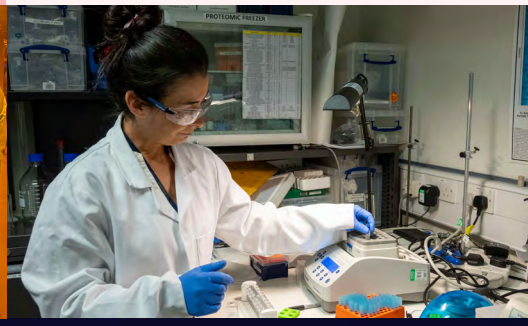
Antimicrobial awareness *p.19*

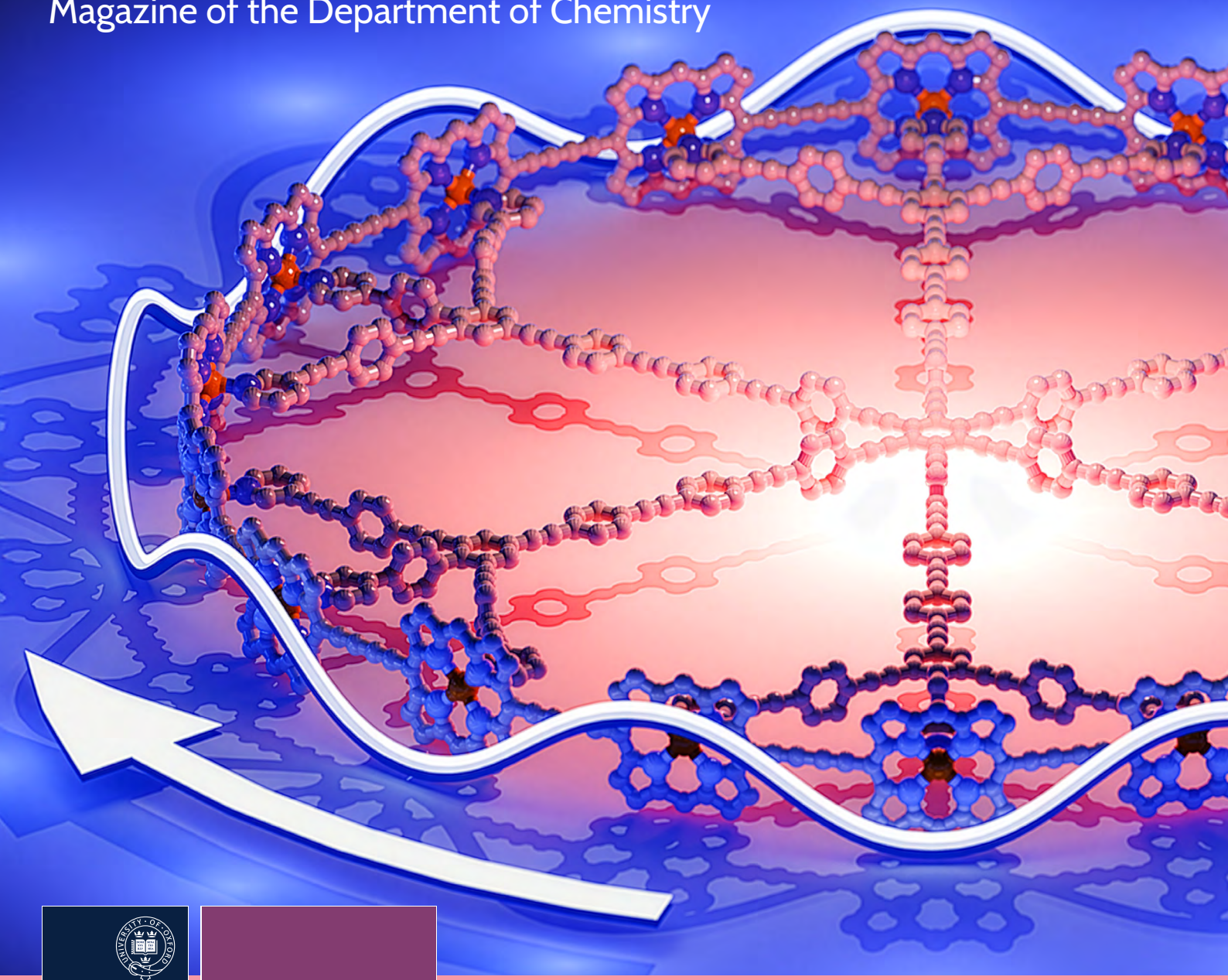
Materials for the future *p.24*

Analysing ancient chemistry *p.16*



Periodic

Magazine of the Department of Chemistry



UNIVERSITY OF OXFORD

DEPARTMENT OF CHEMISTRY

Issue 13
2025 – 26

From the Head of Department

Welcome once again to a new edition of Periodic. A year has flown by since the last issue, and the Department has been as busy as ever as we continue to focus on bringing excellence to our research and teaching.

Rising costs and uncertainties about student recruitment make these tough times for universities in general, and chemistry departments in particular, but our community has shown the imagination and creativity to succeed under pressure. I'm proud of my colleagues' collective effort to that end, which has been more successful than ever in obtaining a growing pool of grant funding, while also recruiting and training incredibly talented undergraduate and postgraduate chemists.

There isn't enough space here to detail everything happening at Oxford Chemistry – the stories in the pages of this magazine will give you a taste, and they represent the tip of a much bigger iceberg.

The purpose of an academic department is to enable individual and collective endeavour. I'm pleased that many of our staff and students' efforts have been recognised this year by prizes and awards from around the world – some are detailed on the following pages. The success of our community (past and present) is the cornerstone of our reputation. This reputation remains our greatest asset, and we are confident that all who have worked and studied here (past and present) have helped to build this reputation. If you're reading this as one of our alumni or a friend of the Department, then you've already contributed to these achievements. Thank you.

Through the course of this year, we've welcomed a number of new academic staff. James Durrant, Ji-Seon Kim, Paul McGonigal, and Jason Chin have come to us as professors, while Daniel Congrave and Alyssa-Jennifer Avestro have joined as fellows. These new members of our community are working on a diverse range of research questions in areas such as sustainable energy and materials, molecular design and dynamics, and synthetic biology, driving forward Oxford's mission to tackle global challenges through scientific innovation.

Jason Chin joins Oxford from the Laboratory of Molecular Biology in Cambridge as a joint appointment with the Ellison Institute for Technology (EIT), where he will lead the Institute for Generative Biology. EIT has entered an alliance with the University to address key challenges for the 21st century, mixing academic excellence with the potential for commercial success. Hagan Bayley has also joined the institute, and will maintain a part time appointment in Chemistry while leading EIT's programme on Materials and Devices for Life Sciences.

Paul Beer, John Foord and Bill David retired from the Department

Professor Stephen Faulkner

at the end of Trinity Term, having left their mark on Chemistry and Oxford, and we are looking forward to seeing them continue their journey with us as emeriti.

Sadly, there have also been more permanent farewells. Edman Tsang was a friend and colleague over many years, and we were all shocked by his sudden illness and death while still fully in harness. Graham Richards, the first head of the unified Department of Chemistry, will be remembered as one of the moving spirits that turned the Chemistry Research Laboratory from a dream into reality. I'm sure you will join me in sending condolences to their families. We intend to celebrate their lives in the coming year, and hope that many of you will join us.

As always, it remains a pleasure to meet so many of you at events in Oxford and the wider world and I hope to see you again soon. We're keen to provide opportunities for you to engage with one another and with us – watch this space! ■

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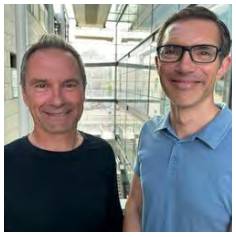
News and achievements

For more stories throughout the year, visit chem.ox.ac.uk/news

Prof Philipp Kukura was elected a Fellow of the Royal Society in May 2025, in recognition of his work in the development and application of novel methodologies based on light scattering to study biomolecular structure, interactions and dynamics. In August 2025, Philipp was also awarded the Royal Society Clifford Paterson Medal for pioneering and democratising mass photometry, a novel means of mass measurement for single biomolecules.

Prof Andrew Goodwin FRS received the Royal Society Faraday Discovery Fellowship. Andrew was one of the first seven scientists chosen across the UK for this new long-term Royal Society scheme, which supports exceptional mid-career research leaders. Andrew's Faraday project will explore materials with "responsive disorder," studying several types of disorder found in things such as glasses and polymers, with potential applications in areas like computing.



Profs Darren Dixon and Michael Willis were named Arthur C Cope Distinguished Scholars by the American Chemical Society. Michael was recognised for opening up sulfur dioxide chemistry with new reagents and catalysts, while Darren was cited for innovative catalysis and concise total syntheses of complex natural products.

Prof Anna Regoutz received the IUPAC Emerging Innovator Award in Analytical Chemistry in June 2025. Anna was cited for her leadership of an interdisciplinary team of researchers exploring the structure-electronic structure relationship in inorganic solids with the aim of integrating such materials into opto-electronic devices.

Prof Christiane Timmel was awarded the International EPR Society Medal in Chemistry. Christiane was recognised for her contributions to the application and development of electron paramagnetic resonance in chemistry.

Richard Compton, Aldrichian Praelector Emeritus, was awarded the International Society of Electrochemistry's Frumkin Medal, which recognises outstanding lifetime contributions to the field of fundamental electrochemistry. Richard's contributions include electroanalysis, photo-, sono- and spectro-electrochemistry, electrochemistry of room-temperature ionic liquids; single-entity electrochemistry, and the simulation and modeling of electron transfer and mass transport at electrified interfaces.

Prof Dame Carol Robinson was a guest on BBC's Desert Island Discs in August, sharing some of her favourite music and talking about her life and work.

Profs Yimon Aye and Madhavi Krishnan each received an Advanced Grant from the European Research Council. The grants, each worth up to €2.5 million, give senior researchers the opportunity to pursue ambitious projects that could lead to major scientific breakthrough. Yimon's project will aim to develop technologies that can map the activity of immunometabolites in living organisms, while Madhavi will explore the origins and consequences of counterintuitive long-range forces between objects in solution.

Yuxing Zhou was awarded a Schmidt AI in Science Postdoctoral Fellowship. Yuxing, working in the Deringer Group, will use AI-driven modelling to understand amorphous oxides for solar cell design.

Dr Rachel Quarrell received a Teaching Award from the University's Mathematical, Physical and Life Sciences Division for contributions to chemistry education and for supporting student learning across the Department.

Daria Turculeț, DPhil student in the Perkin group, won the inaugural Sir George Iacobescu Award for Academic Excellence in a competition organised by the Romanian Embassy in April 2025. Daria received the award for a presentation about her work as part of the effort to fight antibiotic resistance.

The Biocatalytic Nitro Hydrogenations Team, led by Prof Kylie Vincent, was awarded one of the Royal Society of Chemistry's Horizon Prizes, which celebrate discoveries and innovations that push the boundaries of science. The prize recognised the group's achievements in developing a greener process to synthesise amine-containing chemicals that are widely used in pharmaceuticals, agrochemicals and many other areas of the chemical industry. (See photo on previous page.)

Waynflete Professor of Chemistry, Véronique Gouverneur, received two Visiting Professorships in the US in 2025: the Rowland Pettit Centennial Visiting Professorship at the University of Texas at Austin and the Ojima Distinguished Lectureship in Chemistry at Stony Brook University.

The Chemistry Teaching Laboratory's first-year practical course was highly commended at the Vice-Chancellor's Awards, presented by VC Professor Irene Tracey in May 2025. The team behind the course were highly commended in the Innovative Teaching and Assessment award category for empowering first-year chemistry students to make their own experimental design choices from the first term of their studies in Oxford. (See photo of the CTL team below.)

Several members of the CTL team were also awarded Fellowships and Associate Fellowships by AdvanceHE this year, recognising a personal and institutional commitment to professionalism in learning and teaching. Ewan Forsyth (far right below), Charlotte Hancox (fourth from right), Julie Kalmoni and Matt Reveley were all awarded FHEA, while Tom Birkett (second from left), Prabath Jayasuriya, Sameeksha Mishra and Ben Oxley all received AFHEA.

Dr Dan Congrave was awarded a Starting Grant from the European Research Council, intended to enable early-career researchers to pursue their most promising ideas. Dan's work will aim to exploit original structural organic chemistry to design and synthesise new materials that are unprecedented in how they absorb and emit light.

In March 2025 DPhil students Kieran Agg (Perkin group), and Annina Lieberherr (Manolopoulos group), were selected as finalists in STEM for BRITAIN. This annual competition celebrates early-career researchers, who are given the opportunity to present their research to MPs and peers in the Houses of Parliament. ■

New research

DPhil students Maisy Barnett and Neave Taylor report on some of the latest research from the Department of Chemistry

Powering the Internet of Things

Novel indoor photovoltaic materials

doi.org/10.1038/s41377-024-01620-0

As more of our world is digitised and electrified, energy efficiency must be improved in homes and industry to avoid putting additional strain on energy resources. One way of achieving this is through harnessing ambient light indoors to power small devices.

These devices may include signs or sensors for measuring environmental factors, like humidity and temperature, which could feed back into climate management systems in buildings. Using many of these devices in buildings could build up an Internet of Things (IoT) that integrate to increase energy efficiency within homes and businesses.

