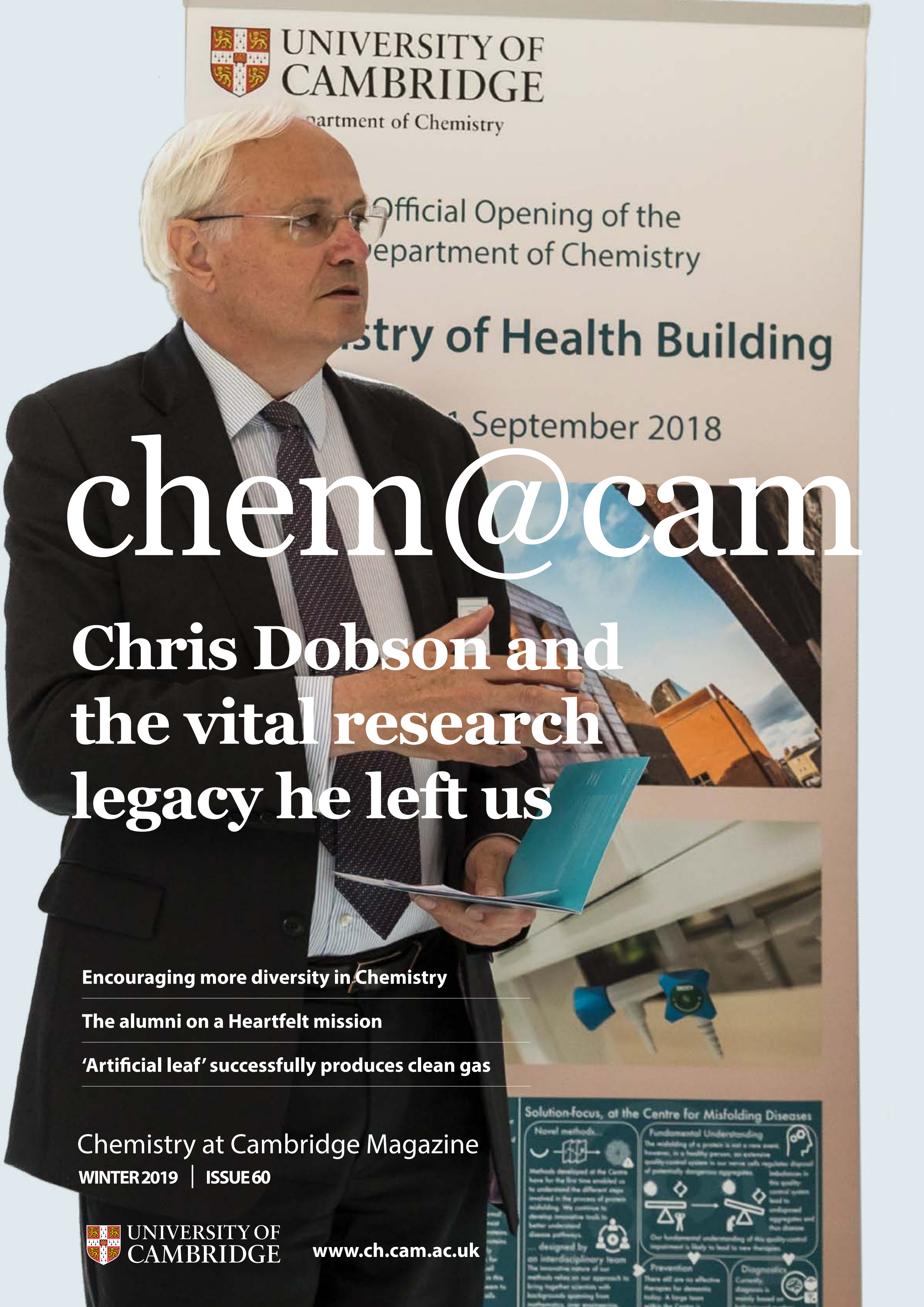

chem@cam

Chris Dobson and the vital research legacy he left us

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WINTER 2019 | ISSUE 60

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Welcome

Many of you will already have heard of the untimely death of Professor Sir Chris Dobson in September. This is a very sad loss and it has been keenly felt by all he knew and worked with over his long and extremely fruitful career.

Chris was a great networker and collaborator who interacted with, and inspired, a vast network of fellow scientists from around the world. He also won great loyalty and respect from them, his students and co-workers. In fact, it is clear – from the number and warmth of the tributes paid to him – that many people regarded Chris as a very significant person in both their scientific and personal lives.

Chris leaves us with a substantial scientific legacy, and a tangible one in the form of the Chemistry of Health Building, which houses the Centre for Misfolding Diseases – both of which are very much the product of his energy and vision. He also leaves us with an energetic and forward-looking team, well able to push forward with his vision. You can read about how they are doing so in the pages of this issue.

We are beginning to think about an appropriate way in which to commemorate Chris and his achievements, and will be able to say more about this in future issues of *Chem@Cam*.

Elsewhere in this issue, you can catch up with the latest happenings from the department and from some of our alumni, and encounter researchers here with extraordinary stories to tell.

In keeping with the spirit of the times when 'Carbon Zero' is becoming a dominant theme, you can also read about how our research is contributing to the development of electric vehicle batteries, the use of sustainable timber in construction and cleaner fuels for the future.

Talking of our contribution, readers will also notice that *Chem@Cam* no longer comes in a plastic wrap but is now sent out in a compostable (potato starch) film. "Every little helps", as they say...

James Keeler
Head of Department

Cover photo of the late Chris Dobson at the opening of the Chemistry of Health building taken by Nathan Pitt.

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Alumni events in 2020

Alumni conference – *'Diversity in Chemistry: Different Paths to Success'*
10:30–16:00
Friday 7 February 2020
Department of Chemistry

Why isn't there more diversity in the scientific workplace? We know there are many positive benefits to the quality of research when it involves scientists of different ages, nationalities, backgrounds and gender. Yet scientists from under-represented groups still struggle to be included in the research lab, while unconscious bias and traditional attitudes to what constitutes scientific 'success' are proving stubbornly hard to alter. What can we do to change this?

This is the theme of a one-day alumni conference on Friday 7 February 2020 – *'Diversity in Chemistry: Different Paths to Success'.* Following last year's enthusiastically-received *Women in Chemistry* alumni event, (and responding to the feedback we received afterwards), this year we're broadening the discussion beyond gender.

In a day of talks, panel discussions, workshops and open Q&A sessions, we'll consider the benefits to science of having a more diverse workforce, and practical ways of bringing scientists from under-represented groups into the lab, including via mentoring, volunteering and internships.

We'll look at the challenges involved in adjusting our attitudes to what qualifies as 'success' in science. And we'll discuss how publishing models – which can contain inherent, unintended bias – might change or be adapted. Workshops will include practical advice for those wanting to return to work in science after a career break, and a session on challenging attitudes to the traditionally perceived divide between science and art given by alumna Rivka Isaacson. *(See news story on page 9.)*

Confirmed participants so far include:

- Melinda Duer, Professor of Biological and Biomedical Chemistry, University of Cambridge.
- Karen Salt, Deputy Chair of the UK Research and Innovation External Advisory Group for Equality, Diversity and Inclusion; and Acting Deputy Director, Culture and Environment, UK Research and Innovation.
- Mary Hockaday, Controller, BBC World Service English and diversity champion for the BBC News Group.
- Fiona Hutton, Head of Scientific, Technical & Medical Open Access Publishing, Cambridge University Press.
- Matthew Day, Head of Open Research Policy & Partnerships, Cambridge University Press.
- Joy Warde, STEM Careers Adviser, University of Cambridge Careers Service.
- Alumna Claire Hansell, Senior Editor, Physical Sciences, *Nature*.
- Alumna Rivka Isaacson, Reader in Chemical Biology, Department of Chemistry, King's College London.
- Emma Pewsey, Comment & Careers Editor, *Chemistry World*.

The day will start with coffee and registration at 10:00 am before a keynote speaker opens the conference. That will be followed by a panel discussion and then a choice of workshops on ways of overcoming hurdles that currently block inclusion and diversity.

After lunch, there will be a second set of breakout sessions before a 'Question Time'-style debate, where we'll open up the discussion to delegates and give them the opportunity to put questions to the panel. The day concludes with refreshments and a final opportunity for networking.

The conference is free to attend but spaces are limited and we anticipate a high level of response. So if you would like to take part, please register early to ensure a place at: https://diversityinchemistry.eventbrite.co.uk

Annual Chemistry Open Day
10:00–16:00
Saturday 14 March 2020
Department of Chemistry

We're holding our ever-popular Chemistry Open Day in March 2020 and will be delighted to see alumni and their families at this fun annual event, part of the University of Cambridge Science Festival.

As usual, the day will include some explosive demonstration lectures by Teaching Fellow Dr Peter Wothers. His theme will be '*The Chemistry of Light*'. Today, we take it for granted that we can have light at the flick of a switch, but before the invention of modern electric lights, the only way of making light was through chemistry. As Peter explores the elements involved in generating light over the centuries, there will be plenty of

flashes and bangs to keep you on the edge of your seats! Peter will give his lecture three times during the day and we've been able to reserve a limited number of places at these lectures for alumni and their guests. The times are:
11:00–12:00
13:30–14:30, and
16:00–17:00.
You can book your places online at:
https://thechemistryoflight.eventbrite.co.uk
The lectures are always very popular so early booking is advisable. Please be advised, they contain loud bangs and are suitable for ages 7+.

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

Annual Alumni Reunion 2020
with lecture, drinks and dinner
Date to be confirmed

We are currently planning our Chemistry Alumni Reunion 2020.

It will follow the style of the reunion held earlier this year, when over 100 alumni attended a special lecture at which Dr Peter Wothers took us time-travelling through the events leading up to the publication of Mendeleev's Periodic Table. After his talk, alumni enjoyed meeting up with each other at a drinks reception hosted by the department, and there was then a dinner for those who had been in the department up to 1979.

We're now finalising details of our 2020 reunion which will include a lecture and drinks reception that are free to attend and open to all alumni and their partners. There will then be a dinner for alumni who were in the department up to 1989.

Invitations to this event will go out by email in early 2020. To ensure you receive yours, please visit the Cambridge Alumni Relations website to update your contact choices (www.alumni.cam.ac.uk/contact/update-your-details) to include receiving news and events emails from us.

This enables you to receive the summer issue of *Chem@ Cam* (which goes out by email only) and the occasional emails we send about events we hold in the department.

News

A new incumbent for our oldest Chair

Professor Matthew Gaunt, an outstanding synthetic chemist whose work has been recognised by a series of awards, was elected to the Yusuf Hamied 1702 Chair of Chemistry in July.

Matt's research focuses on inventing new ways to stimulate organic molecules to react by using catalysts. He and his research group have found many new and better methods for making complex small molecules that are important in areas such as drug discovery, and developed strategies that enable the chemical modification of biomacromolecules – such as peptides and proteins – that provide new tools for chemical biologists. His group is also interested in exploring how new technological advances, such as high-throughput experimentation platforms, can accelerate chemical synthesis to provide scientists with faster access to molecules such as new pharmaceutical candidates.

