atmosphere). Lead author Dr James Keeble says: "We wanted to see if we can identify robust recovery of the stratospheric ozone layer resulting from decreased CFC emissions."



To do this, postdoctoral researchers James Keeble, Luke Abraham and undergraduate student Hannah Brown analysed modelled total column ozone values in the North and South polar regions, the tropics, and the mid-latitudes of the Northern and Southern hemisphere. But the researchers, working with Professors John Pyle and Neil Harris (Cranfield University), had a difficult task.

One complexity was the large variability of ozone, which is also affected by natural occurrences such as the eruption of Mount Pinatubo in 1991, changes in the solar cycle, and variations in sea surface temperatures. Not only that, but the variations themselves are different at different latitudes. For example, ozone concentrations in high northern latitudes vary significantly between winter and spring, but they are more stable in the southern hemisphere.

To account for these variabilities, the researchers used coupled chemistry-climate model (CCM) simulations to analyse ozone concentrations and predict ozone trends. Each simulation constitutes a possible future evolution of stratospheric ozone, taking into account different variabilities, and allowing greater confidence in the mean trend, as the number of variabilities is included. "The model was extensively validated by comparing it with satellite observations of ozone made over the last few decades and found to do a good job, giving us confidence in the projected ozone trends," says James.

Because of the large natural variability of ozone concentrations, the team did not use dates of minimum ozone as a gauge of ozone recovery. Instead, they defined ozone recovery in three ways: first, as a slowed rate of ozone decline, second, as a positive trend upward and third, by comparing current ozone concentrations to historic values.

Using the CCM simulations to analyse trends of total ozone from 2000-2017 and accounting for natural cycles, the group found that ozone was increasing at most latitudes, and that these increases were statistically significant in the mid-latitudes in both hemispheres. Based on these models, they projected that significant positive trends could be identified in the tropics and at the highest latitudes within the near future. The researchers concluded that by 2030, we will be seeing significant positive trends in total column ozone in all latitudes, although ozone values lower than the 1980 annual mean could still occur in some regions until late this century. "Statistically significant increases in total column ozone are a real sign that ozone recovery is occurring, but recovery can only be said to be complete when total column ozone values reach their pre-CFC values," says James.

Professor John Pyle, who was recently awarded the Royal Society's Davy Medal for his 'pioneering leadership in understanding the depletion of the global ozone layer', said: "These trends send a positive signal that nations and industries can work together to repair damage to the environment, and to protect it for future generations."

James Keeble, Hannah Brown, N. Luke Abraham, Neil R.P. Harris, and John A. Pyle. *On ozone trend detection: using coupled chemistry–climate simulations to investigate early signs of total column ozone recovery research*, Atmos. Chem. Phys., 18, 7625-7637, 2018.

Staying in touch

Want to keep up with the department and what we're doing?
Visit our alumni website.
Follow us on Twitter.
Or watch us in action on YouTube.

YouTube:
https://bit.ly/2A3D3UK

Twitter:
@ChemCambridge

alumni website:
www.ch.cam.ac.uk/alumni

Noticeboard

Honours & awards

Knighthood
Professor Chris Dobson, Professor of Chemical and Structural Biology, was awarded a knighthood in the Queen's Birthday Honours in June for his contributions to Science and Higher Education.

ACS Hero of Chemistry
Alumnus Dr Ray Finlay was chosen by the American Chemical Society as a Hero of Chemistry. Ray is one of four scientists from AstraZeneca honoured for their development of Tagrisso™, a new specialised treatment for patients with EGFR-mutated non-small cell lung cancer.

Royal Society: Royal Medal
Professors Sir Shankar Balasubramanian and David Klenerman were jointly awarded The Royal Medal, one of The Royal Society's highest honours, for their development of next generation DNA sequencing.

The EAS Award for Outstanding Achievements in Magnetic Resonance was presented to Professor Clare Grey at the Eastern Analytical Symposium in November.

Royal Society: Davy Medal
The Royal Society's prestigious Davy Medal went to Professor John Pyle for his "pioneering leadership" in furthering our understanding of the depletion of the ozone layer and the substances that destroy it.

Asteroid 12651 Frenkel
Professor Daan Frenkel received an unusual 70th birthday present in July when an asteroid was named after him – a fitting gift for a scientist whose research has shed light on the state of carbon in stars. His name now graces the asteroid 12651 Frenkel, as designated by the International Astronomical Union Minor Planet Centre.

The Scopus Early Career Researcher UK award for 2018 in Biochemistry, Genetics and Molecular Biology went to alumna Serene Chen. She completed her PhD in the Dobson group here, where she studied protein aggregates such as the alpha-synuclein protein, whose deposition is one of the hallmarks of Parkinson's disease. As a postdoctoral research fellow at Imperial College London, Serene focused on the structures of aggregates using advanced imaging techniques. She continues to work closely with the department's Centre for Misfolding Diseases.

Books

Dr Timothy K Dickens, Dr Stuart Warren
Chemistry of the Carbonyl Group: A Step-by-Step Approach to Understanding Organic Reaction Mechanisms Revised Edition (Wiley, 2018) ISBN: 978-1-119-45956-9

Promotions

Dr Bill Nolan has taken over as Director of Teaching from Dr James Keeler, when Dr Keeler became our new Head of Department. Dr Nolan has a depth of experience when it comes to our own teaching programme and more widely in the University. He has come full circle, having earned his PhD in Organic Chemistry here.

Dr Peter Wothers, who is well known for his many outreach activities including the popular Chemistry Open Day lectures, will take on Dr Keeler's former role of School and Outreach Officer.

Retirement

We recently said goodbye to several staff who between them have given over 160 years of service to the department.

Mykola Karabyn retired at the end of June after 42 years here. Mykola said "I really enjoyed working with you all and will miss daily life in the lab, but I'm looking forward to my new life of leisure."

Paul Skelton and **Steve Wilkinson** retired in July. Both had been here for 39 years. Paul worked as a member of the Mass Spectrometry team, helping many people with their research. Steve spent a lot of his time as a lab technician working on the third floor, helping members of the department with their chemistry needs.

In September **John Palmer**, Building Services Manager, retired after 20 years of service and **Peter Grice** *(pictured above left)*, Senior Technical Officer, who had overall responsibility for NMR in the department, retired after 26 years here.

We thank them all for their contributions to the department and wish them an enjoyable retirement.

How you can contribute

Help us to help students

This issue features some outstanding postgraduate students who would not have been able to take up their places here without financial support.

We are always looking to create more funded places for deserving students. The Lord Lewis Research Studentship in Chemistry, set up in memory of the late Jack Lewis, supports a student to be a member of Robinson College while studying for a PhD in Chemistry. We have similar studentships with Selwyn and Jesus Colleges. They bring benefits to both the department and the colleges, but most importantly support outstanding students who otherwise could not afford to study here.

If you would like to find out more about funding a studentship in chemistry at your own college, please contact our Head of Department, Dr James Keeler at chemhod@hermes.cam.ac.uk Or visit our 'Support Chemistry' web pages at www.ch.cam.ac.uk/support-chemistry to learn about other ways you can support chemistry at Cambridge.