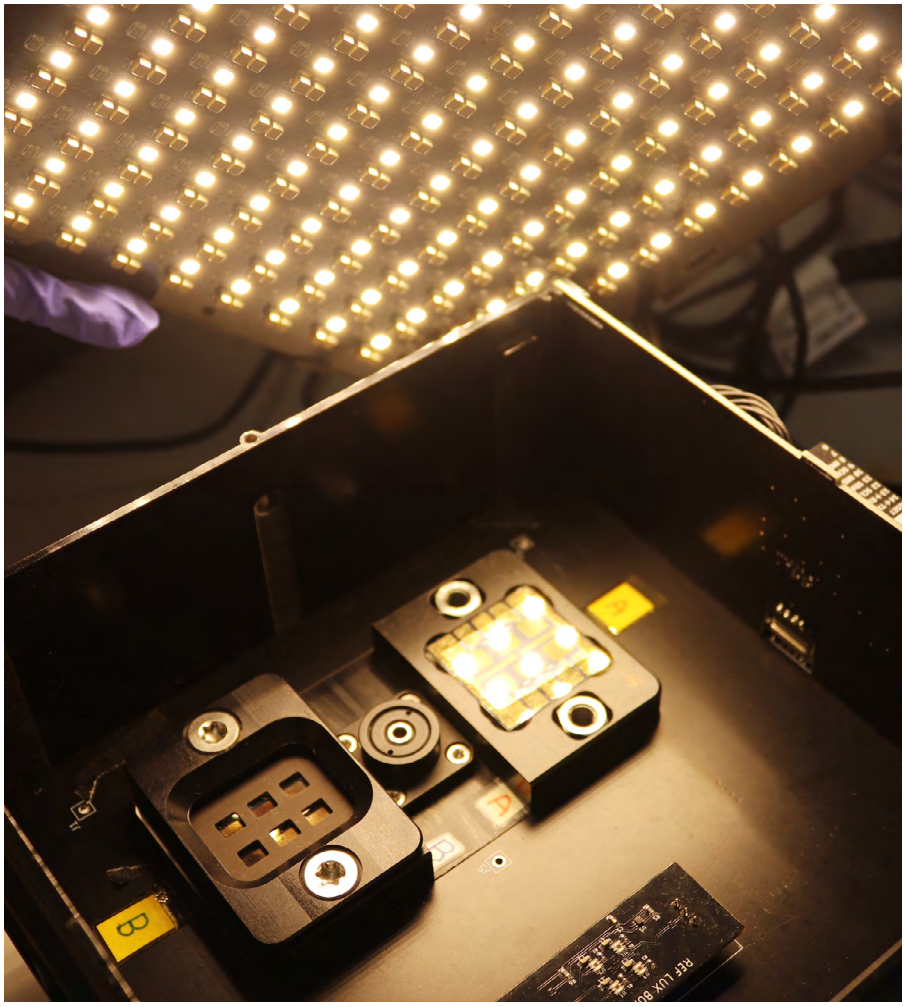
Unfortunately, the materials we are familiar with as outdoor solar cells are not suitable for indoor use, as the wavelength and intensity of indoor light and sunlight are completely different. Most indoor photovoltaics suggested to date lack efficiency in these conditions, or contain toxic materials that make them unattractive for consumer use.

An Oxford team led by Prof Robert Hoye in collaboration with several other institutes has demonstrated antimony sulfide (Sb_2S_3) as a world class indoor photovoltaic material, achieving the highest efficiency at the time of publication for such films in typical office lighting conditions.

Sb_2S_3 films are a great candidate for use in indoor photovoltaics because they are non-toxic and the wavelengths over which they can be used to produce solar energy matches extremely well with typical indoor lighting conditions, meaning they have very high theoretical efficiencies. Their material properties also make them well-suited for cheaper manufacturing, and they can form flexible and lightweight films, making them extremely adaptable.

The efficiency of Sb_2S_3 for photovoltaic applications has so far been limited by the light-generated charge-carriers recombining before they can be extracted as electrical energy. These recombination events occur with much greater frequency at crystal grain boundaries, so by reducing the density of crystal grain boundaries of a thin film, these recombination events will occur less, and the efficiency will increase.

Hoye and his team used monoethanolamine (MEA) as an additive in the fabrication of these films to engineer Sb_2S_3 films with fewer grain boundaries and therefore better efficiency. Through density functional theory (DFT) calculations they found that the MEA additive acts as a molecular bridge between the antimony source and the desired substrate during film



formation. This bridging behaviour allowed the antimony and sulfur to react more quickly and with less complexity than the traditional synthesis, resulting in large, smooth crystals in the film surfaces.

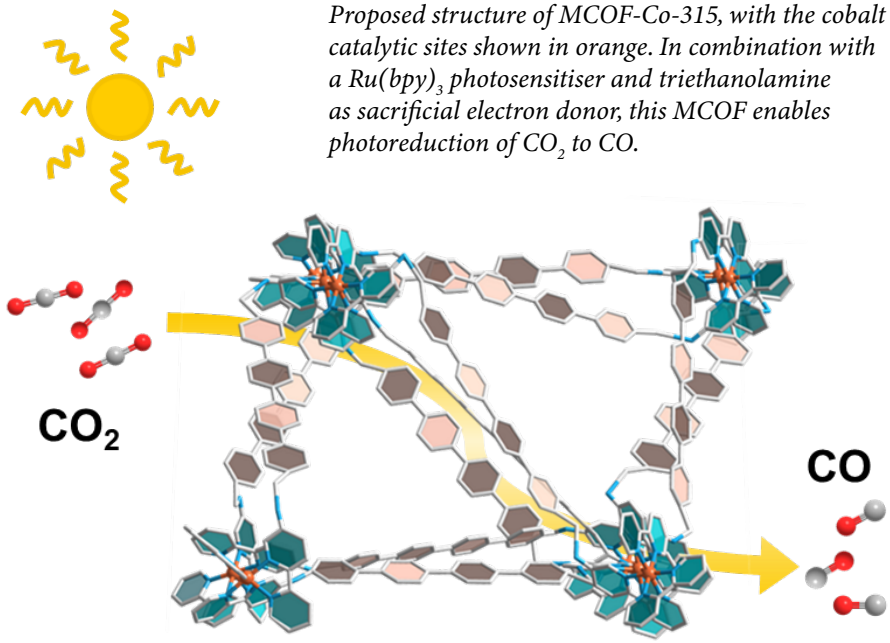
The engineered Sb_2S_3 films were incorporated into a practical minimodule for environmental sensing. The device was able to be powered in office lighting for nearly fourteen hours while transmitting environmental data to a mobile phone via Bluetooth. The solar cells also showed excellent storage stability indoors, losing less than 4% of their efficiency over the course of a month. Going forward, longer chained ethanolamine-based additives may work as even better molecular bridges during fabrication, helping boost cell efficiency and longevity even further. ■

New approaches to carbon waste

Using robust metal–covalent organic frameworks to reuse waste carbon

doi.org/10.1021/jacs.4c18450

Many industrial sectors vital to modern society rely on carbon. Even as we move towards a net-zero future, the unique chemistry of carbon means many key sectors (including maritime shipping, industrial cement manufacture, steelmaking, aviation and chemical raw materials) will still rely on carbon-based products in the foreseeable future. Currently, these products are primarily derived from non-renewable fossil fuels like oil and natural gas, but an Oxford team led by Prof Iain McCulloch, with lead researcher Wanpeng Lu, has demonstrated an alternative way to valorise the harmful greenhouse gas by-product, carbon dioxide, in a recent article published in the *Journal of the American Chemical Society (JACS)*.



Proposed structure of MCOF-Co-315, with the cobalt catalytic sites shown in orange. In combination with a $Ru(bpy)_3$ photosensitiser and triethanolamine as sacrificial electron donor, this MCOF enables photoreduction of CO_2 to CO.

The team has developed a novel catalyst known as MCOF-Co-315, which reduces carbon dioxide in the presence of light into carbon monoxide, a key industrial precursor to a huge variety of carbon products, which can be used in place of petrochemical precursors. Ultimately such a process could include direct air capture.

This novel catalyst consists of a metal-covalent organic framework (MCOF) where metal catalytic actives sites, in this case cobalt, are embedded in a covalently bonded organic skeleton. MCOFs share the characteristics of high surface area and porosity with their more well-known chemical counterparts, metal organic-frameworks (MOFs – see p.30 for news of Oxford alumnus Richard Robson, who was awarded the Nobel Prize in Chemistry this year for his early work on MOFs). In contrast to MOFs, MCOFs contain covalent bonds in their backbone rather than relying on weaker coordination bonds between metals and organic linkers, making them more structurally stable. This hugely increases their stability and reusability as catalysts, with MCOF-Co-315 maintaining over 90% of its performance over five collection and production cycles.

The controlled placement of the catalyst within the covalent scaffold also helps minimise unwanted charge recombination during the catalytic cycle, meaning less energy from sunlight is wasted and efficiency is improved. When exposed to simulated solar radiation, MCOF-Co-315 produced carbon monoxide with an extremely high specificity and a quantum efficiency that rivals other state-of-the-art materials.

In addition to demonstrating the performance of MCOF-Co-315 for reducing carbon dioxide, McCulloch and a team of collaborators have explained how this was achieved through a detailed mechanistic study encompassing a wide variety of complementary techniques, including electron paramagnetic resonance (EPR) spectroscopy led by Dr Claudia Tait. Further work is ongoing to boost the carbon monoxide production rate to industrially relevant levels. ■

What to do with all that CO_2?

Using Zintl ions to turn waste carbon dioxide into a methanol surrogate

doi.org/10.1038/s41467-024-54277-z

Almost 42 billion tonnes, or the equivalent of three million Boeing 747 jets: that's the mass of CO_2 emissions produced in 2024. In order to combat the ongoing climate crisis, we need to find productive ways that recycle waste CO_2 and repurpose the greenhouse gas for good.

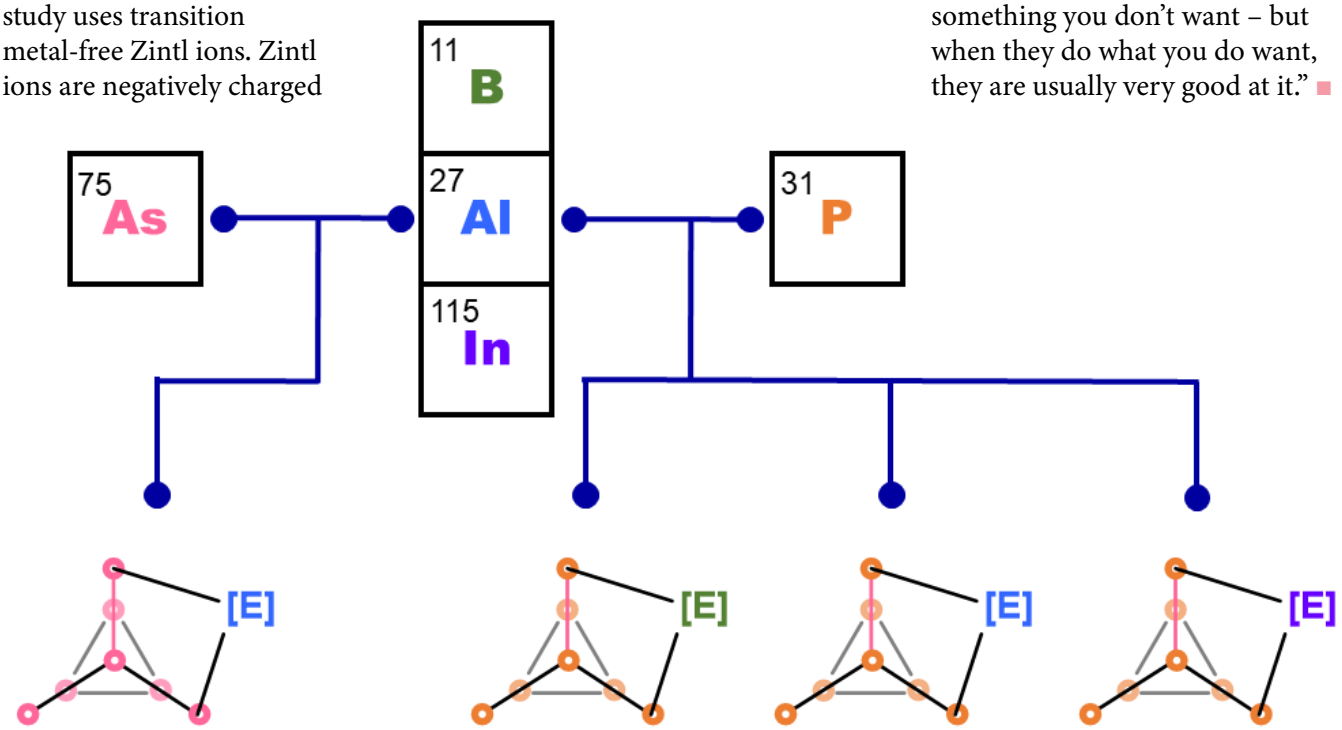
Researchers from the groups of Profs Meera Mehta and John McGrady have recently reported a method to transform CO_2 into a methanol surrogate. As the global demand for methanol is expected to reach 280 million metric tonnes in 2030, recycling CO_2 into methanol presents an opportunity to repurpose a substantial amount of CO_2 gas and help close the carbon cycle. The methanol can be used as a fuel, or as a carbon one (C1) building block for synthesising simple molecules.

Published in the journal *Nature Communications*, the group's study uses transition metal-free Zintl ions. Zintl ions are negatively charged clusters primarily composed of group 14 or 15 element such as silicon, phosphorus or arsenic. They demonstrate the syntheses of a series of clusters that have the general formula $[(R_2E)Pn_7]^{2-}$, where E is boron, aluminium or indium, and Pn is phosphorus or arsenic (see figure below). These clusters were compared as catalysts for the reduction of CO_2 gas into methanol. By comparing selectivity, turnover number (TON) and turnover frequency (TOF) the team found that the species with aluminium present were the most active.

The presence of the $[Pn_7]$ framework allows for the catalysts to be recycled multiple times. This is a strong advantage over other methods as it is extremely uncommon for homogenous catalysts – those where the catalyst and reagents are all in the same phase – to be highly recyclable. Comparing all criteria, the researchers concluded that the Zintl ion cluster, $[(^iBu_2Al)P_7]^{2-}$, is the optimal candidate for the proposed reduction due to its high performance and recyclability.

The team used experimental and computational methods to probe the mechanism, and revealed an unproductive intermediate that acts as a thermodynamic sink. This means that the intermediate is exceptionally stable, and as a result any proceeding reactions are thermodynamically unfavourable. The studies also suggest that activation of the H–B bond for the hydroborative reduction of CO_2 is part of the slow step in the catalytic cycle. This was further supported by kinetic and isotopic labelling studies. Investigations are ongoing into the full mechanism for this reaction.