In recognition of this work, Matt was awarded the 2019 Synthetic Organic Chemistry Award by the Royal Society of Chemistry. He previously received the Society's Corday-Morgan Medal in 2013, and the American Chemical Society Cope Scholar Award in 2016.

Professor Steve Ley, his predecessor as 1702 Professor, said: "I am delighted Matt Gaunt has been appointed. He is a wonderfully creative scientist and I wish him every success for the future." The Yusuf Hamied 1702 Chair of Chemistry (recently renamed after Dr Yusuf Hamied, an eminent alumnus whose generous donation supports it) is one of the oldest Chairs of Chemistry in the UK. Its first incumbent was Giovanni Vigani (1702-12), a contemporary and friend of Sir Isaac Newton, and it has subsequently been held by a number of renowned chemists, including Nobel Laureate Lord Todd. Matt, the 16th incumbent, says: "I feel very privileged to be joining a group of remarkable scientists who have made pioneering and transformational contributions to chemistry. This Professorship, and its generous support from Dr Yusuf Hamied, will provide opportunities for me to realise my vision of how synthetic chemistry can drive advances in chemical biology and biomedical science.

- Read the full announcement on our website at www.ch.cam.ac.uk/news/new-incumbent-our-oldest-chair

New professor is world-record holder

Professor Angelos Michaelides ran this year's London Marathon wearing a traditional white lab coat, safety goggles and lab gloves, and carrying test tubes from his four-year-old daughter's science kit. That's because he was attempting to set a new world record for the '*fastest marathon dressed as a scientist (male)*' and this was the official outfit required.

Angelos was running to support WaterAid, an international charity working to provide clean water and decent toilets to people all over the world. And water and its structure are close to his heart: as a Professor of Theoretical Chemistry at University College London, he has been working on a better understanding of water and ice, especially the molecular-level insight needed to solve some of the world's water problems. He is interested in developing and applying computer simulation approaches to better understand materials and their surfaces, "with the most important substance of all – water – being a particular focus," he says.

Now Angelos is bringing his expertise to this department as he takes over the Professorship of Chemistry (1968) here. "I am absolutely delighted he is joining us," says Head of Department Dr James Keeler. "He not only brings us some truly innovative and outstanding science, but also a record of bringing people together to work in teams across institutions and disciplines." For his part, Angelos is "very excited to be returning to Cambridge and the opportunities this holds for strengthening existing, and developing new, collaborations." Oh, and his marathon attempt? It was a success: he set a new time of three hours and 22 minutes.

Tributes to Professor Sir Christopher Dobson

When our distinguished colleague Professor Sir Christopher Dobson died in September, tributes poured in to this pioneering researcher into the fundamental chemistry of neurodegenerative diseases.

He had been diagnosed with cancer earlier in the year. When his death was announced, University Vice-Chancellor Professor Stephen J Toope said: "Chris's loss will be felt keenly by those of us who had the enormous good fortune of counting him as a friend and colleague. I personally mourn the passing of a profoundly decent and compassionate man of towering academic achievement."

That description very well sums up Professor Dobson, who was better known to his colleagues simply as 'Chris'. Many of the comments left in the online condolence book at St John's College (where Chris was Master) mourned the loss of a man of great warmth and kindness, as well as a prolific and brilliant scientist. One entry is typical of many others: "Chris was a scientific mentor to my wife and helped her through a very difficult time during her PhD. I can honestly say that were it not for Chris's belief in her, she may well have left science. She is now a successful academic, and we will forever be indebted to Chris for that."

Chris held the John Humphrey Plummer Professorship of Chemical and Structural Biology here since his arrival in 2001. As he recounted in an interview in the spring 2018 *Chem@Cam* (issue 58), it was chance that first sparked his interest in the behaviour of proteins in human cells 25 years ago. Over subsequent years, he became a leader in research into protein misfolding – the phenomenon behind neurodegenerative diseases such as Alzheimer's, Parkinson's and motor neurone disease. The work carried out by him and his colleagues and collaborators has helped advance the global understanding of these conditions.

Our Head of Department Dr James Keeler said: "Chris's scientific contributions over a long and very productive career were outstanding, and his legacy will live on in the many people he welcomed into his research group or collaborated with.

"Chris was a great nurturer of scientific talent and his group has, over the years, had a huge influence on the direction of research well beyond Cambridge." His research achievements were recognised by numerous awards, including a Knighthood in the Queen's Birthday Honours 2018 for his contributions to Science and Higher Education.

In 2013 Chris co-founded this department's Centre for Misfolding Diseases, which has brought together researchers from a wide variety of scientific backgrounds to investigate the molecular processes underlying neurodegenerative diseases. Chris was also instrumental in establishing our Chemistry of Health building, which now houses the Centre and where this research continues.

"Chris has been an inspiring figure through his dedication to science and to supporting others to fulfil their potential," says Professor Michele Vendruscolo, a long-term collaborator with Chris, and Director of the Chemistry of Health. "He had the rare ability of transforming the lives of many of those that worked with him."

Dr Keeler adds: "The Chemistry of Health Building is a testament to his vision and energy. But more than any building, he leaves behind an outstanding scientific legacy. Our thoughts are with his family – and with his wider academic family who will surely feel his loss very keenly."

Chris is survived by his wife Dr Mary Dobson, their sons Richard and William, and his beloved dog, Jimbo.

- *Read more about the work going on in the Chemistry of Health building in our feature on page 15.*
- *We are currently considering how best to honour Chris and the work he undertook in this department. We'll be sharing more details about this project in the next issue.*

Viewing the invisible

Alumni explore science through art

Two alumni of this department took part recently in '*Viewing the Invisible*' – a BBSRC-funded project bringing scientists together with artists to explore the similarities in their working methods.

As Dr Rivka Isaacson, now a Reader in Chemical Biology at King's College London, and Dr Julian Huppert, Director of the Intellectual Forum at Jesus College Cambridge, sat for their portraits, they were filmed in conversation with the artists. They discussed the similarities in their approaches and working methods in a project that aimed to challenge the popularly-held belief that science and art exist at polar ends of a spectrum.

Rivka did her PhD here with Professor Sir Alan Fersht, researching the inherited gene-mutation disorder FAF (familial amyloidosis, Finnish type) before going as a postdoc to Harvard. Today, her research group uses biophysical techniques, with a focus on NMR spectroscopy, to determine macromolecular structure and interactions of molecules relevant to health and disease.

In her portrait session, she quizzed painter Christopher Grey about how artists capture things that are not immediately visible. When he explained how they sometimes use unnatural colours such as bright purple to add natural-looking highlights that bring a portrait to life, Rivka realised there was a similarity there with her own scientific work.

"We introduce special isotopes into our proteins to make them visible," she told him. "In doing so, we can pinpoint a lot of molecular detail we would never be able to see in real life."

Julian did his PhD with Professor Sir Shankar Balasubramanian on the four-stranded DNA structures known as G-quadruplexes that can function as genomic switches. He asked artist and sculptor Scott Pohlschmidt, of London Fine Art Studios, about how he works in planes and shifts of tone to create a three-dimensional object on a two-dimensional surface. As the video shows, when he learned that Pohlschmidt often starts a portrait by reducing the subject's face to a set of discrete 3D component parts, Dr Huppert said this chimed with the work he used to do to understand the three-dimensional structure of DNA by reducing it to smaller units.

Above: Rivka Isaacson taking part in the *Viewing the Invisible* project. Below, as she appeared in *Chem@Cam* in Winter 2001.

The portraits, along with the videos about their creation, were shown as part of a multi-stranded exhibition at King's College London in September. "Through the close study of shapes and constituent parts," the organisers explained, "scientists and artists alike seek to demystify the human form. *Viewing the Invisible* showcases the ways in which both disciplines work together, exploring how scientists and artists can support each other in disseminating research and enriching creativity."

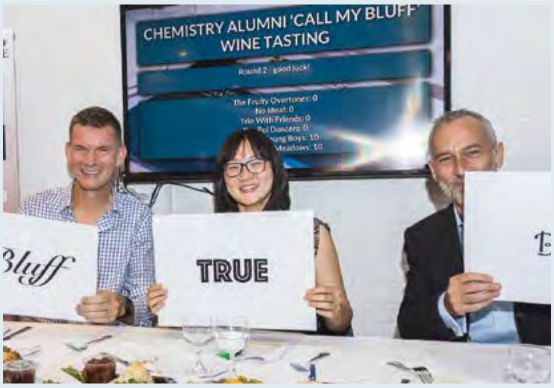
The videos can be still seen on YouTube (at https://youtu.be/92JExDU44dw) and Rivka, one of the project organisers, is hoping that the exhibition may now be hosted in other locations, including potentially here in Cambridge. "I come to Cambridge several times a year to examine PhDs or meet up with friends and colleagues," she says. "I'm currently exploring options for a potential exhibition venue, so watch this space."

- Rivka will be running a workshop about the *Viewing the Invisible* project at our *Diversity in Chemistry* alumni conference in February. See page 8 for details.

Alumni wine tasting

An evening of research news and 'fake brews'



There was something for everyone: reunions between former students and their supervisors, research highlights in posters and a talk, and a race to the bottom of a glass of wine. Yes, it was our annual Chemistry Alumni 'Call My Bluff' Wine Tasting, held during the University Alumni Festival.

This year, knowing that our alumni like hearing about the latest research in the department, we not only gave them a glass of sparkling wine on arrival but also the chance to meet graduate students and see their research posters. Then atmospheric chemist Andrea di Antonio, a third-year PhD candidate, gave a short talk on his research into atmospheric pollutants and the most efficient ways of measuring them using networks of low-cost sensors. Andrea had won an award for this talk earlier in the week in our 'Chemistry Showcase' event for graduate students. Then it was time for alumni to match their wits with our panel of in-house wine 'experts'.

Over four rounds of wines, teams including the self-proclaimed *Fruity Overtones* and *Pol Dancers* had to guess which panellist was describing the wine truthfully and who was presenting 'fake brews.' It was an evening of good wine, bad puns, and lots of bonhomie.

Many thanks to our panel, pictured above: alumnus James Harrison, CEO of Cycle Pharmaceuticals; Research Fellow Jenny Zhang; and Deputy Head of Department Nick Bampos. Our guests told us they loved the banter, the camaraderie and, of course, the wine – in fact, the biggest complaint seemed to be that the evening had to end! But the good news is it will return next year, on Friday 25 September 2020. And responding to many requests from our alumni for a talk on the chemistry of wine, our guest speaker will be Dr Alex Thom. Alex is a lecturer here in Theoretical Chemistry and a wine enthusiast; he'll be giving a talk about some of wine's chemical characteristics. Look out for your invitation in next spring's *Chem@Cam*.

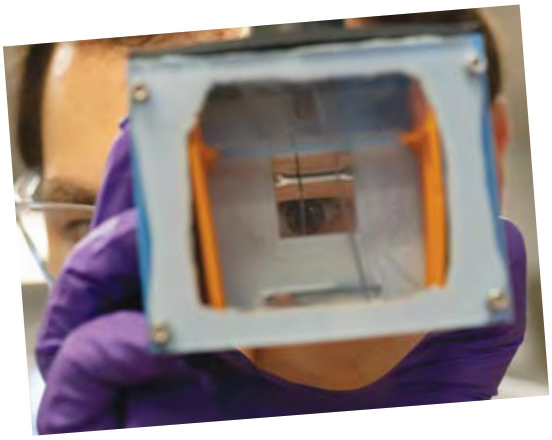
‘Artificial leaf’ successfully produces clean gas

Reisner Group

A widely-used gas that is currently produced from fossil fuels can instead be made by an ‘artificial leaf’ that uses only sunlight, carbon dioxide and water, and which could eventually be used to develop a sustainable liquid fuel alternative to petrol, researchers here showed.

The carbon-neutral device sets a new benchmark in the field of solar fuels, after the researchers here demonstrated that it can directly produce the gas – called syngas – in a sustainable and simple way.

Rather than running on fossil fuels, the artificial leaf is powered by sunlight, although it still works efficiently on cloudy and overcast days. And unlike the current industrial processes for producing syngas, the leaf does not release any additional carbon dioxide into the atmosphere. The results were reported in the journal *Nature Materials* in October.



“Every day you consume products that were created using syngas. Being able to produce it sustainably would be a critical step in establishing a sustainable chemical and fuel industry.”
Professor Erwin Reisner

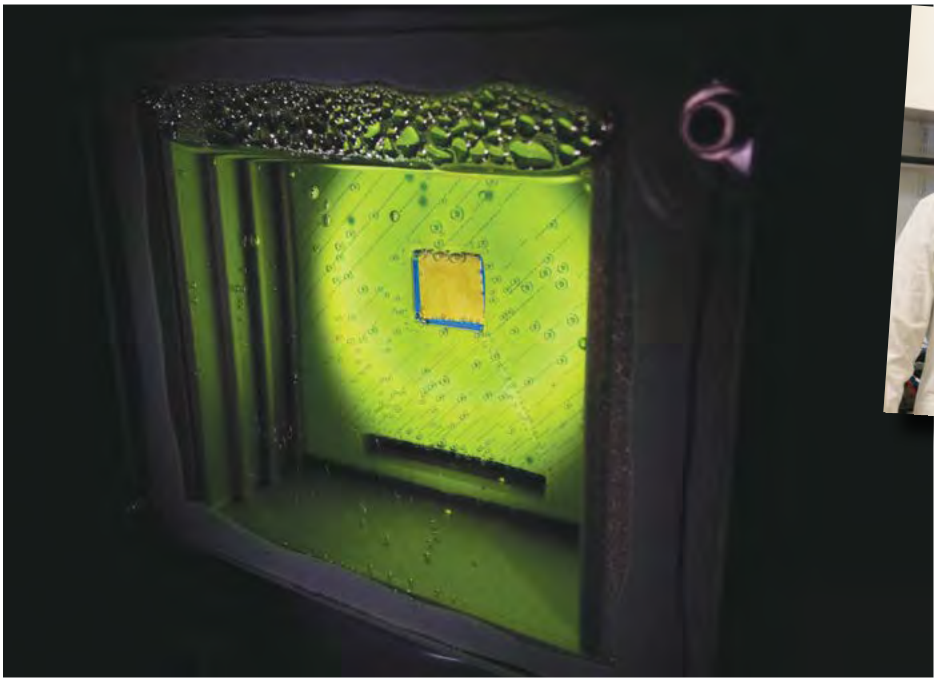
Syngas is made from a mixture of hydrogen and carbon monoxide, and is used to produce a range of commodities, such as fuels, pharmaceuticals, plastics and fertilisers.

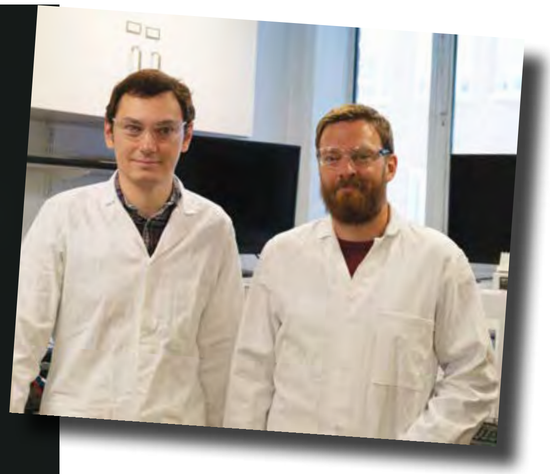
“You may not have heard of syngas itself but every day, you consume products that were created using it. Being able to produce it sustainably would be a critical step in closing the global carbon cycle and establishing a sustainable chemical and fuel industry,” said senior author Erwin Reisner, a Professor here, who has spent seven years working towards this goal.

The device Reisner and his colleagues produced is described as an ‘artificial leaf’ because it is inspired by photosynthesis – the natural process by which plants use the energy from sunlight to turn carbon dioxide into food. On it, two light absorbers, similar to the molecules in plants that harvest sunlight, are combined with a catalyst made from the naturally abundant element cobalt. When the device is immersed in water, one light absorber uses the catalyst to produce oxygen. The other carries out the chemical reaction that reduces carbon dioxide and water into carbon monoxide and hydrogen, forming the syngas mixture.

As an added bonus, the researchers discovered that their light-absorbers work even under the low levels of sunlight on a rainy or overcast day.

“This means you are not limited to using this technology just in warm countries, or only operating the process during the summer months,” says PhD student Virgil Andrei, first author of the paper. “You could use it from dawn till dusk, anywhere in the world.”





Virgil Andrei (on facing page and above left) with Erwin Reisner in the lab. Main image: the 'artificial leaf' device.

Images: courtesy of Virgil Andrei and Chanon Pornrungroj.

The research was carried out in the Christian Doppler Laboratory for Sustainable SynGas Chemistry here in the department. It was co-funded by the Austrian government and the Austrian petrochemical company OMV, which is looking for ways to make its business more sustainable.

"OMV has been an avid supporter of the Christian Doppler Laboratory for the past seven years. The team's fundamental research to produce syngas as the basis for liquid fuel in a carbon neutral way is groundbreaking," says Michael-Dieter Ulbrich, Senior Advisor at OMV.

Other 'artificial leaf' devices have also been developed. But our researchers say the reason they have been able to make theirs produce syngas sustainably is thanks to the combination of materials and catalysts they used.

These include state-of-the-art perovskite light absorbers, which provide a high photovoltage and electrical current to power the chemical reaction by which carbon dioxide is reduced to carbon monoxide, in comparison to light absorbers made from silicon or dye-sensitised materials. The researchers also used cobalt as their molecular catalyst, instead of platinum or silver. Cobalt is not only lower-cost, but it is better at producing carbon monoxide than other catalysts.

The team is now looking at ways to use their technology to produce a sustainable liquid fuel alternative to petrol.

Syngas is already used as a building block in the production of liquid fuels. "What we'd like to do next, instead of first making syngas and then converting it into liquid fuel, is to make the liquid fuel in one step from carbon dioxide and water," says Erwin.

Although we are making great advances in generating electricity from renewable energy sources such as wind power and photovoltaics, Erwin says the development of synthetic petrol is vital as electricity can currently only satisfy about 25% of our total global energy demand. "There is a major demand for liquid fuels to power heavy transport, shipping and aviation sustainably," he says.

"We are aiming at sustainably creating products such as ethanol, which can readily be used as a fuel," says Virgil. "It's challenging to produce it in one step from sunlight using the carbon dioxide reduction reaction. But we are confident that we are going in the right direction, and that we have the right catalysts, so we believe we will be able to produce a device that can demonstrate this process in the near future."

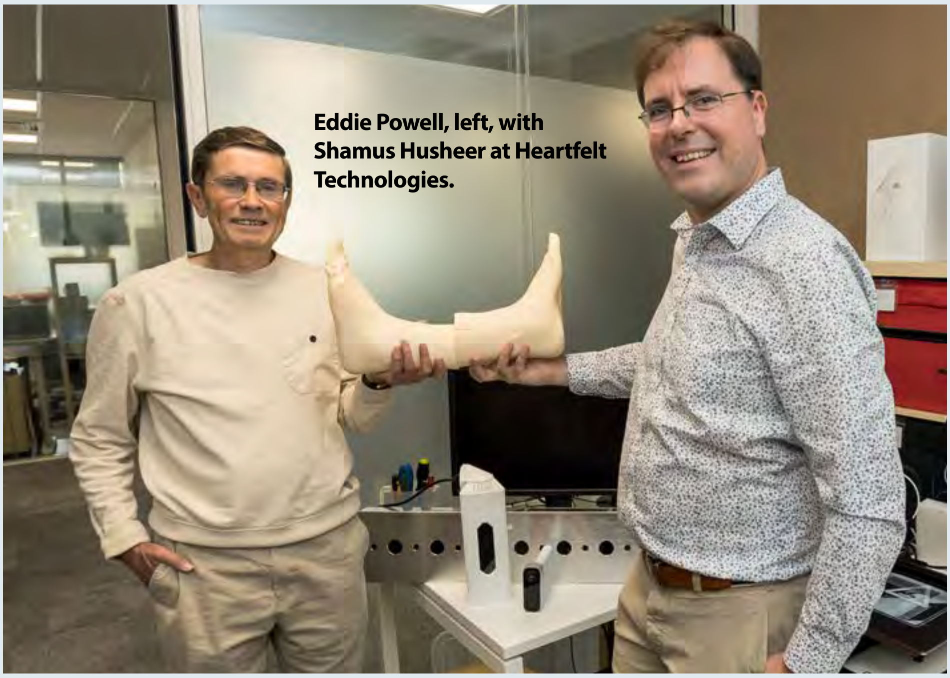
Reference:
Virgil Andrei, Bertrand Reuillard and Erwin Reisner. 'Bias-free solar syngas production by integrating a molecular cobalt catalyst with perovskite-BiVO_4 tandems.' *Nature Materials* (2019). DOI: 10.1038/s41563-019-0501-6

The research was also funded by the Winton Programme for the Physics of Sustainability, the Biotechnology and Biological Sciences Research Council, and the Engineering and Physical Sciences Research Council.

Alumni join forces for a Heartfelt mission

They were born on opposite sides of the world and did their Chemistry PhDs in this department three decades apart. Then a Cambridge business angel introduced them. Now Eddie Powell is a mentor, colleague and investor in Shamus Husheer's latest start-up. The pair – who describe themselves respectively as "a member of the awkward squad" and "a recidivist entrepreneur" – tell *Chem@Cam* about how they work together.

Not many people would see a swollen ankle as a business opportunity. But Shamus Husheer did.



Eddie Powell, left, with Shamus Husheer at Heartfelt Technologies.

It happened in 2015 while the inventor and entrepreneur was chief technology officer at Cambridge Temperature Concepts (CTC), a company he'd co-founded with other graduate students during his PhD here. Using his skills and interest in instrumentation design (the focus of his project), CTC had developed a wearable fertility monitor for couples struggling to conceive. And it worked.