Bono van IJzendoorn, one of the authors of the study, said: "Zintl clusters always find a way to do something you don't want – but when they do what you do want, they are usually very good at it." ■

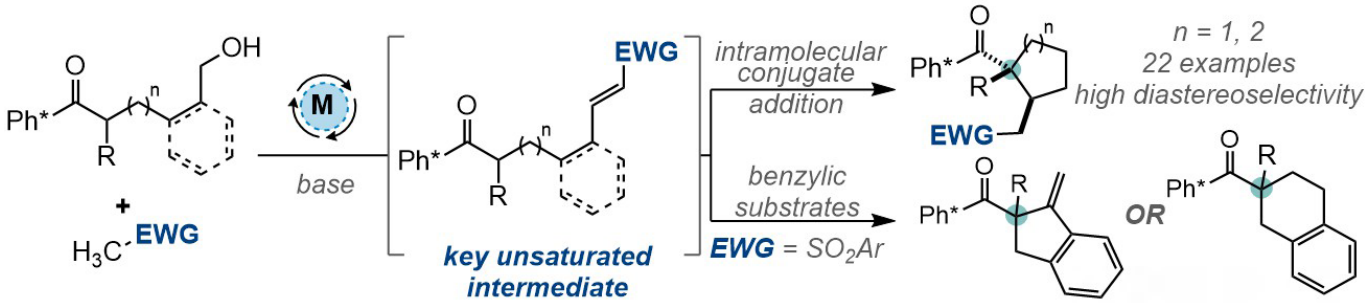


The group's study demonstrated the synthesis of a series of clusters that have the general formula $[(R_2E)Pn_7]^{2-}$, where E is boron, aluminium or indium, and Pn is phosphorus or arsenic. The schematic here demonstrates the "family tree" of Zintl ion clusters that can be formed from these elements by combining different choices of elements.

Borrowing hydrogen for synthesis

Making stereoselective five- and six-membered rings with catalysis

doi.org/10.1002/anie.202423179



Borrowing hydrogen for organic synthesis: removing hydrogen from the system allows for the formation of highly congested stereocentres with high diastereoselectivity in a single step.

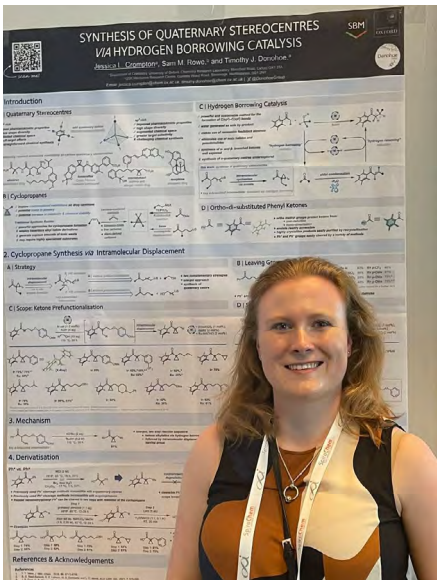
Hydrogen borrowing (HB) catalysis is a powerful synthetic strategy commonly used in organic chemistry. This catalytic process relies on a catalyst borrowing hydrogen from the reactants – but whether or not it gives the hydrogen back is a different matter.

Recently, Prof Tim Donohoe's group has used HB catalysis to synthesise a variety of different five- and six-membered carbon rings. Using this method, the researchers were able to achieve a high degree of stereoselectivity, with the catalyst forming only one major product. Isolating a pure stereoisomer of a molecule is important for biological and pharmacological applications, where different spatial arrangements of functional groups can result in molecules with very different properties to each other. Often, obtaining a pure isomer of product is not easy, requiring expensive and time-consuming separation techniques. As the Donohoe group have demonstrated in their recent study, finding reaction pathways that obtain a single isomer directly represent a significant advantage over alternative methods.

Reported in *Angewandte Chemie*, lead author Dr Jessica Crompton and the research team describe the optimisation process of this catalytic reaction. During these investigations they found that a manganese metal catalyst performed best, outperforming various different metals including iridium and ruthenium. This is a notable advantage of the method, as manganese is an earth abundant metal in comparison to the other more expensive and rare metals investigated.

Once the researchers had optimised the conditions, they investigated the scope of the catalysis. The team was able to successfully demonstrate the HB catalysis procedure on more than 20 different substrates with promising yields and high stereoselectivity. Following this, the group was able to further derivatise the isolated products to form a range of useful fragments which retained the three-dimensional orientation of functional groups.

Prof Tim Donohoe says: "Hydrogen borrowing catalysis is an extremely efficient method for carbon-carbon bond formation that works by shuffling around the positions of hydrogen atoms. In her work, Jess has shown that much more complex systems containing quaternary carbon centres can be accessed by diverting the shuffling process so that hydrogen is in fact removed from the reaction system. This work is also notable for its use of an earth abundant metal as a catalyst (here manganese) replacing more expensive and less easily available alternatives." ■



Dr Jessica Crompton, lead author of the study, presents her work at the Belgian Organic Synthesis Symposium 2024.

Profile: Prof Adam Kirrander

Born to Polish parents in Sweden, Adam studied at Uppsala and Oxford. After periods of research in London, Paris and Harvard, he started his group at the University of Edinburgh. He returned to Oxford in 2022 as a tutorial fellow at St Peter's College.

Can you introduce your group's research for us?

We're interested in how the collective motion of electrons and nuclei govern and generate chemical transformations, especially when molecules are excited by light. We aim to understand these processes by developing methods to simulate them from first principles as well as by devising new measurements that give more insight into what's going on.

A lot of this work, especially in terms of measurement, has been driven by new light sources called X-ray free electron lasers. They can be precisely controlled to produce very short pulses of light, and this allows us to investigate the extremely short timescale on which electrons and nuclei move.

Often in chemistry our thinking is dictated by the arrangement of nuclei and electronic structure at equilibrium – the states they are in for most of the time – but actually, lots of interesting things happen far away from the equilibrium in atomic and molecular states that only exist for brief moments of time. One neat thing about our methods is that you get to see what molecules and systems do in these states. Eventually if we understand all these behaviours well enough, we might be able to engineer or design new molecules that have particularly useful properties in their response to light.

How do you see the connection between computational and experimental work in your field?

I think that link is very natural and beneficial, and almost a necessity in this particular domain. The main challenge, experimentally, is that you get a limited view of what is inherently a tremendously complex process. You get valuable information, but it's just one peek at what's happening.

Simulations and theories are essential in order to interpret what people measure, so it's a natural symbiosis where people work together. My research group is part of a few big projects that have tried to overcome limited information by, for instance, studying the same process by complementary ultrafast techniques in order to build a more complete experimental picture. That also allows us to stress-test and challenge simulations and theory.

These types of bigger experiments involve a lot of different people working together. A collaborator described it as conducting an orchestra, where everyone has an important role to play. I think it makes the research fun, and very stimulating.

What are the possible applications arising from your work?

We are very much on the fundamental side of trying to understand the basic principles – but still, there's a lot of application areas that involve interactions between light and molecules. In particular, photoexcited processes are an important technological frontier. They are important in anything from photocatalysis to

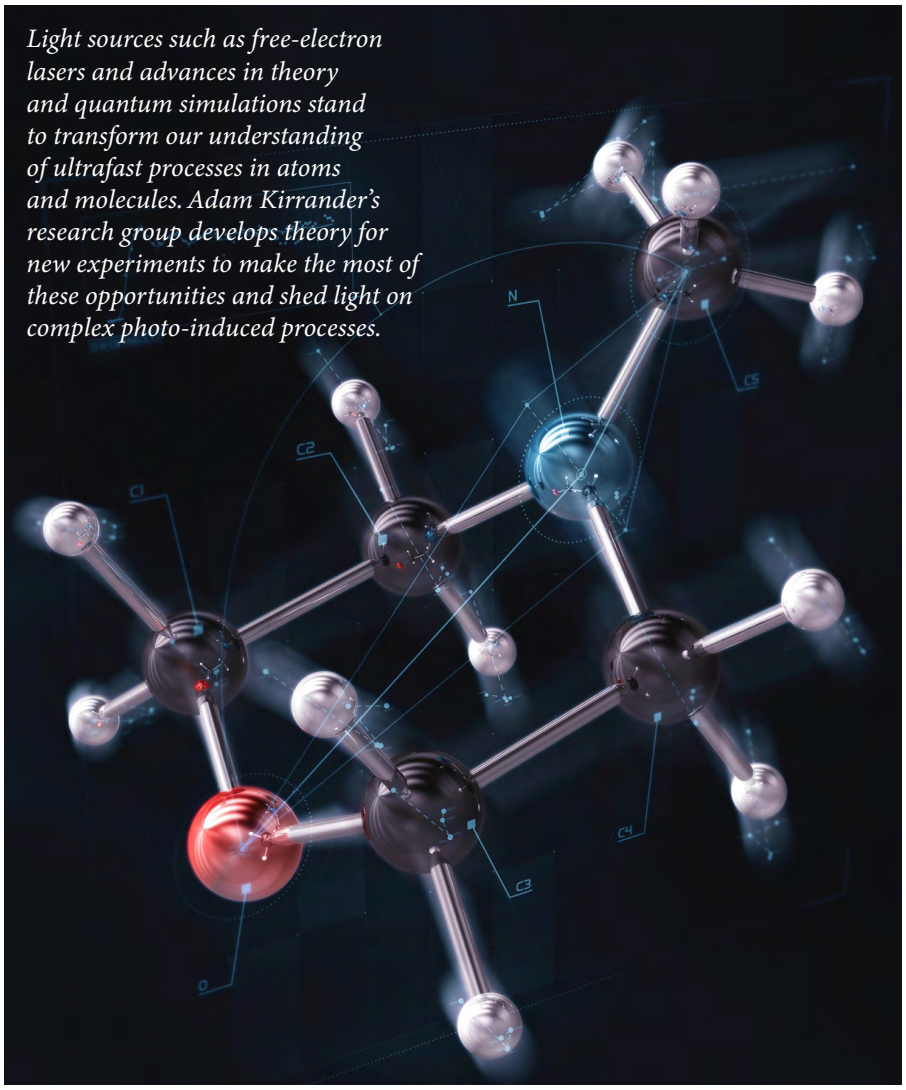
photodynamic cancer therapies, quantum computing, molecular photonics, and photovoltaics.

We have done some more applied work, for example one of our postdocs, Joe Cooper, has looked at the photochemistry involved in molecular solar-thermal systems (MOSTs). In these systems, solar energy is stored in strained molecules and can be released as heat later on. Joe looked at the quantum mechanics of the light-driven photoisomerization of these molecules. Another postdoc, Lauren Bertram, investigated how the photophysics in a set of heterocyclic molecules changes with the different nitrogen positions. This is the kind of mapping needed to rationally design molecules with specific photophysical properties. Understanding how that works is important, as lots of photoactive molecules are built on these motifs.

What initially got you interested in ultrafast processes?

I think I've always been curious about what electrons get up to. I remember at undergrad when we learned the simple particle-in-a-box model of a conjugated molecule. You can do a back of the envelope calculation to predict the approximate wavelength at which it will absorb light. The fact that you can do some relatively simple math to predict something so profound is truly amazing.

The ultrafast community is a gathering point for people who are interested in the dynamic motions of electron and nuclei, and trying to understand the physics of these processes. It became a very natural home for me. Now that all these new light sources have appeared over the last ten to fifteen years it makes it even more exciting, because we get to see our pen-and-paper ideas turned into reality and actual measurements.



Light sources such as free-electron lasers and advances in theory and quantum simulations stand to transform our understanding of ultrafast processes in atoms and molecules. Adam Kirrander's research group develops theory for new experiments to make the most of these opportunities and shed light on complex photo-induced processes.

Are there any specific projects or ideas that you're really excited about?

One of the things that I'm really excited about is measuring the correlation of electrons – the way they move together – since this is one of the most fundamental aspects of matter. It's what makes electronic structure theory difficult, but it's also what gives rise to many of the wonderful properties of atoms and molecules.

Now, we're seeing ways to probe this very fundamental property in a way that hasn't been possible before, and also away from equilibrium, which is very exciting. I'm also intrigued about pushing measurements to the degree where we can do quantum tomography – reconstructing the quantum state of an atom or molecule from many different measurements – which would allow us to fully characterise complex quantum mechanical systems.

How has the experience of moving back to Oxford been?

It's a great place to come back to. I have amazing colleagues who do really ambitious and challenging research, and it's nice to be in that environment. As a department we have many wonderful applied projects, but there is this breadth of science here that includes the curiosity-driven, which I think is a really valuable thing. I also like the teaching; we have excellent students and a rigorous curriculum that's fun to teach. It's a great place to work, and I'm very happy to be here. ■

New academic colleagues

2025 saw several new professors join the Department of Chemistry

Jason Chin FRS

Jason Chin joined the University of Oxford in May this year, taking up a joint appointment with the Ellison Institute of Technology (EIT) and the Department of Chemistry. A pioneer in generative biology, he is the Founding Director of EIT's new Generative Biology Institute. His research explores the reprogramming of the genetic code to create organisms with novel biochemical functions. Before moving to Oxford, he was a Programme Leader at the Medical Research Council Laboratory of Molecular Biology and Professor of Chemistry and Chemical Biology at the University of Cambridge, where he developed groundbreaking methods in synthetic biology.

James Durrant CBE FRS

James Durrant joins Oxford as Professor of Photochemistry and Sustainable Energy. He previously held joint appointments as Professor of Photochemistry at Imperial College London and as Sêr Cymru Solar Professor at Swansea University. His research focuses on understanding and improving photoinduced charge separation and recombination in solar energy conversion systems. These include molecular, polymer, and semiconductor materials used to generate electricity or fuels from sunlight. His work underpins advances in renewable energy technologies, bridging fundamental photochemical mechanisms with applied materials innovation for clean, sustainable power generation and fuel production.

Ji-Seon Kim

Ji-Seon Kim joins Oxford as Professor of Electronic Materials after serving as Professor of Solid State Physics at Imperial College London. Her research combines materials physics and spectroscopy to develop sustainable semiconductors for energy technologies. She investigates charge transport and structure–property relationships in organic and hybrid materials, including mixed electronic–ionic and organic–inorganic systems. Her work contributes to flexible electronics, light-emitting devices, and biointerfaces. At Oxford, she advances environmentally responsible materials supporting next-generation technologies and scalable manufacturing for a low-carbon, resource-efficient future.