Initially marketed with the eye-catching tagline "*Pregnant in 12 months or your money back*", the DuoFertility monitor helped hundreds of women to become pregnant. "As a result of that company, I have at least 1,500 babies," Shamus says now with a grin. "Probably rather more..." But after ten years, CTC was being bought out by a group of its investors. For Shamus, it was time to move on.

Patients whose shoes don't fit

He still had a strong interest in building instruments. For his PhD, he'd worked with Jacqui Cole "designing and building instrumentation for synchronising lasers, x-ray pulses from synchrotrons, and sub-atomic particles from nuclear sources" and he'd thoroughly enjoyed the experience. "My three-year PhD was the best five years of my life!" he jokes. And though his move into healthcare had been accidental, he decided he wanted to stay in the field. "It's great to work in a sector where you are able to help people". So he set about interviewing clinicians to get some ideas. His quest paid off one night at dinner when a cardiac surgeon began grumbling about his heart failure patients. "They ended up on his heart transplant table simply because they didn't tell him their feet and ankles were so swollen, their shoes didn't fit any more."

Shamus's ears pricked up as the doctor explained that when a heart failure patient's feet swell, it's a warning. A failing heart does not pump as much oxygen-rich blood around the body as a healthy one, and the lower blood oxygen and flow prompts the kidneys to assume blood has been lost. So the kidneys retain fluids and salts in order to make more blood, and the fluids pool around the ankles, leading to the telltale swelling. If this is picked up promptly, patients can easily be

“My three year PhD programme was the best five years of my life!”
Shamus Husheer

“My PhD was great fun. However my fellow PhD students were brighter than me...”
Eddie Powell

treated at home with diuretic tablets that open the kidneys and flush out the excess fluid, reducing the strain on the heart. But if it’s not spotted – and some patients don’t – they end up in hospital. So it would be great, the surgeon said, if there was an easy way to spot this early on.

‘I can build a machine to detect that’

For Shamus, it was a eureka moment. “I knew how to design instrumentation. And I knew a little bit about computer vision. So I told him ‘I can build you a machine to detect that’. ” He recruited some of his former colleagues from CTC – including Gareth Williams, who had done his PhD research in computer vision, and Oriane Chausiaux who had become a specialist in the medical regulation involved in running clinical trials – and together they started Heartfelt Technologies to develop a suitable monitor.

“Heart failure is now the single biggest cause of hospitalisations for the over-65s,” Shamus explains. “And there is a particular group of patients – frail, and often with dementia – who don’t monitor their health regularly. They miss the signs and end up being admitted to hospital repeatedly, creating a poor quality of life for them, and an enormous burden for the NHS.” The device Heartfelt has developed to address this sits on a patient’s bedroom floor and takes pictures of their feet every time they walk past – crucially, without them having to remember to do anything. It records and transmits the data, and when it registers that the patient’s feet are swelling, it sends an alert to their GP.

After four years’ work, the monitor is patented, has regulatory approval, and is legal for use in the US where it’s attracting interest. (Not surprising given that on average across the UK and US, the cost of a nurse’s home visit to a patient is $100, while a patient’s hospital stay is nearer $10,000.) Meanwhile, the device is also being piloted here in an NHS programme. And the information it is gathering from the patients is being used to refine its operation. The more data the monitor collects, the more it helps to train the recognition algorithms in its neural networks, so that it can interpret what it is ‘seeing’ with increasing accuracy.

Recognising human flesh

“It has to learn to recognise human flesh, for example, and pick it out in a picture,” explains Eddie Powell, a fellow alumnus of this department and a non-executive director of Heartfelt. “If the bedroom carpet is a similar colour to the foot, the camera can have difficulty distinguishing it. Or the sheets on the bed may be reflective to infra-red light. These kinds of challenges still need to be overcome.” Eddie is an investor in Heartfelt, as he was at CTC. But here he is playing an additional and more proactive role, bringing his “grey hair and business experience” (he’s 30 years older than Shamus) to the company to help it out.

Eddie first came to Cambridge in 1967. He arrived at Churchill College from a West Midlands grammar school to study Natural Sciences and then decided to stay on in Lensfield Road for a PhD. As “inorganic chemistry was then the flavour of the month”, he went to work with Martin Mays’ group, who were “looking at organo-metallic complexes with a particular view to understanding organo-metallic catalysis”. Eddie did his PhD on the ‘isocyanide complexes of cobalt, rhodium and iridium’.

“It was great fun and I enjoyed it immensely,” he says. But he knew, when he finished, that he wasn’t going to stay in the subject. “I realised that Chemistry was producing more PhDs than any other subject and most of them were brighter than me! So I thought I’d look for a different game.”

A start-up calls

He turned to finance, first training as an accountant and then becoming finance director in a series of firms, including Marconi Instruments and construction engineering business Colt. Then a Cambridge start-up came calling. Abcam had been co-founded in 1998 by scientist Jonathan Milner (who saw an opportunity to supply antibodies to support protein interaction studies) and entrepreneur David Cleevely.

Curriculum Vitae:
Eddie Powell

Born:
Berlin, 1948

Education:
Churchill College 1967 - 1973, Undergrad & PhD

Employment:
Marconi Instruments; Colt Group Ltd; Abcam; Camnutra; Heartfelt Technologies.

When the pair met Eddie, the firm was still very small in size and "I didn't understand why they wanted to recruit a finance director from a firm with a £100 million turnover," he says. But all soon became clear: Abcam wanted to sell their antibodies via the (then relatively new) phenomenon of the internet. They needed to raise some money to do that, so the founders were looking for a finance director "with grey hair and demonstrable business experience" to help them win over investors. Eddie jumped at the chance to return to Cambridge. "My wife Ruth and I had met here in Cambridge and we both loved it. So we thought it was a great opportunity to come back."

He took up his post at Abcam in early 2000. But the firm's initial attempts to get backing proved unsuccessful. "We walked the streets of London, seeing loads of venture capital firms – and not one would touch us," Eddie recalls. "The dotcom bubble had just burst and nobody was interested in an internet-based business." They came back to Cambridge where they managed to raise £300,000 from local business angels instead, and the rest – as they say – is history. Today, Abcam is one of Cambridge's greatest business successes. It sells over 100,000 biological research products to life scientists in 140 countries and is valued at over £2.2 billion.

Entrepreneur turns investor
Following Abcam's flotation, Jonathan Milner turned business angel, investing in start-ups to help them out, in the way others had invested in him. He became the chairman of, and an investor in, CTC and Eddie joined him in putting money in. After CTC was taken over, and Shamus approached him about investing in Heartfelt, Eddie readily agreed. "I was looking for something else to get involved in. I thought Heartfelt's concept was a good one and worth investing in," he says. "And I knew the entrepreneurs."

As they sit at an office table together, it's clear that Eddie and Shamus have a good working relationship. They swap banter, with Eddie telling Shamus "not to listen" while he describes how Shamus sometimes over-complicates his pitch, and Shamus in turn cheerfully describing Eddie as "a bit awkward".

"In fact, within the Cambridge business angel community he's well known for it," Shamus adds, while Eddie nods in agreement. "He's certainly turned up at meetings, heckling and asking difficult questions. But that's what we need, and it's helped knock us into shape. I'd rather have Eddie in private spotting the holes in our plan, or telling me when my talk gets overly technical, than have someone do it in public."

Curriculum Vitae: Shamus Husheer

Born:
New Zealand, 1976

Education:
Waikato University 1995-98, BSc (Tech); Otago University 1999-2001, MSc; Hughes Hall 2002 - 2007, PhD

Start-ups:
mo.jo; Sonnet Models; Cambridge Temperature Concepts; Heartfelt Technologies.

Being a critical friend
But clearly they also respect each other. As well as playing the vital role of 'critical friend', Eddie has helped Heartfelt in a number of ways. He's encouraged them to be financially prudent, which is why Heartfelt is repurposing existing technology as it develops its monitor, rather than building it all from scratch. "And all credit to him and his co-founders," Eddie says. "We raised £1.1 million and they've operated for four years on it and have got about 90 per cent of the way there." A trade sale of Heartfelt in the next couple of years to a large medical technology firm looks increasingly likely, and potential candidates are already expressing interest.

Shamus in turn is grateful for Eddie's many forms of support, including "opening his contacts book for us – and getting friends to open theirs." As Shamus says, "If he can't answer our questions, he knows other people who can." And in turn, Shamus himself is taking what he's learned and passing it on to others, including students and postdocs in this department. He's on the board of SensorHut, a gas detection sensor company set up by Tanya Hutter (pictured above) when she was a research fellow in this department.


SensorHut founder Tanya Hutter

With other budding entrepreneurs here, Shamus provides a critical perspective on business plans and encourages them to keep their pitch simple.

"Eddie's sat there often enough with a glazed look on his face, saying it to me," he laughs. "Now I'm the one saying it to them!"

The vital research legacy Chris Dobson left us

Colleagues of the late Chris Dobson, Professors Tuomas Knowles (*left*) and Michele Vendruscolo (*right*) in the Chemistry of Health building.

With the death of Professor Sir Chris Dobson in September, we lost a brilliant scientist committed to tackling the scourge of neurodegenerative diseases like Alzheimer's. But though he has gone, his vital work lives on inside our Chemistry of Health building and Una Finlay Laboratory – a state-of-the-art facility for studying neurodegenerative disorders that Chris helped set up. It is enabling researchers to advance our understanding of the deviant proteins that cause these diseases, and develop tools for their early diagnosis. Meanwhile Wren Therapeutics, a spin-out in the building's incubator, is developing new drug discovery methods and preparing new drug targets for clinical trials. Rachel Gardner visits the building, and meets the Cambridge alumnus with a special reason for supporting it.

Sitting in King's College Chapel in the autumn of 2015, listening to Professor Chris Dobson describe his group's world-leading research into neurodegenerative disorders, Derek Finlay *(Emmanuel, 1952)* had a eureka moment.

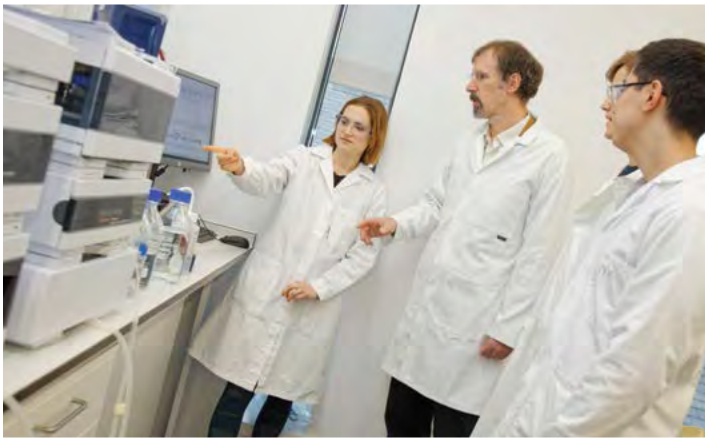
At home in Perthshire, his adored wife Una was seriously ill with Alzheimer's disease. The incurable disorder was taking its toll both on her and her family. Yet here in his *alma mater*, scientists were making breakthroughs in understanding the underlying causes of such diseases and talking optimistically about finding ways to treat them. "When I heard Chris Dobson outlining his hopes for what they might achieve, I thought to myself, 'I have to meet that man', " Derek says. "I wanted to find out more about what he and his team were doing and the prospects for their research."

And so began a relationship between Derek – an alumnus of Emmanuel College, where he had studied Law – and the Department of Chemistry. Soon Derek was being invited into Lensfield Road to hear presentations from Chris and his colleagues Professors Michele Vendruscolo and Tuomas

Knowles. The three co-directors of our Centre for Misfolding Diseases talked to him about their research into protein misfolding and its role in neurodegenerative diseases such as Alzheimer's, Parkinson's, Huntington's and motor neurone diseases.

As a lawyer, rather than a scientist, some of the terms they used were unfamiliar to Derek. He nonetheless found the meeting an eye-opener. "What struck me," he recalls, "was the very distinct nuance to the conversation. I was used to talking to doctors about the illness. But among chemists there was a completely different focus on where the answers might lie."

As Tuomas Knowles explains now, that different focus is entirely deliberate. "It has become clear that the way diseases have been classified in the past, based purely on descriptions of their symptoms, does not always map onto what's actually happening in the body," he says.



The Vendruscolo research group at work in the Chemistry of Health building.

"Protein misfolding diseases – such as Alzheimer's, Type 2 diabetes, or the eye condition macular degeneration – used to be considered as different diseases because they start in different parts of the brain, affect various organs in the body and progress at diverse speeds. But over the last 15 years or so, researchers have recognised what Chris Dobson had long been advocating: that at a molecular level these disorders display striking similarities." And that brings the tantalising potential, he says, that unlocking the answer to one disorder will unlock answers to others as well.

Making a difference

Derek Finlay was so intrigued to hear about this work, and so hopeful it could benefit patients suffering from these devastating illnesses, that he donated £5 million to the Chemistry of Health building. This very generous act of private philanthropy, along with industrial and charity investment and public funding from the UK Research Partnership Investment Fund, played a key role in making the building possible. And the building is now fulfilling several vital functions. It gives the Centre for Misfolding Diseases the physical base that it lacked before. Unusually, it also houses a business incubator that will help translate findings from the research into clinical and commercial applications. (It is currently almost unique within the University to have an incubator embedded within a department.) Our Molecular Production and Characterisation Centre is also there, providing an array of modern biological and bio-physical facilities to the researchers.

Mr Finlay and his family were present for the building's official opening in September last year, and for the unveiling of the special memorial within it to his late wife Una, who sadly died in May 2016. In honour of Una, and in recognition of her interests in healthcare (she had been a long-term and much-valued volunteer for Macmillan Cancer Support), the main laboratory is named the Una Finlay Laboratory. A plaque on the wall bears a photo and information about Una, reminding everyone of the purpose of the work going on in the lab.

Personal motivations for the research

Such reminders of the huge societal problem created by Alzheimer's provide real motivation to the researchers, says Tuomas Knowles. He is using his expertise in physical chemistry to develop new approaches for detecting and studying the aberrant proteins that cause Alzheimer's disease and other misfolding disorders. Being able to find, identify and understand them would help us diagnose these diseases in patients much earlier, and that would be a vital breakthrough.

"Diseases like Alzheimer's can be in the body for up to 10 years before patients develop symptoms, and by then it's too late for us to be able to treat them effectively," he says. "That's most likely one of the reasons why we've seen several high-profile drugs trials failing recently.

"In all the protein-misfolding diseases, there are these really problematic species of aberrant proteins – transient oligomers – that lead to the downstream biological problems. They are very small and in many cases very short-lived and we've hit a roadblock in detecting and targeting them. We've got as far as we reasonably can with conventional methods. That's why we're now pushing new types of technologies that are sensitive enough to detect them."

And the building's advantage is that it brings together in one place a wide range of chemistry aimed at doing just that, from Tuomas's physical chemistry approach (quantitative characterisation of protein behaviour), to the protein science approach (working to understand the way the disease behaves at a molecular level), to the biological chemists' approach of understanding how the disease links with biological function. "We think that to really make progress on a problem this big, we have to take all these approaches into account," Tuomas says.

"My colleague Michele Vendruscolo has done some fantastic research into trying to develop specific antibodies that can detect particular types of conformations," he adds. This work includes rationally designing antibodies so that they bind to regions of the aberrant proteins, revealing their numbers and positions for diagnostic applications, or stopping them from killing cells for therapeutic interventions. Research on this was published earlier this year in *Nature Communication* (and reported in the spring 2019 issue of *Chem@Cam*).

The study showed that the smaller protein aggregates that can permeate the cell membrane can be inhibited by antibodies that bind to the C-terminal region of amyloid-beta, and that slightly larger protein aggregates that cause an inflammatory response in brain cells called microglia can be stopped by antibodies that target the N-terminal region of amyloid-beta. It argued for a wider approach to treating Alzheimer's and suggested that instead of looking for a single 'magic bullet', it would likely take a cocktail of therapies to treat the disease.

New collaborations coming forward

This was a collaborative study involving other researchers in the Chemistry Department and across the University, including the Department of Veterinary Medicine, the Cavendish Laboratory and UK Dementia Research Institute. And there are new potential collaborators coming forward now, says Professor Vendruscolo, as a result of having the new building, a highly visible location for the Centre for Misfolding Diseases.

"We've got as far as we reasonably can with conventional methods. That's why we're now pushing new technologies sensitive enough to detect the really problematic species." ***Tuomas Knowles***

"The building's greatest impact has been to provide us with a place to realise our vision for developing biophysical methods for understanding and treating protein misfolding diseases," he says. "It is also proving key in giving to our work a visibility that it did not have before, to everyone from funding bodies to private investors and to the general public. This is also greatly helping us with our recruitment of PhD students and postdocs, the researchers who are going to drive this work forward in the future."

And that is also good news as investment and collaboration are vital in translating research findings into treatments.

***Above*, Derek Finlay and his daughter Fiona (centre) at the formal opening of the Chemistry of Health building. They are flanked by the Vice-Chancellor Professor Stephen Toope (far left) and Chris Dobson (far right), and by Dame Fiona Reynolds, Master of Emmanuel College, and Lord Wilson of Dinton, former Master of Emmanuel College.**

Tuomas Knowles is making accessible to the wider biological and biomedical community the tools and approaches based on laminar flow microfluidics through a startup company, Fluidic Analytics.

Meanwhile Wren Therapeutics, the spin-out business based in the building's incubator, is developing an innovative drug discovery method based on chemical kinetics, and indeed new drug molecules that may go into clinical trials next year. And having such work take place in the same location as the initial research was carried out is really beneficial, says Michele Vendruscolo.

"Publishing a paper with a proof of principle is the first key step, but it is then even more challenging to use that research to generate actual products. Our vision is to generate a seamless transition from the academic research. When industry partners take academic research forward, it may not be straightforward – the transmission of the know-how, and the change of personnel and lab standards, is inevitably problematic. But when there is a closer link between the industry partner and the academic research, that leads to a smoother, and ultimately more successful, process."

Derek Finlay is hopeful of progress. Una's death, just a few weeks short of their 60th wedding anniversary, was a devastating blow to him and his family. Una had always travelled with him and supported him when his work in the food industry took him around the world, setting up a home for the family in whichever city they found themselves. "We had great times," he says. "She was very tolerant of moving from one country to another and though it was hard work, she always made it fun. I was very lucky to have her." So for him the opening of the building, and the unveiling of the lab named after her, were "a very special and poignant day for me and my family".

They all hope, he adds, that the discoveries made here will help transform the lives of those suffering, now and in the future, from neurodegenerative disorders and that the opportunities the building offers for complementary research approaches, and for researchers and industrial partners to work together more closely, "will speed up the search for ways to delay, ameliorate and ultimately abolish these dreadful neurodegenerative diseases."

- *The visibility of the research taking place in the Chemistry of Health building has led to an increase in the numbers of graduate students applying to do their PhDs here. PhD students are the researchers of the future, but the decline in funding for their studies means we can't fund all of the many talented individuals who apply here. If you would like to know more about ways to support research studentships here, or setting up joint studentships in Chemistry at your own college, please contact chemhod@hermes.cam.ac.uk*

"Why I take part in this research."

As a researcher in both the Knowles and Dobson groups, Dr Emma Yates Sukdao has had a strong personal motivation for her work.

Her original interest in the chemistry of health, she explains, stemmed from witnessing her father's struggles with bipolar disorder, which could not be effectively managed with medications. That led her into creating systems to measure the interactions between proteins that take place in the body, and the effects – and potential side-effects – that can happen when a protein is targeted by a drug.

During her PhD she developed a new system to measure these interactions, with an eye on developing drugs that produce fewer side-effects. She has also worked on new tools to probe the attributes of the aberrant proteins that kill cells in patients with Parkinson's and Alzheimer's diseases.

As a Research Fellow at Emmanuel College (where Derek Finlay was a student), she has had the opportunity to meet him at a college event. And like him, she has seen the impact of dementia at first hand.

"My grandfather had Dementia with Lewy bodies," she explains, "and seeing my grandmother caring for him really impressed on me how much we need innovation in treatments. Alois Alzheimer first described Alzheimer's disease as long ago as 1906, but there are still no drugs on the market that can halt the progression of the disease – all we can really do at the moment is mask the symptoms. We have to develop basic compounds that can impact the mechanism of the disease."

Having a purpose-built facility, she says, really helps to support the science that goes into this work. Since she arrived in 2011, the number of researchers working on misfolding diseases has expanded considerably. "And that makes it harder to do good science. Certain instruments require a particular set-up in order to ensure the quality of the data they produce, but it's hard to insulate an atomic force microscope appropriately if everyone is walking past it. So it's great," she says, "to have this new facility where there is more space and everything is so well thought out."

Noticeboard

Awards

Recognising research 'of international impact'
Dr Silvia Vignolini has been awarded a Philip Leverhulme prize, an honour for early-career researchers whose work has had international impact and whose future career is exceptionally promising.

Silvia researches bio-inspired optical materials. Her group investigates how colour is produced in nature through complex structures, and works to recreate these processes in the lab through bio-mimetic materials that produce brilliant and striking colours without chemical pigmentation.

Her researchers have been using cellulose as a new photonic material to develop structures with vivid colours or that appear ultra-white, without environmentally damaging or high-cost additives. "I am very happy," she says. "The prize will help my group continue our search to understand how polysaccharides like cellulose create hierarchical structures in cell walls."

PhD student's prize-winning anti-counterfeit work
Theoretical Chemistry PhD student David Izuogu is part of the IsoTagiT team that won the 2019 Trinity Bradfield Prize (for researchers keen to commercialise their work). They are building a unique anti-counterfeit technology to combat fake goods and components, using a solution that combines blockchain, organic chemistry and spectroscopy to create a unique signature. David says: "Counterfeits pose genuine, global safety concerns – the WHO estimates that one in 10 medical products in developing countries are illegitimate, contributing to hundreds of thousands of deaths a year. And within electronics, illicit semiconductors have infiltrated legitimate supply chains of the military, aviation and medical sectors, so there is an absolute need for semiconductors of known provenance." IsoTagiT will now work with the Bradfield Centre at Cambridge Science Park on commercialising their technology.