Paul McGonigal

Paul McGonigal, who studies dynamic processes in organic functional materials, joins Oxford as Professor of Organic Chemistry. His research explores molecular motion and self-assembly, revealing how dynamic behavior can be programmed into chemical systems. Paul began his independent career at Durham University as Assistant Professor in 2015 and Associate Professor in 2021, before moving to the University of York as Reader in 2023 and Professor in 2024. In 2025 he took up his current role at Oxford and became the Courtenay Phillips Fellow at Merton College. His group designs responsive molecular materials with controllable mechanical and optical properties. ■

Dr Mike Fairclough in the radiochemistry facility at the Oxford Imaging Methods Epicentre.

Oxford Imaging Methods Epicentre

A new state-of-the-art radiochemistry research hub based at Oxford Chemistry

The Oxford Imaging Methods Epicentre – or OxIME – aims to devise the next generation of positron emission tomography (PET) radiotracers. These isotopically labelled chemicals can be used to investigate cancer biology, brain and heart function, and to support diagnostic and drug discovery campaigns.

OxIME was launched by Véronique Gouverneur FRS, Waynflete Professor of Chemistry, alongside fellow Oxford academics Ben Davis FRS, Science Director & Professor of Chemical Biology at the Rosalind Franklin Institute & Department of Pharmacology and Daniel Anthony, Professor of Experimental Neuropathology, Department of Pharmacology.

Over the last couple of years, a cyclotron, hot cells and other special radiochemistry equipment have been carefully installed in the Rodney Porter building, including delivery of the cyclotron via crane (keen readers of Periodic may remember striking images of this operation, which were included in issue 11). After months of preparatory work, the facility is now fully operational, and is the first cyclotron facility solely dedicated to innovation and research.

The facility contains a particle accelerator that can be used to make four short-lived radioactive nuclei, ^{18}F, ^{11}C, ^{13}N and ^{15}O, all of which can be used for a variety of research applications. Many of the chemicals produced in the facility can be used as radiotracers: special isotopically labelled chemicals that can be used in PET scanning for disease diagnosis, staging and assessment of treatment efficacy.

The cyclotron itself has integrated, 120-centimetre-thick concrete shielding, comprising two 12.5-ton doors that open (very slowly!) on automatic remote-controlled hinges. Once the particle accelerator has produced the radioisotope it is delivered via a lead-lined pipeline to the radiochemistry facility next door, where scientists can perform chemical reactions using highly specialised equipment.

As well as the cyclotron itself, the OxIME facility includes three hot cells: lead-shielded containment units that house automated radiochemistry systems, used to perform remote-operated chemical reactions with the

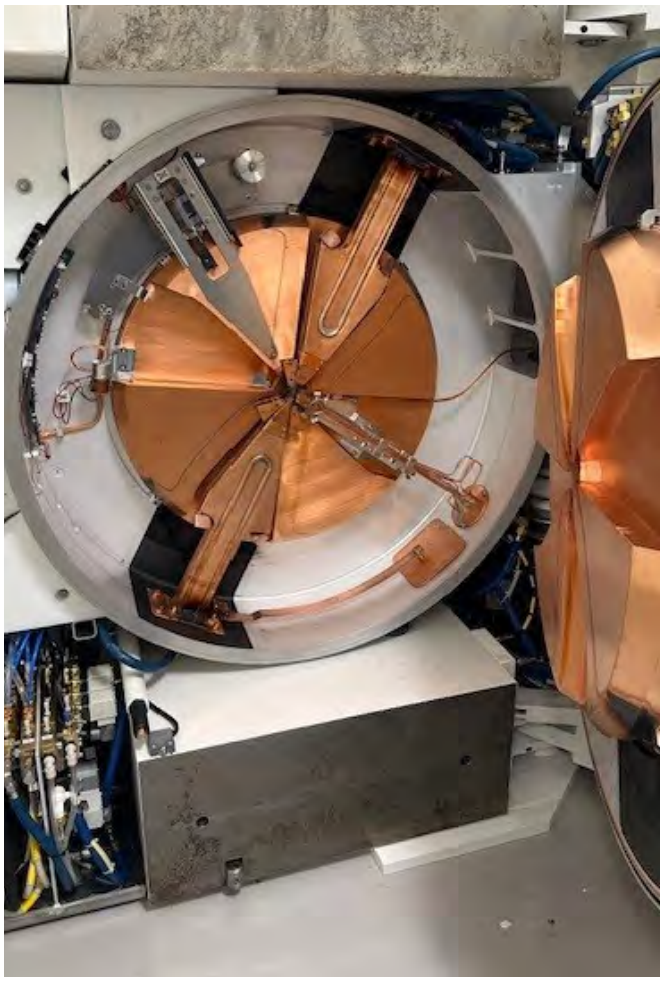
cyclotron-produced radioisotopes. The automated radiochemistry systems allow the operator to remotely perform radiochemistry reactions, purify radiotracers by high-performance liquid chromatography (HPLC) and formulate radiotracers for pre-clinical imaging as required. Once the radiochemistry is complete the operator can use remote manipulators from outside the hot cell to move vials containing radiotracers to an awaiting lead pot in the hot cell dispensing drawer. From here the radiotracer vial can be safely moved to a lead shielded fume hood for quality control testing and further experiments. The facility also includes a specially shielded glove box, enabling users to safely perform manual experiments with the radioisotope products.

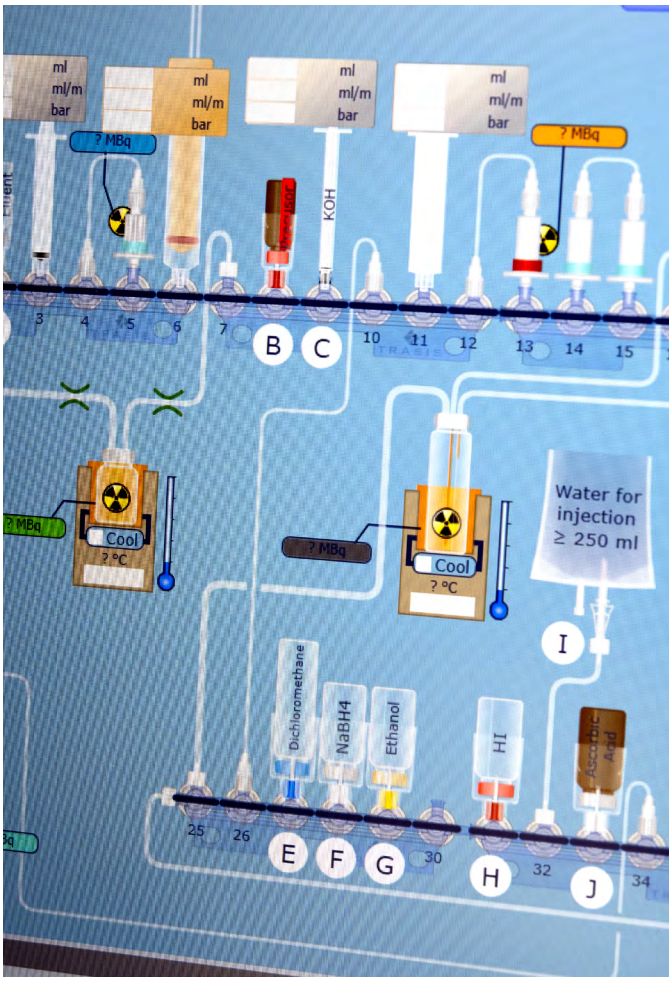
Dr Mike Fairclough, who runs the new radiochemistry facility, joined the Department earlier in 2025. After his studies at the University of Manchester he worked as a research radiochemist while completing a part-time PhD in PET radiochemistry. After the closure of Manchester's Cyclotron and Radiochemistry facility during the Covid-19 pandemic, he helped to take the equipment offline, and then in a bizarre turn of events worked to successfully recommission the cyclotron and hot cells in collaboration with the Medicines Discovery Catapult. He is excited to join this brand-new facility here in Oxford from the outset, and keen to help the team drive forward their exciting research vision.

Dr Fairclough said: "I was thrilled to join the team, knowing this was an unmissable opportunity. OxIME stands as a cutting-edge cyclotron and radiochemistry facility, poised to lead pioneering PET radiochemistry research in the UK and beyond."

Every aspect of the OxIME facility is designed with radiation protection and safety in mind. Crucially, the medical radioisotopes produced have short radioactive half-lives, meaning that no legacy radioactivity is left behind. This also means that our radiochemists must work fast, in order to make use of the quickly-decaying radioactivity. The team behind OxIME are experts in radiochemistry and radiation safety with many years' experience, which is supplemented by knowledge from radiation protection advisors, to ensure that safety is always the top priority at OxIME.

Professor Véronique Gouverneur FRS said: "OxIME is a unique radiochemistry facility aimed at accelerating the invention of novel PET radiopharmaceuticals applying a mechanistic and AI-driven approach. Combined with the breath of expertise in synthetic chemistry of the department, we anticipate that this research hub will rapidly make an impact, and improve patient healthcare for years to come." ■





New spinout company set to transform chemical sensing

L–R: Dr Daniel Miles–Barrett, Dr Dean James, Prof Claire Vallance.

A new spinout company emerging from research in Prof Claire Vallance's lab is poised to transform the field of chemical sensing. Drawing on technology first developed for quantum computing, Mode Labs has created a platform capable of measuring almost any analyte in solution, anytime and anywhere.

Armed with this innovation, Mode Labs aims to disrupt the way water quality is monitored, making chemical analysis portable, affordable, and ready for use in real-world environments. The company has raised £3 million in seed funding to take chemical sensing into the field. Its platform offers lab-level sensitivity while using a thousand times less reagent, consuming a fraction of the power, and costing just ten per cent of current technologies.

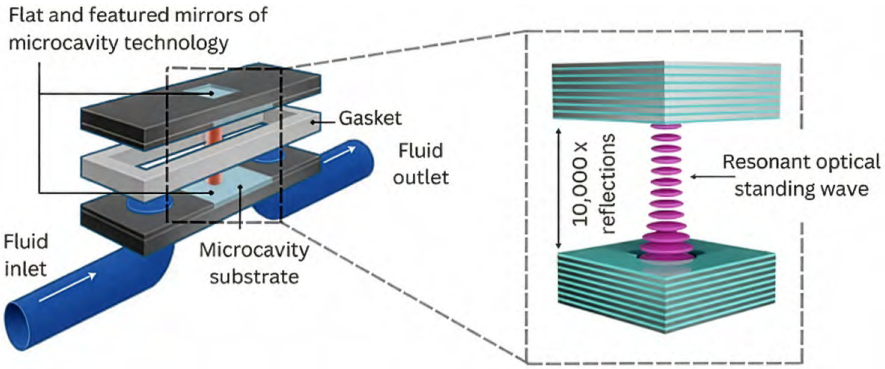
Mode Labs is built on over fifteen years of research from the departments of Chemistry and Materials. Its founding team brings together Professors Claire Vallance and Jason Smith with CEO Dr Dean James and Head of Engineering Dr Daniel Miles-Barrett. Together, they have developed a patented sensing system that repurposes technology originally designed for quantum computing to detect almost any chemical in liquid form.

The timing of this innovation could not be more significant. The UK's Environment Act 2021 mandates the deployment of tens of thousands of chemical sensors across the country's waterways by 2035, creating an urgent demand for robust, real-time monitoring solutions. Mode Labs is stepping forward to meet that need.

With successful field trials already completed, the company's latest investment – led by Oxford Science Enterprises, the University of Oxford Innovation Fund (UOIF), and GK Goh Ventures – will enable Mode Labs to expand its team, develop market-ready products, and focus initially on monitoring phosphate and ammonia levels in rivers and streams.

Mode Labs' technology represents a fundamental shift in how chemical sensing and water quality analysis are carried out. Traditionally, high-resolution chemical data has been confined to centralised laboratories – expensive to obtain, slow to process, and often inaccessible to those who need it most. Mode Labs is changing that model by combining cutting-edge optics and quantum-inspired engineering into a portable, rugged system designed for real-world use. From detecting nutrient pollution in rivers to safeguarding drinking water and supporting industrial compliance, the company's platform aims to make high-quality environmental data available to all.

"This investment will unlock access to precision chemical monitoring for anyone, anytime, anywhere," says Dr Dean James, CEO of Mode Labs. "With low-cost plug-and-play devices we can deliver clear and concise measurement data where it is needed most. Working with our customers, our mission is to protect the environment and human health by monitoring and reporting changes to our ecosystems in real time, allowing for immediate intervention." ■



A laboratory at your fingertips: micron-scaled quantum technology reflects light through a sample 10,000 times, giving 10,000x more sensitive measurements.

Celebrating student innovation

Ingenuity in research with real-world purpose

The 2025 Jamie Ferguson Innovation Awards celebrate Oxford's next generation of problem-solvers, recognising research that not only breaks scientific ground but aims to change lives.

A collaboration between Oxford University Innovation (OUI) and the Chemistry and Materials departments, the Jamie Awards are now in their fourth year. The event continues to honour the memory of Jamie Ferguson – a much-loved OUI colleague and tireless advocate for student entrepreneurship and creativity – who passed away during the COVID-19 pandemic.

L–R: Aleksy Kwiatkowski, Haozhe Xiao, Yiyi Wang, Leo Simon, Sebastian Golojuch.

The 2025 Jamie Award Winners

This year's winners captured the spirit of innovation that Jamie championed: curiosity with direction and research driven by a desire to solve hard problems.

Sebastian Golojuch

DPhil, Chemical Biology

While mRNA technology became a household name during the pandemic, its potential is far from tapped. Sebastian's work unlocks new ways to improve how mRNA behaves in the body – by chemically modifying it using "click chemistry" after it's been assembled by enzymes. This modular platform could make mRNA therapies more stable, more targeted, and more effective – paving the way for tailored treatments in everything from cancer to rare diseases.

Yiyi Wang

DPhil, Engineering Science

Yiyi's research focuses on developing tiny glowing materials known as LG-MOFs, where light-emitting dyes are encapsulated inside metal-organic frameworks. These materials could help improve medical imaging or fight document fraud with anti-forgery inks. Crucially, Yiyi has devised a faster and greener method of producing LG-MOFs – cutting reaction times by over 90%.

Aleksy Kwiatkowski

DPhil, Synthesis for Biology and Medicine CDT

Messy, incomplete lab notes slow down experimental and computational science. Aleksy's project re-imagines how experimental data is captured, using speech rather than scribbled notes, to improve accuracy, reproducibility and collaboration. By improving how data is logged and shared, it boosts reproducibility and transparency – a modern answer to one of science's oldest headaches.

Haozhe Xiao

DPhil, Clinical Medicine

Haozhe's project rethinks how we treat obesity – one of the most pressing and difficult health challenges of our time. Obesity drives major diseases but remains hard to treat due to limited drug targets and side effects. Haozhe's approach offers a safer, longer-lasting strategy for obesity treatment and a path toward first-in-class therapeutics.

Leo Simon

Undergraduate, Engineering Science

The aim of the project was to challenge the foundation of modern infrastructure. Leo developed a carbon negative, bioengineered alternative to Portland cement, replacing a 200-year-old process with one that self-repairs, resists decay and sequesters carbon. Alongside offering a 460% improvement in flexural strength and a tenfold increase in toughness, it is projected to offset the carbon emissions of over 600 million people whilst reducing global infrastructure maintenance costs by up to 40%. The platform promises not just sustainable construction but a systemic shift in how we build. ■

Oxford chemists identify honey offering in a 2,500-year-old shrine

Researchers from the McCullagh group have solved a decades-old archaeological puzzle by re-investigating residue found in bronze jars excavated from a 6th century BCE Greek shrine in Paestum, southern Italy. Published in the *Journal of the American Chemical Society*, the study presents the first biomolecular evidence that the residue once contained honey, likely in the form of honeycomb.

The underground shrine, discovered in 1954, included several bronze jars containing an orange-brown sticky substance. Archaeologists initially assumed it was honey, an important substance in the ancient world and often left in shrines as offerings or buried alongside the dead. However, over 30 years, three teams analysed the residue but failed to confirm honey, concluding that the jars contained some kind of fat contaminated with pollen and insect parts.

In this new study, researchers used modern analytical techniques, including mass spectrometry for proteins and small molecule analysis, to determine its molecular makeup. This integrated approach identified sugars, organic acids, and royal jelly proteins that would have remained undetected using a single method. The results showed that the ancient residue had a near-identical chemical fingerprint to modern beeswax and was similar to modern honey. Further insights came from comparing the results with analyses of modern honeycomb samples and experimental simulations of degraded honeycomb.

Dr Luciana da Costa Carvalho said: "This research is a reminder that archaeological collections hold untapped scientific potential and shows how new information can be revealed when modern analytical techniques and multidisciplinary collaborations are combined."

Professor James McCullagh, Director of Oxford's Mass Spectrometry Research Facility, said: "The application of multiple analytical techniques was key to the success of this study. By applying several mass spectrometry and spectroscopic approaches we were able to reveal a comprehensive picture of the residue's molecular composition, enabling us to distinguish between contaminants, degradation products, and original biomarkers."

The study was made possible by a partnership between the Ashmolean Museum and the Archaeological Park of Pompeii. Dr Kelly Domoney, Heritage Science Manager at the Ashmolean, explained: "In preparation for the exhibition *Last Supper in Pompeii* in 2019, our colleagues at the Archaeological Park of Paestum and Veila made several important loans, including a Greek bronze hydria from the Heroon and its organic contents. We were permitted a unique opportunity to re-analyse those contents using modern instrumentation at the University."

The authors hope this work will inspire further re-analysis of legacy materials, especially those held in museum collections where sampling is limited and earlier tests proved inconclusive. ■

You can read more in the *Journal of the American Chemical Society*: doi.org/10.1021/jacs.5c04888

A new carbon allotrope

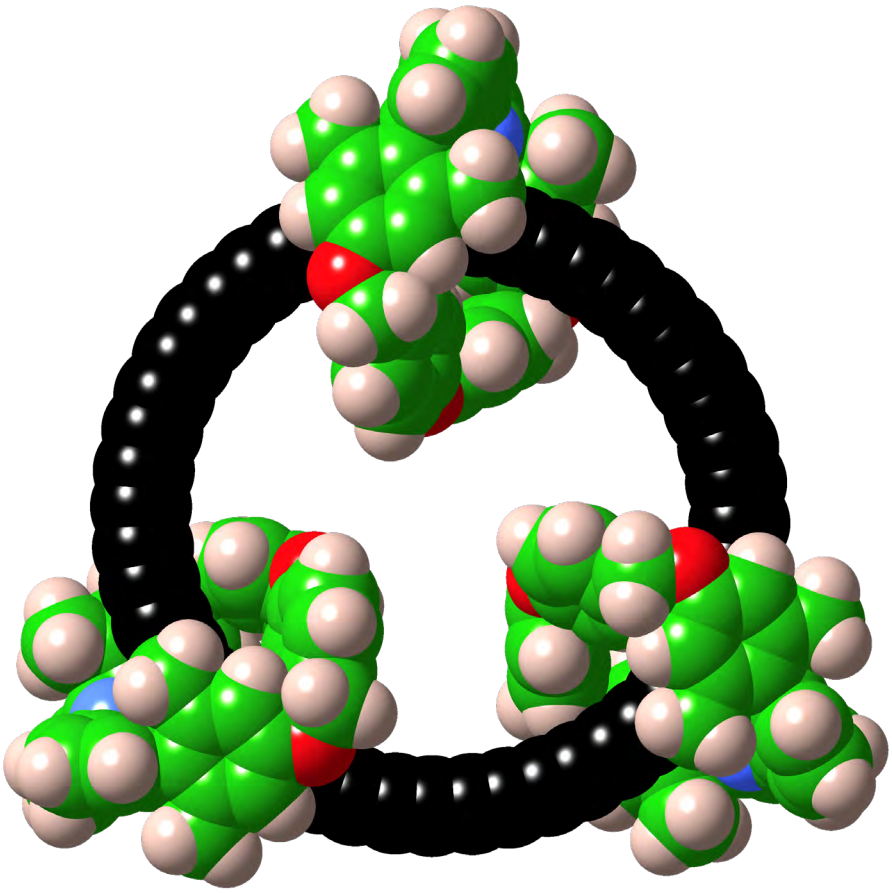
Oxford chemists have synthesised a new molecular form of carbon

The new molecule – cyclo[48] carbon, made up of 48 carbon atoms in an alternating single/triple bond pattern – is stable enough to be studied in liquid solution at room temperature.

The study – only the second example of a new type of molecular carbon allotrope that can be studied under normal laboratory conditions – was recently published in the journal *Science*.

In a new study led by the Department of Chemistry, chemists demonstrated the synthesis of a cyclocarbon that is stable enough for spectroscopic characterisation in solution at room temperature.

The synthesis of a new type of molecular carbon allotrope that can be studied under normal laboratory conditions is a rare achievement. The only previous example was the synthesis of fullerenes by Krätschmer *et al.* in 1990.



In the new study, the molecule cyclo[48]carbon was synthesised as a [4]catenane, i.e. with the C_{48} ring threaded through three other macrocycles. These threaded macrocycles increase the stability of C_{48} by preventing access to the protected cyclocarbon.

Previously, molecular rings consisting purely of carbon atoms have only been studied in the gas phase or at very low temperatures (4 to 10 K). Now, the team have synthesised a cyclocarbon that is stable in solution at 20 °C (half-life 92 hours). This has been achieved by using threaded macrocycles, choosing a large cyclocarbon with a low level of strain, and developing mild reaction conditions for the unmasking step in the reaction (where a precursor molecule is transformed into the final product).

The cyclocarbon catenane was characterised by mass spectrometry, NMR, UV-visible and Raman spectroscopy. The observation of a single intense ^{13}C NMR resonance for all 48 sp^1 carbon atoms indicates that all of the carbons are in equivalent environments, which provides strong evidence for the cyclocarbon catenane structure.

Lead author Dr Yueze Gao said: "Achieving stable cyclocarbons in a vial at ambient conditions is a fundamental step. This will make it easier to study their reactivity and properties under normal laboratory conditions."

Study senior author Professor Harry Anderson said: "This achievement marks the culmination of a long endeavour to synthesise cyclocarbon catenanes, based on the hope that they might be stable enough to study at room temperature. The original grant proposal was written in 2016, based on preliminary results from 2012–2015."

"It is satisfying to have reached this point, because there were many times when the goal seemed unrealistic and unachievable. This work would not have been possible without the outstanding facilities for NMR spectroscopy in the Department of Chemistry at Oxford."

The study also involved researchers from the University of Manchester, the University of Bristol and the Central Laser Facility, Rutherford Appleton Laboratory. ■

You can read more about the study in the journal *Science*: doi.org/10.1126/science.ady6054

From the lab to the world

Training our researchers to engage with society

Chemistry plays a vital role in tackling complex global challenges, from sustainable energy to new materials and climate resilience. But scientific breakthroughs only reach their full potential when shared beyond the academic community. Recognising this, the Department not only advances fundamental science, but also invests in training the next generation of researchers to become skilled communicators, collaborators, and societal contributors.

A focus beyond discovery

Oxford Chemistry's mission is clear: to advance global understanding of chemistry and apply that knowledge to address pressing societal needs. As a research powerhouse with award-winning teaching, the Department understands its privileged position in shaping public understanding, especially among young people and communities historically underrepresented in science. Through programmes of outreach and public & community engagement with research (PCER), the Department supports researchers and professional staff in delivering outward-looking, socially conscious research that builds public trust and advocates for the chemical sciences.

Aims that drive engagement

Our outreach and PCER strategy is built on three key aims:

(1) Inspire and inform: Foster global conversations around the chemical sciences by demystifying our research, promoting further dialogue on its impact, as well as encouraging young people to pursue chemistry.

(2) Collaborate broadly: Work with non-academic partners, schools, and community groups, to co-create projects that share perspectives and knowledge.

(3) Reflect and respond: Engage with public values and priorities to shape relevant, responsible research that has real-world impact.

These translate into action through programmes which include structured training and opportunities for researchers.

Focusing on past and future materials in Oxford's Museum of Natural History

Equipping researchers from day one

A recent innovation is the Fundamental Skills in Outreach and Public Engagement (FSOPE) module, introduced in the Inorganic Materials for Advanced Manufacturing Centre for Doctoral Training (IMAT CDT – see p.24). This new course trains DPhil students in both the theory and practice of engagement.

Run by the Department, the module spans three terms. Firstly, students learn how to design and evaluate outreach activities through weekly workshops. In groups, and with support from colleagues in Oxford's Museum of Natural History, they develop a hands-on activity for families and schoolchildren.

During their industrial placements in the second term, students individually create an online careers resource focused on an industry specialist. These profiles aim to broaden awareness of career paths in chemistry, particularly for school pupils exploring future options.

Finally, in the third term, students deliver their interactive activity during half-term and inbound school visit days for the Building Bridges Partnership Project.

Postdoctoral researchers are supported in their training by their supervisors and senior leaders from the Department and wider University.

Professor Simon Aldridge (Director of the IMAT CDT), who spearheaded this departmental innovation, said: "By the end of the module, students not only understand the principles of effective engagement, they have put them into practice, building confidence and communication skills to carry into their academic careers."

Supporting at each career stage

A further advance this year has been a course specifically designed for postdoctoral researchers. Supported by a University of Oxford PCER Fellows scheme, this tailored series of workshops helps participants deepen their understanding of how to contextualise their chemical sciences research and its societal connections, map and engage with relevant stakeholders, plan effective and purposeful engagement activities, and secure funding and recognition for their efforts.

Professor Andrew Goodwin, Associate Head of Department (Research), said: "By investing in this focused programme, the Department is proactively building capacity and embedding engagement skills at the heart of research practice, empowering postdocs to create more impactful science and stronger connections with society."

A model for modern chemistry

The Department's approach offers a compelling model for training researchers not just to innovate in the lab, but to listen, inspire, and lead in society. At a time when trust in science is both essential and under pressure, we are helping to shape a future in which chemists are both innovators and ambassadors. ■

Crush the Bugs!

New initiative supports schoolchildren's understanding of antimicrobial resistance

Many of the medicines we use to treat diseases caused by microorganisms are becoming less effective. This process, known as antimicrobial resistance (AMR), occurs when certain disease-causing bacteria, viruses, fungi and parasites are no longer affected by our current antimicrobial medicines.

AMR poses a growing threat to global health, food security and achieving the 2030 Sustainable Development Goals (SDGs). According to a 2023 World Health Organization study, however, 78% of countries surveyed reported that primary and secondary school children do not receive education on antimicrobial resistance.

To overcome this gap, researchers and staff within the Department of Chemistry and at the Ineos Oxford Institute for Antimicrobial Research (IOI) have created a suite of outreach activities under the umbrella of 'Crush the Bugs!', raising awareness of AMR and how to combat this threat.

Developed for secondary school students, the outreach programmes are aligned with the GCSE and A-level science curricula while also grounded on IOI's drug discovery programme.

"By making science accessible to students, we hope to demystify the work taking place in Oxford and excite students about further education and careers in science."

Dr Helen Smith, postdoctoral researcher at the IOI and contributor to Bug Fight!

"Outstanding quality of delivery, resourcing and engagement. A very valuable experience for the students ... exceptional outreach."

School teacher

"The more people that know what antibiotic resistance is, the more people can take action. Whether this is taking your full course of antibiotics, or one day becoming a researcher actively looking for solutions, we want to inspire the next generation to play an active role in combatting antibiotic resistance."

Emily Freeman, IOI DPhil student and co-creator of Bug Fight!

Handling past scientific equipment in Oxford's History of Science Museum

'Bug Fight!' is an in-school workshop educating Key Stage 4 students (aged 14–16) about the process of finding and developing effective antibiotic treatments. This interactive workshop draws on research in the Schofield Group on combination therapies for drug-resistant infections. These treatments combine an antibiotic with a bacterial enzyme inhibitor which stops the bacteria from breaking down the antibiotic so it can successfully treat infections.