Alumni become staff
Two alumni who completed their PhDs here became members of academic staff in October. Dr Alexander Forse – who completed his PhD under the supervision of Professor Clare Grey – joined as a lecturer in Materials Chemistry. Alex came to us from the University of California at Berkeley where he was a Philomathia Research Fellow. His work is focused on understanding and improving materials that can reduce greenhouse gas emissions and tackle global warming.

Dr Alex Thom – whose PhD here was supervised by Professor Ali Alavi – became a lecturer in Theoretical Chemistry. He focuses on Theoretical and Computational Chemistry, specializing in method and software development. Alex has held a Royal Society University Research Fellowship in this Department since 2012. He also spent a period at the University of California at Berkeley working with Professor Martin Head-Gordon.

Aaron wins Reaxys Prize
Congratulations to recent graduate student Aaron Trowbridge: he was one of three winners of the prestigious 2019 Reaxys PhD Prize, which celebrates outstanding research by young chemists worldwide. The prize is awarded annually by Elsevier. Aaron studied for his PhD with the Gaunt group here, where his work also won a departmental 'Outstanding Thesis' award. He is now a postdoc in the Macmillan Group at Princeton.

Appointments

Welcoming Chiara
Dr Chiara Giorio, currently tenure-track Assistant Professor at the University of Padua, will be joining us on 1 March 2020 as a new lecturer in Atmospheric Chemistry. It is a return to the UK for her, since she followed her bachelor's degree and PhD (both from Padua) with a stint here as a postdoctoral researcher up to the end of 2016. We look forward to welcoming her back to the department.

Women in Chemistry

Josie Gaynord

Josie Gaynord is a PhD candidate here under the supervision of Professor David Spring. Her research looks at one of the biggest problems threatening global public health: antimicrobial resistance.

My research sets out to develop new types of antibiotics. Antimicrobial resistance is a global concern at the moment which could threaten public health and food provision as bacteria can develop resistance quickly to common antibiotics. My research is looking at creating new antibiotics which combine old and new drugs with different mechanisms of actions to try and prevent resistance from developing.

As a chemist, I am constantly amazed by biology. Some of my research is looking into creating new drugs for blood-related diseases, and recently I was able to spend the day looking at blood cells through a microscope – this might not sound very interesting but being able to see it all with my own eyes was incredible and not something you're able to do day-to-day as a chemist. I want to improve healthcare and this helps spur me on when nothing is working. I think it's important for all scientists to keep in mind why we want to do our research, and why it is important. I hope my research will lead to at least one drug which is more effective, or has fewer side effects, that what is currently available to patients.

My work is laboratory-based – I spend the majority of my time synthesising biologically-relevant compounds. To test these, I visit groups or institutions that the Spring Group has collaborations with, including other departments, other universities and industrial pharmaceutical companies (all within Cambridge). I also have a collaborative research project with a group at the Technical University of Denmark, so have travelled there in the past. It's always a great moment when I finally manage to make a compound that I've been working on for months. After trying again and again, it's such a good feeling when the hard work pays off.

I am lucky that I am surrounded by amazing, inspirational and nurturing women who are there to help me and prove that women can succeed in STEMM. Having mentors and strong female friendships within your field is very important.

You should always be ambitious and work towards your goals, but remember to give back. Do every outreach, public speaking and wider-engagement event you are offered, because representation is one of the most important things. Subconsciously, young girls will never believe that they can be successful if women in STEMM are not visible.

- *This story, by Sarah Collins, first appeared on the University website as part of their 'Women in STEM' series.*

Tamsin Newlove

Tamsin Newlove was 15 when she obtained her Maths A Level, and 17 when she won a Roentgenium Award (the highest award) in the Cambridge Chemistry Challenge. Along with the other winners, she was invited to a Chemistry summer school here – an experience that encouraged this Southampton state school student to apply to Cambridge for Natural Sciences. She is now a fourth-year undergraduate here, working towards her MSci.

I have always enjoyed science. Perhaps I get that from Mum who used to be a nurse and was very good at maths and science. My sister studied science subjects too and that spurred me on, because we're only one school year apart and quite competitive!

I was given a lot of support by my school and sixth form college. Both took part in outreach events to encourage our interest in science. I remember some university students bringing a planetarium into our school, and I did a trip to the Chemistry Department at Southampton University with my sixth form college. It was a large college with a good science department, so it had the resources and advisers to support students like me who wanted to apply to Oxbridge.

I've now been here three years and this summer I did a project with the Grey Group where they study the nature of solid-state materials that have applications in supercapacitors, fuel cells, and batteries. Before it came to applying for a job or PhD, I wanted to get some experience in a research lab to work out if it was something I'd want to do in the future. I spent eight weeks researching the solid electrolyte interphase (SEI) in symmetric Li/Li cells. The SEI acts as a barrier between the electrolyte solution and the electrode, so it plays a major role in battery performance, determining important factors such as lifespan and safety.

It's hard to analyse as it's only a thin layer and is trapped at the interface. I was trying to characterise it by looking at ways to simulate its properties. The idea was to take a polymer, cast it with a salt, and investigate the way in which it conducts, and what happens to its conduction if you bring in other additives.

It was a great learning experience as it was very different from what I did in my BA. I had never worked with polymers before – because it's not something you do as an undergraduate – so for me that was really interesting. And previously I'd only used solution NMR spectrometry to analyse organic compounds and assign the resultant peaks. The Grey Group does a lot of work in solid state NMR, which is quite different, and they investigate other nuclei alongside carbon and proton. I experienced many other techniques that were new to me, such as using a 'glove box' under an argon atmosphere (when I was working with lithium) and doing impedance spectroscopy.

The funding for my summer project came from a donation given by an alumnus and I am very grateful for his generosity. Cambridge is an expensive place to stay and without the funding, I wouldn't have been able to do this project. It was a great opportunity and I feel I learned a great deal in a short space of time. It also helped me discover how much I enjoy research and made me think more about applying for a PhD.

- **We are grateful to alumnus Dr Robert Perrin (King's College, 1948) for his recent donation to support summer projects including Tamsin's. These projects give undergraduates valuable laboratory experience, expose them to new areas of science, and help them understand how the chemistry they study is applied in practice. We have more demand from students than we can currently meet, so if you too would like to fund a project, please contact our Head of Department, Dr James Keeler: chemhod@hermes.cam.ac.uk**

Building the timber towers of tomorrow

For the last five years, Professor Oren Scherman has spent his Monday afternoons with the other researchers in Cambridge's Centre for Natural Materials Innovation, discussing the challenge of building skyscrapers. Out of wood.

Thanks to recent innovations in engineered timber, low-level timber buildings are being constructed in cities round the world, using cross-laminated wooden panels similar in strength to reinforced concrete slabs. Dr Michael Ramage from the Department of Architecture who heads the Centre argues that the environmental benefits of sustainable timber buildings are huge. "In England alone, we need to build 340,000 new homes each year over the next 12 years to accommodate our population," he says. "Concrete is unsustainable. Timber is a building material we can grow, and it reduces carbon dioxide. Every tonne of timber expunges 1.8 tonnes of carbon dioxide from the atmosphere."

He and the project researchers – drawn from disciplines as diverse as chemistry and architecture, plant sciences and theoretical physics – are eager to see the world's first wooden skyscrapers. They have produced a concept design for the first 300 metre timber building (the Oakwood Tower) in London's Barbican. During this Leverhulme Trust-funded project, they have been tackling the wide range of challenges its construction would involve. So while architecture students have looked (among other things) at how a skyscraper would be affected by high winds when it's constructed from a much lighter material than reinforced concrete, our chemists have been involved at a much lower level – quite literally. "Our expertise is not in the construction of the building but the structure of the wood," says Oren, Director of the Melville Lab for Polymer Synthesis. "We've been looking at timber at the molecular level and at chemical transformations that could strengthen it – such as impregnating it or bulking it out, with synthetic materials."

Oren Scherman helps a young visitor investigate the structure of wood at our Chemistry Open Day last March.

They've also been working with plant biologists and colleagues in biochemistry on how some of the different components of wood – cellulose, hemicelluloses and other structures – fit together. "We're interested in genetic modifications that could be made before the trees are planted that would change the properties of the timber in ways that could be beneficial when it's used as a construction material."

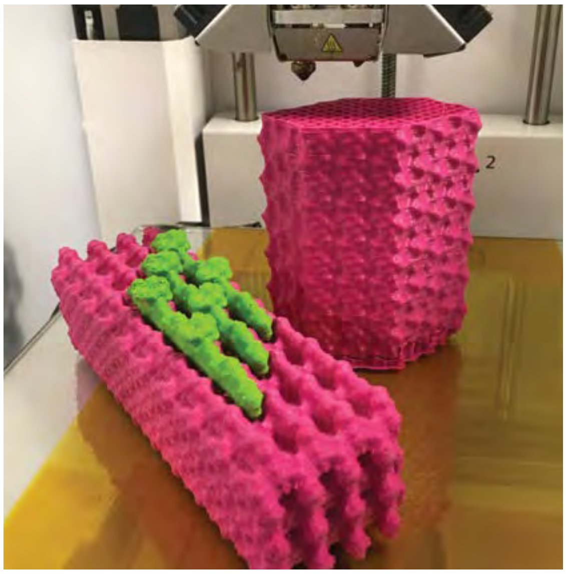
Overcoming constraints

Attractive though timber is as an alternative construction material, it has some limitations. Fire risk is always a primary safety concern. "There's a public perception that fire is the key risk with wood, but in fact if you try to burn a solid piece of wood – like a panel of engineered timber – you will see it doesn't just go up in flames," Oren says. "Instead a layer of char forms on the surface of the timber and this has insulative properties, making it highly protective of the wood beneath that layer."

However, enhancing timber's flame retardancy further is essential, so researchers experimented with embedding graphene in a composite material to use as a coating on timber buildings. "Graphene is a very good thermal-conducting layer," explains postdoc Guanglu Wu, who works in Oren's group here in the Melville Lab. "When we use it as a coating layer, it can disperse the heat much faster than normal coating layers. So it can become a protecting layer."

At the other end of the spectrum, protecting timber against damp is equally important. Recently Guanglu and his collaborators from Imperial College London have been investigating how liquid behaves when it's entered the

Images: courtesy of the Centre for Natural Material Innovation



Above left: how the Oakwood Tower would look as part of the London skyline. Above right: models of how the components of wood fit together, used at the Timber Towers stand at the Royal Society Summer Exhibition.

wood. "We're trying to better understand the way in which fluids diffuse along the grain or channels in the wood," he explains. To do this, water was injected into a piece of timber and then CT scans were taken to build up a picture of how the water diffused through the timber over time.