'Bug Fight!' includes engaging puzzles, as well as a practical investigation using material from the Schofield lab. It challenges students to think like a researcher and make decisions on drug development based on their results.

A key feature of the workshop is a Q&A session with researchers from the IOI, where students learn more about varied career journeys and university life.

In addition to local delivery in Oxfordshire schools, the Department regularly takes the workshop out on roadshows, visiting state schools across the UK. Since its development in 2022–23, 1,904 students across 26 schools in Oxfordshire, Dorset, Cornwall, Buckinghamshire, North Wales, South Yorkshire and Cumbria have taken part.

'Battle the Bugs!' are study days delivered in a collaboration between the Department, the IOI, the History of Science Museum and Trinity College. Students take part in a carousel of activities: interacting with members of the Department, learning more about the University of Oxford's work on life-saving medicines, and gaining hands-on laboratory experience by synthesising their own antifungal compound. This provides school pupils with a rare and valuable opportunity to work in a university laboratory environment.

Students learn about Oxford's long history of antibiotic research, including the stories of Alexander Fleming and Dorothy Hodgkin's work on penicillin. They are able to handle historic objects, and today's active fight against AMR is brought to life by researchers who work on finding new antibiotics. ■

Return of the tearoom

The PTCL common room has been abuzz on weekday mornings since Trinity Term 2025, as the tea and coffee returned to the building after a COVID-induced hiatus

Readers of Periodic may recall the Physical and Theoretical Chemistry Laboratory (PTCL) tearoom fondly from their time as a Part II or DPhil student; for decades it was a place for staff and students to relax and take a break from labs and offices. Even retired members of the Department were regular visitors, appearing at lunchtime to meet old friends and colleagues over soup and sandwiches, and the sunny common room was a flourishing community space. There was decline during the pandemic years, but recently the convivial atmosphere has returned, thanks to the efforts of a team of volunteers, with much help from the Chemistry facilities management team.

Along with refreshing the common room interior with art, plants, and blackboards, the student and postdoc volunteers have been running coffee mornings on a rota, providing opportunities for all members of the PTCL to socialise and mix across research groups, increasing the community spirit of the building.

The new blackboards have been much utilised to assist in scientific conversations, with maths problems and cryptic crosswords, as well as some artistic contributions. The walls are now adorned with new artwork featuring images of colloid drying patterns produced by former MChem student Illaria Beechey-Newman.

The initiative to revive the common room was spearheaded by Professor Susan Perkin and the PTCL coffee committee, joined by many volunteers across the section.

After a successful trial period it is hoped that the tearoom buzz will continue for many terms to come.

Included alongside this article are images from the common room past and present. Readers may recall the friendly faces of Betty Oliver, Marjorie Kirkby, Margaret Henwood and Peter Jackson. If you're a reading this as a Chemistry alumna/us and have memories, images or stories you'd like to share, we'd love to hear from you – please email alumni@chem.ox.ac.uk ■

Elements of the Day

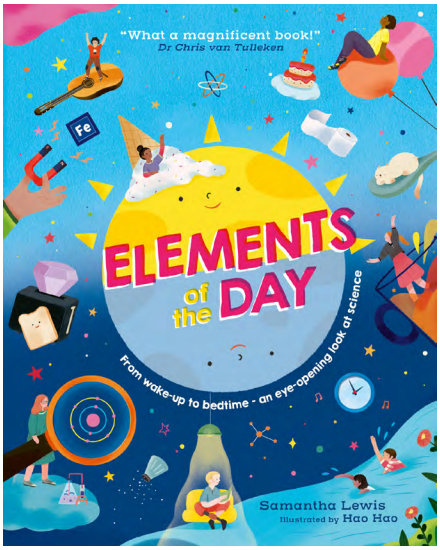
Oxford alumna Samantha Lewis (St Anne's, 1998) has written Elements of the Day, a charming picture book introducing young readers to the chemical world

Has a young child ever asked you why leaves are green? Or how raincoats keep you dry? Or what's in a battery? Samantha Lewis's new book *Elements of the Day*, will be a great read to support budding scientists' inquisitive minds.

This thoughtfully structured book, including delightful illustrations by artist Hao Hao, introduces children to chemical elements through connecting them to moments in everyday life from breakfast to bedtime. The book is suitable for a wide range of audiences, with a narrative drive which will keep older children who can read on their own engaged throughout, and has plenty of interesting illustrations and diagrams that younger children can follow with the help of a grown-up.

Elements of the Day accessibly introduces a wide range of ideas, from the periodic table to the origin of all the elements in stellar fusion. Other topics covered include explaining how breakfast cereals are magnetic due to the presence of iron, how pencils leave marks on a page through shearing off of graphite planes, how a cake rises through carbon dioxide gas production, and how our bodies signal sleepiness through melatonin production.

Samantha's explanations of the importance of structure in determining properties are particularly elegant. For instance, she illustrates allotropes – different structural forms of the same element – by highlighting the difference between the soot that forms on burnt toast (carbon) and diamonds (still carbon) in the breakfast section of the book. She also clearly explains how compounds, like tasty sodium chloride, can be so different from their constituent elements, in this case reactive sodium metal and toxic chlorine gas.



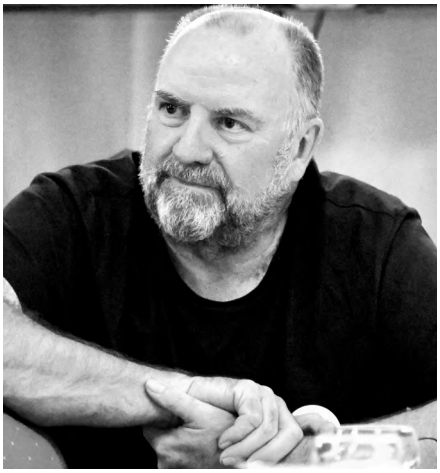
The book has achieved great success so far, having reached the #1 bestseller on Amazon in children's books on chemistry and being selected as *The Times* Children's Book of the Week.

After completing her MChem at Oxford (St Anne's), Samantha Lewis worked as a science teacher before transitioning into television. She now produces and develops science documentaries and podcasts for, amongst others, the BBC and Netflix. Samantha is based in London, where she lives with her husband and two sons.

Samantha said: "There were many things I wanted to be growing up, but by the time I applied to university, I had decided I wanted to be a research chemist, so I could discover a cure for cancer (obviously). Unfortunately, what I actually discovered was that I was really bad at working in a lab (like, dangerously bad)... I hope I can inspire other people to go and discover cures and do all the other wonderful things that scientists do, while not being left in charge of any potentially explosive chemicals!" ■

Shifting paradigms

Dr Neil Carpenter (St John's, 1986) completed a DPhil in 1989, working with Prof George Fleet on the identification and synthesis of anti-AIDS and cancer drugs. He began his career in the chemical industry before moving to strategic business development and consultancy. Here, he talks to Periodic about his varied career and interests.



A background in organic chemistry allows you to see how to get from one place to another. The ability to break paradigms is one of the key things I learned doing my DPhil.

At that time I was investigating anti-AIDS and cancer drugs, which involved working with Kew Gardens. I remember spending several months trying to make a particular molecule, which included a primary triflate group. One Friday at 5 o'clock, George [Fleet] said to me: "If you want to have a go, do, and I will see you on Monday morning." I worked all weekend, and in the end I got a spectrum which proved I'd made the right product. I was staring at it when George came in and said: "Looks like it worked!" The group went on to continue the work, and my thesis became the seminal publication in the area (unknown to me!). I once introduced myself to a speaker at a Chemistry alumni event who had continued George's work, and he said "are you *the* Neil Carpenter?"

That early breakthrough gave me confidence to break paradigms. My career, both in science and business, has been mostly about reframing problems. All the things I do are essentially the same "chemistry" way of working, but in different fields.

For instance, a friend of mine bought the NB Distillery in North Berwick. When we went to look around, I advised him how to do distillation properly, and they have been able to make a rum which has an amazing flavour. We experimented with making chocolate truffles and cocktails, trying rum at different concentrations and different sorts of chocolate. You need enough rum to get a good flavour, but if you put in too much the melting point is reduced and the ganache won't set. Sharing my knowledge of chemistry – how to do proper distillation, extraction of flavours – has enabled us to make a rum with great flavour and colour, in a natural way.

Small companies with great ideas can find it hard to break through and get approval for something new. You need patience and tenacity. Helping companies with the chemistry to solve problems in a good way, and to get better solutions, is what motivates me.

Another project I have worked on involves biodegradeable tree guards, which are made using British wool. This product recently won a Net Zero Award from Confor (Confederation of Forest Industries), for making a specific and measurable contribution to the forestry and wood industry's efforts to deliver the UK's net zero ambitions.

The good thing is that it breaks down slowly over around five years as the tree grows, unlike many other guards that don't biodegrade, and can kill the tree if they don't break as it grows. As the wool degrades, it leaves tiny tubes for lichen to invade and support the breakdown of the guard. The carbon emissions to produce the plastic guards that normally protect those trees from deer and squirrels will be considerable. Having a carbon-neutral guard would be brilliant.

I have also worked with charities that provide support for people diagnosed with and recovering from cancer. With the support of the British Beauty Council and the Made for Life Foundation, I wrote a paper on research around the globe into touch therapy and its benefits for cancer patients. The evidence showed that touch therapy helps people sleep and manage pain better. The UK now has a standard for training therapists in this area, and the Made For life Foundation has trained over 2,000 therapists to make sure people living with cancer can get the support they need.

I use my chemistry every day in the way that I think about things, and in the work I do. That ability to assess things and start from the bottom up, from the chemical building blocks, is really important. I have never been motivated by earning a large salary – what motivates me is the drive to solve problems in a better way and get better solutions.

I would like to continue to help people who need it, especially those who aren't properly looked after. The ability to help people, and the planet, is what motivates me. If you feel you can make a difference, then why wouldn't you? ■

Training tomorrow's scientists

Manufacturing inorganic materials for the future

The EPSRC Centre for Doctoral Training in Inorganic Materials for Advanced Manufacturing (IMAT) is a new DPhil programme based out of the Chemistry and Materials departments. Directed by a team of five senior academics (Profs Simon Aldridge FRS, Simon Clarke, Nicole Grobert, Kylie Vincent and Charlotte Williams FRS), this four-year multi-disciplinary programme accepts around a dozen students each year.

The programme begins with a series of taught courses focusing on a wide range of topics around inorganic materials, including their design, synthesis and characterisation. Following four months of taught course, each student completes a two-month industrial internship at one of the partners involved with the CDT programme. After completing the internship, the students begin 3.5-year DPhil research projects in their chosen field.

As the first cohort come to the end of their first year, let's take the chance to meet some of them and hear about their DPhil experiences.

The IMAT CDT cohort on a visit to National Thin-Film Cluster Facility in Oxford's Department of Physics.

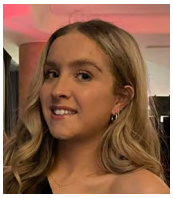
The application process

The application to the IMAT CDT is aligned with the applications to other DPhil programmes at the University of Oxford. For the initial application we had to write 1000 words focusing on our personal interest in a particular field, our past experiences and our motivation to apply to the CDT. Rather than applying to a single project, we had the opportunity to choose and rank three different projects out of a list of around fifty. Spoilt for choice, some may say.

This then led onto various interviews, including 25 minute meetings with the academics associated with the selected projects. I personally felt this was a great opportunity to meet the academics I could be working with. Alongside these more 'casual' interviews we each had a technical panel interview, which served to examine our knowledge in inorganic materials and research skills.

I value that the CDT is run as a cohort scheme. It gives me a great opportunity to meet new friends. It can be daunting to move to a new city, so starting on the taught course was great for easing into the DPhil process. I also enjoyed the industrial internship; I had never worked in industry before, so it was extremely useful to see how different the environment is when compared to academia.

I'd advise applicants to prepare for the technical interview well. As long as you use the prompts that the management team advise, you can't really go wrong. I also think it's a good idea to get to know your supervisors in the initial interviews, ask them lots of questions on how they manage their team. You will be working with them every day so it is important to check that you are compatible with their management style.



Maisy Barnett

The training course

The taught course started by covering all the basics of inorganic chemistry and materials science. We then went into detail about recent discoveries in the field. Throughout the course we also heard from experts and the work they do within industrial settings, and how this ties into academic research.

I particularly enjoyed work we did on science policy. This was different to the more 'core' training, and it was interesting to see how we can use our scientific skills in a different setting.

The CDT has a strong emphasis on industry engagement. We had several visits to industry partners during the course, which were interesting, and provided opportunities to gain insight into how different a lab can be at industry vs academia. It has also helped us to learn about how collaborative research can be, and how basic research translates into real-world applications.

As a material scientist, it was good to get a basic understanding of the underlying principles before entering the field. It also helped provide an introduction to the advanced characterisation techniques that I am going to use in my DPhil.

Gabriella More O'Ferrall

The industrial internship

I worked at Econic Technologies, based in Alderley Park in Macclesfield.

Econic was founded by Professor Charlotte Williams, then at Imperial College London, and now Professor of Inorganic Chemistry in Oxford. They offer a bespoke technology for the synthesis of high-performance products such as flexible polyurethane foams and surfactants, all whilst using CO_2 as a feedstock.

During the two-month internship I was placed in the application development team, whose focus is to test the manufactured products for applications in industry.

The internship was fantastic! I enjoyed living somewhere new and experiencing life in industry. The company invested a lot into my learning and growth as a chemist, and I had a great supervisor who looked after me and was very motivating.

Time management is certainly at the top of the list of valuable skills I learned. During the two months I had several hard deadlines, and it was important to learn to prioritise certain work, and stick to the given time frame. I also gained invaluable communication skills, working in a corporate setting for the first time.

This experience has given me time management, planning and organisational skills, as well as an appreciation of the importance of moving forward. In academia quite often one can get stuck in the "why", which can stunt progress. But after working in industry, I can now appreciate that why is not always as important as progress and results.