As it happens, the Melville Lab has had an involvement with the science of protecting timber for some time, through some work on the preservation of Henry VIII's warship, the *Mary Rose*. Raised from the sea after more than 400 years, the ship's wooden hull was housed in a museum in Portsmouth, but the timbers were so delicate they could not support their own weight. Part of the preservation entailed spraying them with low-molecular-weight polyethylene glycol (PEG) to replace the water in the cellular structure of the wood as it dried out to stop the wood crumbling.

But as the researchers learned, this kind of impregnation treatment is not straightforward. "It's a problem of diffusion: if you take a pre-formed polymer, even if it's a fairly short chain polymer, it's not going to readily diffuse through a fairly thick timber, or a set of timbers, Oren says. "One solution is to use a variety of short PEG chain lengths: as the chains get smaller, so they diffuse through the timber a little bit more." But it would be even better to stop damp from penetrating the timber in the first place because that, and the resulting rot, changes the structural integrity of the material. So he and colleagues have also been looking at the impregnation treatments like those used in Accoya, a commercially available modified timber in which the process of acetylation enables it to resist rot.

Wood contains chemical groups called hydroxyls that absorb and release water. When it is treated with acetic anhydride, and the hydroxyl groups are transformed to acetyl groups, the ability of the wood to absorb water is greatly reduced. "When you acetylate them, you change their surface functionality, changing their hydrophilicity into hydrophobicity. And that is critical because it stops dry rot and waterlogging," Oren says. This research was showcased at the Royal Society Summer Exhibition in July, where visitors could see how efficiently treating timber in this way stops water soaking into it.

Molecular interactions instead of glue and nails

That's why he is interested in exploring the molecular interactions within timber. And he hopes they may yet bring about some truly exciting possibilities for timber construction. "The buildings of the future may be held together through many non-covalent interactions happening at the molecular level, enabling stress dissipation. Perhaps in future, we'll be able to remove the concept of a nail or a screw holding two timber joints together and instead, this will all be done through small molecules that complex together at very specific interfaces and give the wood unbelievable strength."

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See the Royal Society, Economist and University of Cambridge videos on this project on our YouTube channel at: https://shorturl.at/clKW5

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

Please note, letters may be edited for reasons of length.

Correspondence

Our research into the hardening of arteries welcomed by alumni

In the Summer Chem@Cam email, we shared the news that research co-led by this department had identified the mechanism behind the hardening of the arteries. It also showed in animal studies that an antibiotic widely prescribed for acne could be an effective treatment. Alumni welcomed the news.

From Ian Potts (St Catharine's, 1962-5)
"The article on artery hardening came at an opportune time for this 75-year-old. It's good that minocycline has been shown to have no deleterious effect on bone formation. Well done to the researchers. I also like the name Cycle Pharmaceuticals – connecting both with cyclic sites in molecules and with bicycles in Cambridge."

Professor Melinda Duer, who co-led the research with Professor Cathy Shanahan at King's College London, replied: "Thank you very much! It's really heartening to receive messages like this."

A researcher's age is irrelevant

The Summer Chem@Cam email also included an invitation to the Alumni Wine Tasting in September. This year, we asked some students to come to the event and talk about their research to any interested alumni. We described them as 'young researchers' – a phrase one correspondent asked us to reconsider.

From Charlotte Dodson
"Can I ask you to think about your use of the phrase 'young researchers' in the advertising for the Alumni Wine Tasting? Presumably these researchers are not selected because they are young, but because they are PhD students, postdocs, or possibly early career research fellows and lecturers. Even if they were selected on the basis of their age, why is this relevant in a professional context? (In my view, it comes close to objectifying them.) The use of 'young' often implies 'junior', but in many careers, those in their 20s and 30s are considered to be professionals with 5-20 years of experience. Please choose attributes of your volunteers that are relevant to the event, e.g. 'Some of our researchers from across the department...' or 'Some of our PhD students...' etc. "

Event organiser Diane Harris replied:
"We wanted to make it clear that the researchers presenting their work were at the beginning of their career, so our alumni would not be expecting more senior academics. But I take the point completely that there was no need to use the word 'young'. In fact, although we had invited PhD students to present posters, we can have PhD students who have returned to their studies after a career break, or after pursuing a different career. So on reflection it would have been better to refer to them simply as 'PhD students'. We'll keep this in mind in future."

- *If you don't receive the Summer e-Chem@Cam – or emails inviting you to Chemistry Alumni events – and you would like to do so, please visit the University of Cambridge Alumni website (www.alumni.cam.ac.uk/contact/update-your-details) and update your contact preferences to ensure you can receive news and events emails from us.*

Congratulations to our competition winner
The winner of the 'Guess who..?' competition in the last issue (when we asked you to to identify the faces in a 1972-3 departmental photo) was Martin Levy, who was a Theoretical Chemistry research student here from 1970 to 1973. You can see the photo and the names of those who appeared in it on our Alumni website at: www.ch.cam.ac.uk/alumni/

Alumni Postcard

Fay Hartley (Girton, 1965-8)

Greetings from Glossop...
I've returned here from a caving trip to the Vercors Regional Nature Park in south-east France where I survived caving, canyoning and via ferratas ('iron paths' or protected climbing ways), including in the extremely frightening lower Écouges Gorge. I'm a keen potholer and caver.


Image: courtesy of John Duxbury.

I got into caving after reading Natural Sciences at Girton
where I obtained my BA in June 1968 and MA three years later. After my MA, I did a PhD in '*The reaction kinetics of transition metal complexes with gases in solution*' at Aston University with Dr David Miller, who had left Cambridge. It was kind Prof Émeleus – taking pity on me after I had burst into tears at a recruitment interview with ICI! – who got me the job of research assistant with Dr Miller. I was his first research student.

My family ran a pharmacy founded by my grandfather
In order to enter the family business, I then went on to Manchester University and got a first in Pharmacy. A friend who was at Leeds University discovered caving at this time and told me how much she enjoyed it. So on her recommendation, I joined the Manchester University Speleological Society. It was the golden age of cave exploration in the Yorkshire Dales and many discoveries were made in the extensive Three Counties system, such as the Manchester Bypass and the Mancunian Way. I subsequently made contact with the Cambridge University Caving Club and went on caving expeditions with them.

From pills to potholing
A few years ago I sold the pharmacy and have since written a book – *A Glossop Apothecary* – about it. The pharmacy had existed since 1838 and early customers included the 12th Duke of Norfolk. The 19th century entries in the prescription book illustrate the vanishing art of the apothecary, with pills specially formulated for the aristocracy, their estate agents and entourage. Medicines included pills for gout, and draughts for constipation and alcohol-induced eczema. The book also features adverts for bronchial elixirs, and recipes for potions to make hens lay bigger eggs and for diabetic and epileptic dogs. *(If interested, you can find out how to get a copy on the Chemistry alumni website at www.ch.cam.ac.uk/alumni/alumni-postcard-caving)*

Tackling battery degradation

Grey Group

Meet PhD student Haydn Francis. For his research project, he is investigating new technologies that could slow the degradation of electric vehicle batteries.

Haydn is working with Professor Clare Grey on the Battery 'Degradation' project – a search for ways to improve the performance and reliability of batteries so the electric vehicles that use them can travel further, and for longer, before they need recharging.

"As an electric vehicle battery degrades, you lose the amount of distance you can cover. We need to fully understand degradation and find ways to slow it down."

As Haydn explains, 'degradation' is the term used to describe all the processes that lead a battery's performance to decrease over its lifetime. "When your phone is fresh out of the box and you charge it for the first time, you get a nice long battery life," he says. "But by the fiftieth time you charge it, it runs out before you expect.

"On a mobile phone, this is annoying. But when it comes to an electric vehicle, battery degradation means you are losing the amount of distance you can cover. So it's really important that we target a full understanding of battery degradation so we can use materials, and build in measures, to slow these processes down as much as possible."

His four-year PhD programme – and the Battery 'Degradation' Project – is being funded by the Faraday Institution, an independent institute supporting electrochemical energy storage research. They recently produced an outreach video featuring Haydn to explain what they are doing in this project and why they support PhD researchers.

The project is important, Haydn says, as the science of battery operation is much more complex than many people appreciate. "In fact the number of ways a battery can degrade is so numerous, it's a bit of a miracle they work at all!" In his project, he is looking for ways to track the degradation of batteries in real time while they're in operation.

"If we could do that, it would give us more clues about the exact mechanisms of battery degradation," he says, "and it could be used as a diagnostic tool – so you could get an instant reading of the health of your battery. This means that if your battery is in an operating electric vehicle, you can adjust how the battery is operated. And at the end of its life, you can tell what kind of second-life application it might be useful for."

One way of measuring a battery's degradation is by tracking the depletion of lithium within it. "Lithium is the currency in which batteries operate," Haydn says. "It is the lithium ion that is being passed from one electrode to another during a battery's operation."

Doing this inside a car while it's travelling is currently challenging. So Haydn is experimenting with making fluorescent molecules whose light emission changes when they interact with lithium. "If you have an electrolyte solution containing lithium ions inside the battery," he says, "you can measure how much lithium there is by tracking how much the light signal from the molecule changes. That's because the interaction of the molecule with lithium is dependent on the concentration of lithium in the solution."

Haydn is enjoying his research. "It's pretty amazing to be doing this," he says, "because there aren't that many projects that would offer me the chance to combine my interests in organic chemistry and energy storage." He is being co-supervised in this project by Professor Grey and Dr Hugo Bronstein.

Encouraging BAME students to study science

He is also enjoying the opportunities offered by the Faraday Institution programme to promote science in schools and encourage more BAME students to study science.

"I've never felt that there was a barrier stopping me," Haydn says. "But I was at one outreach event in London when a Master's student told me she was excited to meet me because 'I've never seen anyone who looks like me doing a PhD'. She was at a UK university, hoping to go on to a PhD, but hadn't seen anyone from her ethnic background pursuing postgraduate study at her institution.

"That was an eye-opener," he adds. "There may not be physical barriers stoppping BAME students from pursuing science. But there aren't yet enough visible role models to show them the route is open to them."

- See the Faraday Institution video featuring Haydn at https://youtu.be/u4jnVFFNKNc

"A Master's student told me she wanted to go on to a PhD, but hadn't seen anyone from her ethnic background pursuing postgraduate study at her university."

Vijay's long journey

Growing up in poverty in rural India, Vijay Rana almost didn't get an education. "My mum and dad never went to school themselves, and it was a real struggle for them to find the money to educate me," he says. But by borrowing from family and friends, they managed to put him through school – where he first discovered his love of Chemistry – and then university. Today, helped by bursaries that helped him get to ETH Zurich and then here to Cambridge, Dr Vijay Rana is working as a postdoc in the Scherman Group.

Vijay's research is in the field of supramolecular systems, focusing on colloids and hybrid supramolecular hydrogels. Colloids are emulsions where stable particles of one substance are dispersed in a solution of another. "They have different properties, but the ones I am working on can be used as photonic materials," he explains. "I've also been collaborating with Dr Silvia Vignolini and some of her postdocs to make colloidal crystals – for use in materials like crystals and glasses – that form systematic arrangements in water and keep them even when they are shaken.