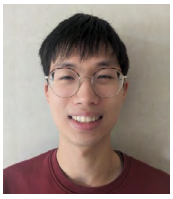
Right now, I definitely would like to go into industry as a career, specifically a start-up company. It gives you many opportunities, lots of freedom to think, and it is a good in-between of academia and big industry.

Josh McConnell

The research project

I'm looking forward to learning new methods of making and characterising polymers, as well as improving my coding skills and understanding of machine learning. I'm excited to carry out research in an area that interests me, and hopefully to become an expert in that area one day.

During the IMAT course we had many opportunities to interact with and learn from scientists working in industry, which helped me to appreciate factors such as scalability that are very important for developing new sustainable technologies. We were also given a dedicated period of time to write research proposals for our projects, which helped me to gain a much better understanding of my research area before starting in the lab.



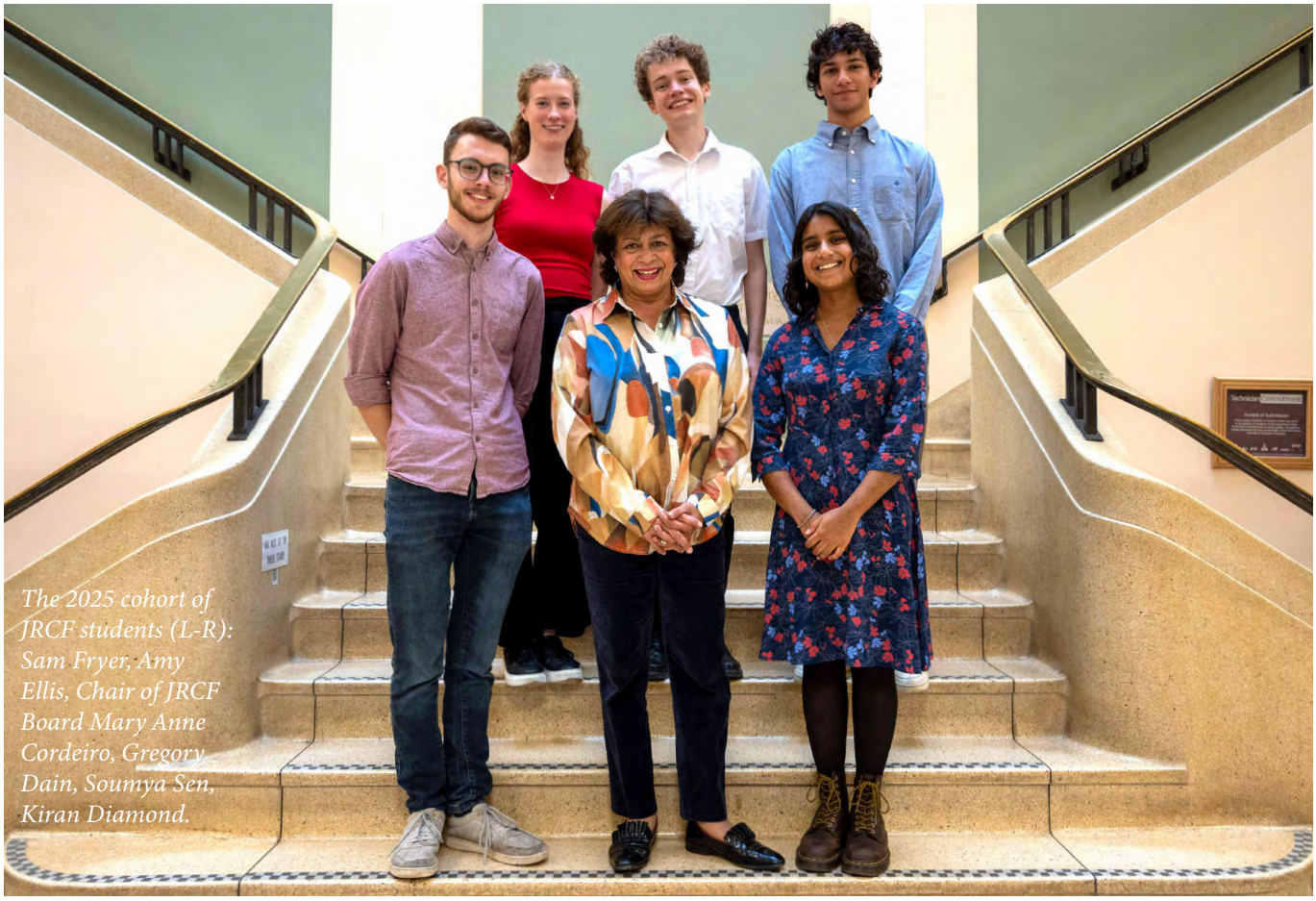
David Ning

Looking ahead

So, the first year of the IMAT CDT has gone smoothly, with the initial cohort integrating well and gaining strong preparation for their research projects. In September, a second IMAT cohort of 13 joined, and this time they started alongside 14 students from another new CDT: Chemical Synthesis for a Healthy Planet (CSHP). A second EPSRC-funded programme, CSHP CDT focuses on developing a sustainable, innovative chemistry culture and training the next generation of synthetic chemists to address major emerging and future global challenges in human health, energy, materials and food security. ■

The Joseph Rufino Cordeiro Foundation summer studentships

A successful initiative to provide summer studentships at Oxford Chemistry is now in its third year. The Joseph Rufino Cordeiro Foundation studentships have so far enabled three cohorts of undergraduates to pursue research projects in sustainable chemistry at Oxford, with supervision from members of Chemistry academic staff, and accommodation provided by Worcester College.



The 2025 cohort of JRCF students (L-R): Sam Fryer, Amy Ellis, Chair of JRCF Board Mary Anne Cordeiro, Gregory Dain, Soumya Sen, Kiran Diamond.

The Joseph Rufino Cordeiro Foundation (JRCF) is chaired by Mary Anne Cordeiro, an alumna of the Department of Chemistry and Worcester College. Mary Anne's family set up the Foundation in 2022 to honour the memory and legacy of the late Joseph Rufino Cordeiro, who was a scientist of Goan origin and educated in India. The JRCF promotes the advancement of science by providing funding for scientific research projects as well as improving research capabilities among early-stage academic researchers and students in higher education.

With the Foundation's goals in mind, the Trustees established the JRCF Summer Research Studentships at the Department of Chemistry in 2023. The programme was designed to provide students, particularly those currently under-represented in chemistry research environments, with the opportunity to pursue chemistry research at Oxford, with a current focus on sustainable chemistry.

The first cohort of students, Nomagugu Moyo, Benjamin Stewart and Sivarajan Sivakumar, arrived in 2023 and undertook projects ranging from ways to reduce pollution from the dyeing industry to the application of machine learning to help identify sustainable battery materials. The students greatly enjoyed their experiences and the Foundation was delighted to attract high quality scholars who presented ground-breaking research.

"I hope the studentship continues for many years so that lots more students can experience the chance that I have been given."

Abigail Mortimer-Ball, former JRCF student

Former JRCF students (L-R) Aleksandra Li, Benjamin Stewart and Akshat Pai during their time in Oxford.

Encouraged by the positive results for this unique programme, in 2024 the Department was delighted to extend the programme and host 5 students: Charlie Muston, Abigail Mortimer-Ball, Natasza Rybacka, Aleksandra Li and Akshat Pai Fondekar. After the successful completion of their placements, all the students said that they were inspired to continue in research, and Abigail commented that the opportunity "made such a massive difference to me and my career trajectory. I hope the studentship continues for many years so that lots more students can experience the chance that I have been given. I learnt so many new skills and the studentship helped me realise that, after my Masters, I would love to pursue a PhD in sustainable chemistry."

Abigail's experience highlights the deep and lasting difference a committed donor can make in the lives of early-career chemists. The programme offers a rare and transformative opportunity to support cutting-edge research while helping talented students build confidence and take meaningful steps toward a long-term future in science – all while honouring the legacy of a loved one.

The successful programme continues to go from strength to strength, and another five JRCF students completed their placements in summer 2025: Gregory Dain, worked in the Ritchie group, Kiran Diamond in the Hoye group, Amy Ellis in the Neidig group, Sam Fryer in the Gregory group, and Soumya Sen in the Tait group. The students worked on a range of projects ranging from green plasma technology and solar energy to materials for advanced energy storage.

Professor Grant Ritchie, Head of Physical and Theoretical Chemistry until Michaelmas 2025 and Fellow of Worcester College says: "The Department has been delighted to host three cohorts of highly talented summer students whose research has focussed on a diverse range of fundamental and applied problems relating to sustainable chemistry. We are extremely grateful to the JRC Foundation and to Worcester College for partnering with us to provide these wonderful opportunities for students. The studentships have become a standout example of how donor-led initiatives can enrich the student experience and bring fresh energy and ideas into the Department's research community."

Mary Anne says: "We were particularly pleased with the large number of applications we received in all three years from a range of students (including some based in Europe). This required the selection panel to be even more focused on shortlisting students based on merit and fit with the Chemistry Department's research themes. I personally was delighted that a student of Goan-origin applied and made the cut to the final five selected for the awards in the second year. We are delighted that the high calibre of students are even more inspired by their work over the summer to continue into a career of research." ■

"The studentships have become a standout example of how donor-led initiatives can enrich the student experience and bring fresh energy and ideas into the Department's research community"

Professor Grant Ritchie, Head of Physical & Theoretical Chemistry

Professor Edman Tsang

The Department of Chemistry is saddened to announce that our colleague, Professor Shik Chi Edman Tsang, died at the end of May in Hong Kong. He had been in hospital since being taken suddenly ill last autumn.

Edman had been a loyal and successful member of the Department of Chemistry for many years, and his friendship and scientific contributions will be remembered fondly by all who knew him.

Edman was Professor of Inorganic Chemistry in the Department of Chemistry from 2007. Before this, he held research positions at the University of Reading, where he had previously completed his PhD in 1990.

His main research interests were in nanomaterials and heterogeneous catalysis, focusing on research with applications in the fields of energy and the environment.

His expertise in the design and architecture of nanocatalysts, and their *in situ* diffraction and spectroscopic characterization, has lead to an increased understanding of catalytic surfaces and interfaces. He also founded OXGRIN, a spin-out company for the development and commercialisation of breakthrough catalytic technologies in green energy applications.

Professor Stephen Faulkner, Head of the Department of Chemistry, said: "Having known and worked with Edman for many years, I'll miss him as both a friend and a colleague. His boundless enthusiasm for chemistry and life was contagious. His research was world-renowned and driven both by curiosity and the need to benefit the world. He has left us too soon, and leaves a legacy of science for the world, and memories for all of us who knew him." ■

Professor Graham Richards CBE FRS

Professor Graham Richards, who died in his sleep on 11 February 2025 aged 85, made exceptional contributions to Chemistry and to the University of Oxford.

Born in 1939, Graham came from a modest background – his mother left school at 11 – but he flourished academically. He read Chemistry at Brasenose College, graduating with a first in 1961, and completed his DPhil in 1964 under Richard Barrow on the electronic spectroscopy of diatomic molecules. After a period in France, he returned to Oxford as Fellow and Tutor in Physical Chemistry at Brasenose and Lecturer (later Reader and Professor) in the Physical Chemistry Laboratory.

His early research on laser spectroscopy of small molecules evolved into pioneering work in computational chemistry, then an emerging field. He applied these methods to biological systems, helping to establish computer-aided molecular design as a cornerstone of modern drug discovery. Among his innovations was an early distributed computing project that harnessed idle home computer time to screen billions of molecules for potential cancer therapies – a venture that ultimately drew on the equivalent of 450,000 years of computation.

As Chairman of the newly unified Department of Chemistry from 1997 to 2006, Graham played a central role in transforming the Department's research environment. He led the £60 million fundraising campaign for the Chemistry Research Laboratory (CRL), opened by Queen Elizabeth II in 2004. The project's success relied in part on an unprecedented equity-sharing arrangement that reflected Graham's entrepreneurial vision.

He also co-founded the University's technology transfer company, ISIS Innovation Ltd (now Oxford University Innovation), which

he directed for two decades. His leadership helped embed a culture of innovation and collaboration between academia and industry that continues to shape Oxford's scientific enterprise.

Although he retired in 2007, Graham remained deeply engaged with the University. He served on Chemistry's Development Board and was a familiar figure in the Department, known for his generosity with his time and his enthusiasm for mentoring younger colleagues.

Professor Stephen Faulkner, Head of Chemistry, said:

"Graham will be missed by all of us in Oxford, and particularly by those who've been inspired by him since undergraduate days. His research track record speaks for itself, but we also remember him as an indefatigable leader and innovator in scientific enterprise."

"I will always remember Graham as the first person to sign off an experiment for me as an undergraduate, and as the person who organised the postgraduate careers event that set me on an academic path. He'll be remembered as the first Head of the unified Department, as the enabler of the CRL, and as a theorist who brought mass participation to big problems. His care for individuals and his enthusiasm for others' success were constant. Our heartfelt condolences go to his widow, Dr Mary Phillips, and to his wider family."

Professor Chris Schofield, Director of Chemistry at the Ineos Oxford Institute, said:

"Graham Richards was a genuine pioneer in applying computational methods to biological mechanisms and drug discovery. He was an inspirational, kind, and generous leader whose vision helped create the CRL, a model for chemistry buildings worldwide, and supported links between industry and research, including the establishment of the Ineos Oxford Institute for Antimicrobial Research."

Professor Mark Brouard, formerly Head of the Department of Chemistry, said:

"As the first Chairman of the unified Department, Graham showed inspirational leadership and foresight. His pioneering work in computer-aided drug design was far ahead of its time. As a lecturer, he made complex ideas seem simple, and later as a mentor, he remained a trusted source of guidance and encouragement. He will be sorely missed by many within Oxford and across the wider scientific community." ■

Prof Andrew Hamnett

Professor Andrew Hamnett, who died on 20 May 2025 aged 77, made major contributions to electrochemistry and to higher education leadership in the UK.

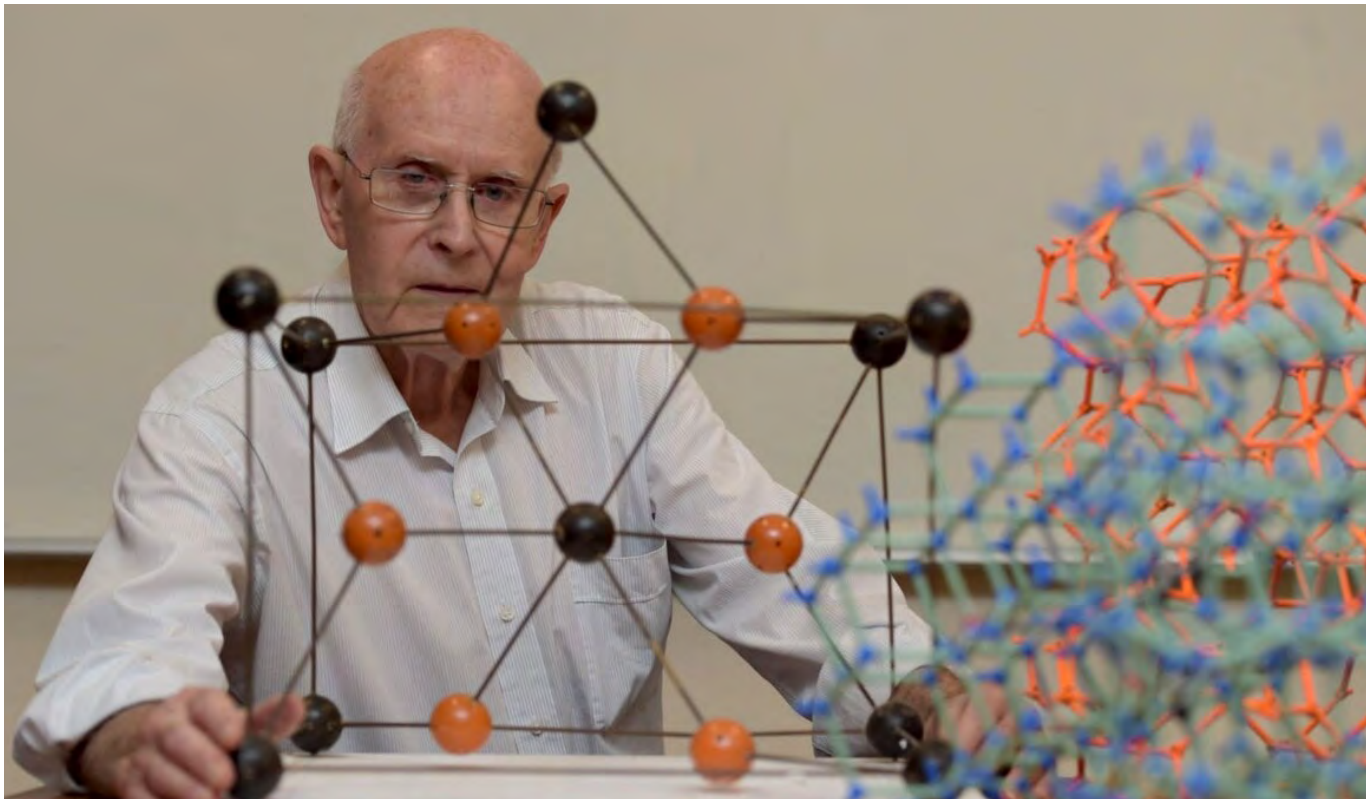
Born in Stockport, he was educated at William Hulme's Grammar School and came to Oxford on a scholarship to study Medicine at University College, switching soon after to Chemistry. He graduated with first-class honours, winning *proxime accessit* to the Gibbs Prize, and completed his DPhil at St John's under Tony Orchard, followed by a Junior Research Fellowship at The Queen's College in 1972. In the Orchard group he conducted pioneering studies in photoelectron spectroscopy, including highly cited work on lanthanide compounds and early investigations of radiation damage in solids. Known for fearless experimentation, he worked with hazardous compounds before becoming a strong advocate for laboratory safety.

After two years in Vancouver with Chris Brion, where he carried out (e,2e) electron scattering experiments and met his future wife Suzanne, he returned to Oxford to join John Goodenough's new energy research initiative. His work introduced advanced electrochemical methods such as *in situ* FTIR spectroscopy and ellipsometry, laying foundations for modern electrochemical interface analysis. In 1980 he became Lecturer in Inorganic Chemistry and Fellow at St Catherine's College.

Appointed Professor of Physical Chemistry at Newcastle University in 1989, he led influential research on fuel cells and electrochemical pollution control, and later served as Pro Vice-Chancellor for Research and then Deputy Vice-Chancellor.

In 2000 he became Principal and Vice-Chancellor of the University of Strathclyde, overseeing major structural reforms, campus redevelopment, and expansion into education and social sciences. Elected Fellow of the Royal Society of Edinburgh in 2002, he received honorary and emeritus distinctions from Newcastle and Strathclyde.

In retirement, Andrew and his wife Suzanne returned to Morpeth, where he was active as a church organist, trustee, and community leader. He is survived by Suzanne, their daughters Erica, Gillian, and Hilary, and grandsons Ralph and Luke. ■



Nobel Prize in Chemistry for Oxford alumnus Richard Robson

The Nobel Prize in Chemistry 2025 was awarded to three chemists, including University of Oxford alumnus Professor Richard Robson FRS, for their work developing metal-organic frameworks.

Prof Robson receives the award alongside Susumu Kitagawa and Omar M Yaghi. The award recognises the creation of metal-organic frameworks, or MOFs – molecules with large spaces through which gases and other chemicals can flow.

MOFs have a diverse range of applications including harvesting water from desert air, capturing carbon dioxide, storing toxic gases and catalysing chemical reactions.

Heiner Linke, Chair of the Nobel Committee for Chemistry, said: "Metal-organic frameworks have enormous potential, bringing previously unforeseen opportunities for custom-made materials with new functions."

Professor Stephen Faulkner, Head of Oxford University's Department of Chemistry, said: "Richard Robson's early work on coordination polymers and metal-organic frameworks combined original structural insights with practical innovation. He laid the groundwork for an entire field that is now fundamental to sustainable chemistry and molecular innovation. Many congratulations to all three recipients for their outstanding achievements."

Robson was born in 1937 in Glusburn, North Yorkshire. He matriculated at Brasenose College, Oxford in 1955, reading Chemistry and receiving a BA in 1959. He went on to study for a DPhil with John Barltrop in Oxford's Dyson Perrins Laboratory, which he completed in 1962, before moving to California for periods of postdoctoral research at the California Institute of Technology and Stanford University. In 1966 he moved to the University of Melbourne and remained there for the duration of his career, where he is now an Honorary Professorial Fellow.

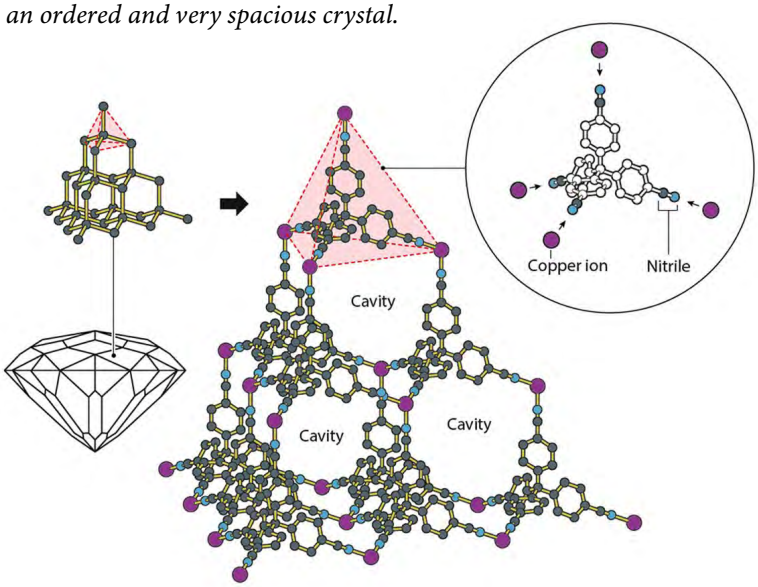
Professor Kylie Vincent, Oxford Chemistry's Associate Head of Department (People) and an alumna of the University of Melbourne, said: "Richard Robson's structural models and his gentle, thought-provoking teaching of solids have stayed with me from my undergraduate study. When I visited Melbourne in recent years, Richard would ask fondly about his former colleagues from the Department of Chemistry in Oxford. I'm delighted to see this recognition for his foundational contributions to solid frameworks."

In 1974, Robson, then a lecturer in Melbourne, was tasked with creating large wooden models of crystalline structures for first-year lectures: sodium chloride, fluorite, and so on. By drilling holes at particular angles into wooden balls, he realised they became "pre-disposed to produce the structure that we were intending to produce".

He wondered whether molecules, if specially designed in a suitable shape, might similarly assemble themselves into ordered structures? This laid the foundation for the study of molecular self-assembly – although it was more than a decade before he finally started work in the lab to test this idea out.

In 1989, Robson showed that copper ions – which prefer tetrahedral geometries – could crystallise alongside specially designed organic molecules with four rod-like arms (see figure). The result: a spacious well-ordered crystal reminiscent of diamond, but with large cavities in its structure.

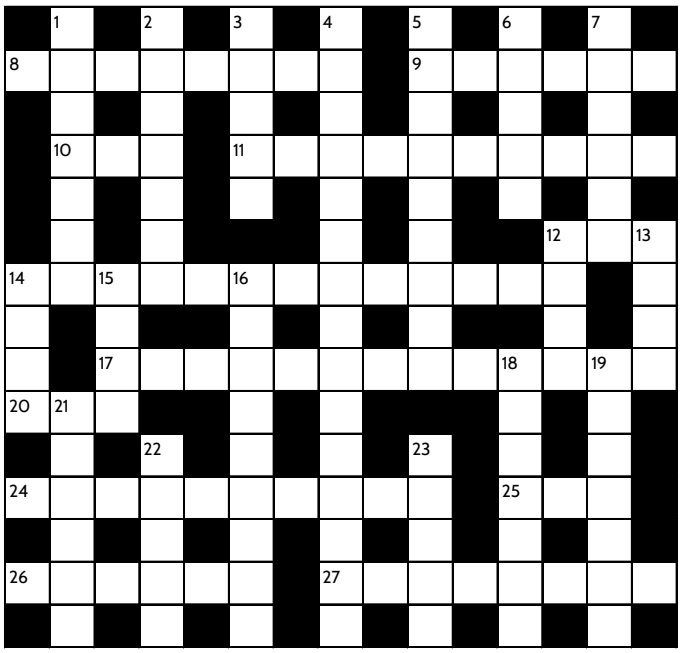
Robson was inspired by the structure of diamond, in which every carbon atom is linked to four others in a pyramid-like shape. Rather than carbon, he used copper ions and a molecule with four arms, each with a nitrile at the end. This is a chemical compound that is attracted to copper ions. When the substances were combined, they formed an ordered and very spacious crystal.



Over the following decades Robson's lab created a variety of molecular building block geometries. His work has since been built upon by Kitagawa, Yaghi, and countless other chemists.

Today, tens of thousands of different MOFs have been synthesised, with a variety of structures and properties. Some of these may contribute to solving some of the greatest chemical challenges of the future, including separating "forever chemicals" from water, breaking down traces of pharmaceuticals in the environment, and capturing carbon dioxide. ■

Chemistry crossword



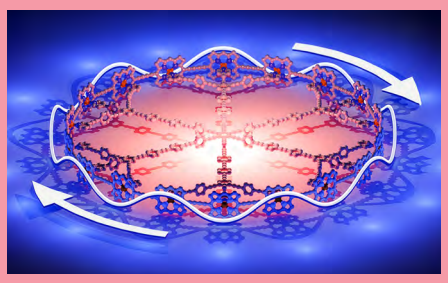
Across

8 *The Clash* frontman Joe _____ (8)
9 Element found in antiseptics (6)
10 Cleopatra's killer (3)
11 Rare earth metal used in magnets (10)
12 One billion times per second *(abbr.)* (3)
14 Giant chemical such as DNA (13)
17 Concerned with heat and energy (13)
20 Become older (3)
24 Enzyme that makes strands of 14 (10)
25 Consume (3)
26 Quantity defined by magnitude alone (6)
27 Fragrant bloom; Mrs Bucket (8)

Down

1 Georgia state capital (7)
2 Yellow element *(Brit. sp.)* (7)
3 Compound with general formula R–C(=O)–NR'R'' (5)
4 Dorothy Crowfoot Hodgkin's field (15)
5 Chain of command (9)
6 Black Sea port (5)
7 Sufficient (6)
12 Microbe (4)
13 Metal used for rust-prevention coatings (4)
14 Layered mineral (4)
15 Quote as evidence (4)
16 Decorative wood inlay (9)
18 Toxic metalloid once used in pigments (7)
19 Ape (7)
21 Sourpuss (6)
22 Series that repeats (5)
23 Conducting element (5)

The solution to the crossword may be obtained by emailing chemistry-news@chem.ox.ac.uk



The cover image depicts a molecule synthesised by Jake Holmes in Prof Harry Anderson's group. Composed of multiple aromatic rings connected by rigid triple bonds, it was designed as a template for constructing an 18-porphyrin nanoring. This macrocycle is poised near the size-limit for aromaticity, yet there is evidence for weak global aromatic and antiaromatic ring currents in the 10+ and 12+ oxidation states, with circuits of 242 and 240 π-electrons, respectively. For details of this chemistry, see J. M. Holmes, et al., J. Am. Chem. Soc. **2025**, *147, 32840–32850* doi.org/10.1021/jacs.5c09149

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Susan Davis, Alumni Relations & Communications Manager

alumni@chem.ox.ac.uk

Alumni Relations and Communications Office,
Physical and Theoretical Chemistry Laboratory,
South Parks Road
Oxford OX1 3QZ

Editors Susan Davis and Thomas Player

Science Writers Maisy Barnett and Neave Taylor

Design Thomas Player

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DEPARTMENT OF CHEMISTRY

UNIVERSITY OF OXFORD