"For this, the colloidal particles must be completely homogenous, all exactly the same size and with the same surface energy and surface charge. So it requires me to be very precise in synthesising them. But I'm good at that," he grins, "and I'm very persistent."

Despite its challenges, he loves the work here. "I'm living my best time ever in research," he says. And after the battle he had in India to get an education, he is seizing every opportunity here to learn. "I always had this hunger for knowledge, but I didn't have good teachers at school or college. But here, there are so many chances to expand your knowledge, from the talks by visiting lecturers, to meetings within our group where we all share our research. I love it, I'm learning so much from it."

He is also getting involved in outreach activities here, so that he can help others to learn. For it is Vijay's long-term aim to return to India and help other children from deprived backgrounds, like him, to get an education. That's why last summer he led a workshop for UK and Japanese sixth-formers in the Melville Lab. This annual UK-Japan Young Scientists' Programme (run by the Clifton Scientific Trust) has taken place in the Melville Lab for a number of years. It brings together high school students from UK and Japanese schools to gain lab experience and skills.

At the July workshop, the students were studying drug molecules in hydrogels together, analysing how different molecular structures affect the rates at which the drugs are released. Vijay, a Marie Curie Research Fellow, was there alongside them, teaching them how to use the equipment, run the experiments, and record and analyse the results. "I've been involved in the workshop in the past," he explains, "but this time I asked to lead it. I want to have more of this type of experience and improve my knowledge of how to reach out to people." He is a natural, according to the Clifton Trust's Dr Eric Albone. "He has a very good rapport with the students. You can see it."

A financial crisis

In running this workshop, Vijay is giving other children the kind of opportunity he never had himself. He comes from a village in a rural area 120 km north-east of Delhi. It's farming country, the most common crop being sugar cane. His parents, sugar-cane farmers, had never gone to school themselves, and Vijay might not have done so – particularly when a brick-making business they set up went disastrously wrong, plunging the family into debt and forcing them to sell their farm land.

But despite their financial problems, his parents recognised that Vijay had an aptitude for learning. So they borrowed from relatives and friends and sent him away to school in an isolated ashram. Sadly, it was the start of an extremely unhappy period in his life.

Vijay in the Melville Lab, below left and above, coaching students on the UK-Japan Young Scientists' Programme.

No textbooks and writing on a slate

The level of education was extremely basic. "We sat on the floor for lessons, we wrote on slates, and never had exercise books, " Vijay says. "And the teaching was poor, the teachers weren't very good at explaining things during our lessons."

He also feels he was subjected to physical and psychological abuse there. "The teachers used to beat us even for very small mistakes," he says, recalling how once a teacher hit him so hard with his shoes that he was left bleeding from wounds to the head. He and other children there were also molested by staff, and other adults, at the ashram. "The ashram was in a very isolated valley and there was no-one there to protect us. At the time I didn't know differently, I thought it was part of ashram life. But I now recognise that we were being abused," he says.

He was overjoyed when he was finally able to come home at the age of 15. But sadly, his life did not get much easier then. His family borrowed more money to send him to high school in their nearest city. "But I sometimes had to miss classes because we just couldn't afford the bus fare." He was also having to fit his studies in around the hours of unpaid work – doing cleaning, working in a shop – demanded of him by an uncle who had lent the family money. Unsurprisingly Vijay became depressed and sometimes thought of ending his life, he reveals. But school friends and family supported him and two tutors who saw how much he wanted to learn gave him extra lessons for free. With their help, he passed his high school exams and then made it through a Bachelor's and a Master's degree. His life was completely turned around when he won a bursary to ETH in Zurich, to study for a PhD, and then a mobility grant from ETH to come to Cambridge as a postdoc.

Helping poor children get an education

And now he wants to give back. "I have had good fortune, and now I'd like to do the same for others," he says. "I want to set up a school to bring children from different parts of Indian society together, where the fees the richer families paid would help make places available for poorer students who couldn't pay. I feel like if I can help one child to do equally well, or better, than me, then I will have achieved something in my life. Everything I have done so far in my life is for me. Now I want to give some good fortune to others."

'Remember how lucky you are'

And does he have any message for those whose journey to this department has been much less arduous than his? "Yes," he laughs. "It is easy to forget to say thanks for what you have or to complain about problems that are fairly small. I say, look at the people who don't have anything close to what you have and remember how lucky you are."

Scientists build first nanocage with antiaromatic walls

Nitschke Group

Researchers working in the Nitschke group here have successfully created the first self-assembled nanocage to have antiaromatic walls. In doing so, they have overturned assumptions about the limits of nano-chemical engineering and created an entirely new nanospace for scientists to explore.

Nanocages – nanometre-sized cavities – are complex, functional structures that are already being used in a range of applications in chemistry, medicine and environmental science. In the Nitschke group, researchers work to design hollow supramolecular capsules or 'cages' that can be employed to collect, transport and deliver cargoes of molecules to where they are needed. They could have a use in safely delivering drug therapies within the body, or replacing the current high-cost, high-energy processes used in chemical and petroleum refining.

But while many research teams have so far developed nanocages with aromatic walls, none have previously done so with antiaromatic compounds because of the challenges posed by their inherent instability. This changed in October this year when a team – including Dr Masahiro Yamashina of the Tokyo Institute of Technology, Professor Jonathan Nitschke here and Michael Pittelkow from the University of Copenhagen – reported in the journal *Nature* their creation of "a self-assembled cage composed of four metal ions with six identical antiaromatic walls". The work was completed while Dr Yamashina was working here as an Overseas Research Fellow of the Japan Society for the Promotion of Science.

Above: **The project team in the Nitschke Group. From left to right: Dr Tanya Ronson, Dr Masahiro Yamashina, Professor Jonathan Nitschke and Dr Roy Lavendomme.**

The breakthrough opens up new lines of research in this field. Aromaticity and antiaromaticity, as the paper explains, are fundamental concepts in chemistry and the preparation of antiaromatic molecules and the study of their properties has been of longstanding interest to chemists, but also of longstanding difficulty.

Aromaticity refers to a property of ring-shaped organic compounds that makes them highly stable, whereas antiaromaticity describes compounds that are far more reactive, due to a difference in the number of so-called π electrons shared by the ring.

"The idea of constructing an antiaromatic cage is one we have been looking at for several years," says Professor Nitschke, corresponding author on the paper. "But the synthetic process involved is extremely arduous and challenging and a previous attempt that was made here using a different method failed. Masahiro had to overcome a great many blind alleys and difficulties during this work. But he was very persistent and now that he's succeeded, he has opened a door to scientists who want to explore the area further."

The team's search for a suitable building block for their antiaromatic nanocage led them to a 2012 study by Hiroshi Shinokubo and co-workers in Japan. This study reported the synthesis of an unusually stable, nickel-based antiaromatic compound called norcorrole. Then, drawing on the expertise of Professor Nitschke and his group in sub-component self-assembly, the researchers succeeded in building a three nanometre-diameter cage with a norcorrole skeleton.

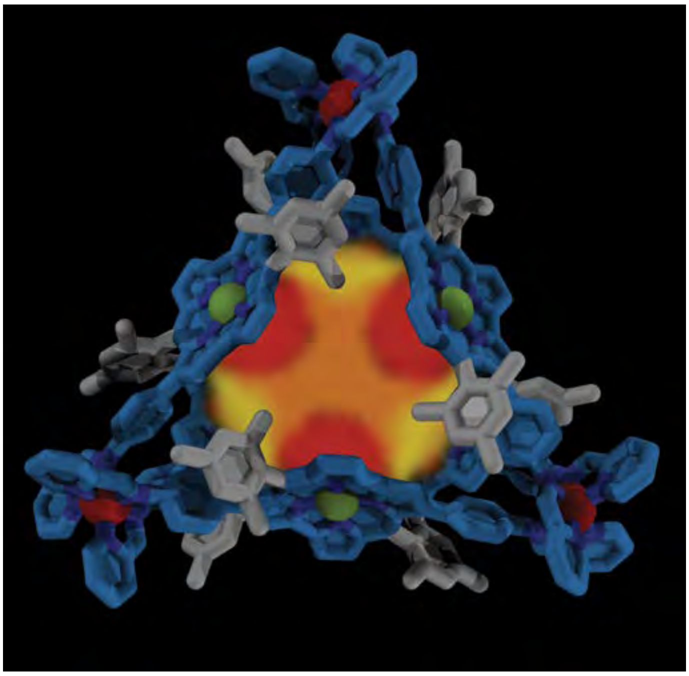
They tested the degree of antiaromaticity within the cage and the unique environment inside it. They encapsulated a number of guest molecules within this new cage and discovered, as they had predicted, that when exposed to an external magnetic field – for example, inside a nuclear magnetic resonance (NMR) spectrometer – these molecules experienced a de-shielding effect. The antiaromatic-walled cage can thus be considered a new type of NMR shift reagent, the researchers say, meaning that it could be a tool for analysing and interpreting the finest structures of organic compounds.

NMR spectroscopy is a technique used to observe local magnetic fields around atomic nuclei. The sample is placed in a magnetic field and the NMR signal is produced by excitation of the nuclei sample with radio waves into nuclear magnetic resonance. The intramolecular magnetic field around an atom in a molecule changes the resonance frequency, thus giving access to details of the electronic structure of a molecule.

"If we put a guest molecule into one of these antiaromatic cages into an NMR spectrometer," says Professor Nitschke, "it de-shields them – i.e. it moves the signals of the molecule away from where they ordinarily are, and away from where they might overlap with other signals and you can clearly see what is going on inside them.

"We have done this for fairly simple molecules. But we'd like to be able to do it for more complex molecular systems where there are a lot of signals and they tend to lie on top of one another. We have previously encapsulated proteins – which are large, complex molecules – inside aromatic cages. If we could now encapsulate a protein inside an antiaromatic cage, it would give us a much clearer picture of what is going on inside it."

"We have not been able to do this in the past. But we could now and this advance opens up a whole new space to explore."



Above: **X-ray crystal structure with a 3D NICS grid, showing magnetic deshielding experienced within the nanospace. Antiaromaticity becomes stronger in the order of yellow < orange < red color.**

References:
Masahiro Yamashina, Yuya Tanaka, Roy Lavendomme, Tanya K Ronson, Michael Pittelkow & Jonathan R Nitschke. 'An antiaromatic-walled nanospace'. *Nature* (2019). DOI: 10.1038/s41586-019-1661-x

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How you can contribute

Help us to help students

This issue highlights the importance of funding for our students.

Thanks to a gift from alumnus Dr Robert Perrin, undergraduate Tamsin Newlove was able to undertake a summer project here, broadening her research experience and furthering her interest in a PhD. Meanwhile postdoc Vijay Rana (above) reveals how his life was completely changed by the financial support he received to complete his education. But every year, we must turn down applications from highly talented individuals for studentships because of a lack of funding.

Would you like to help? You could support anything from an undergraduate summer project up to a full research studentship in Chemistry. For further details, please contact our Head of Department, Dr James Keeler: chemhod@hermes.cam.ac.uk