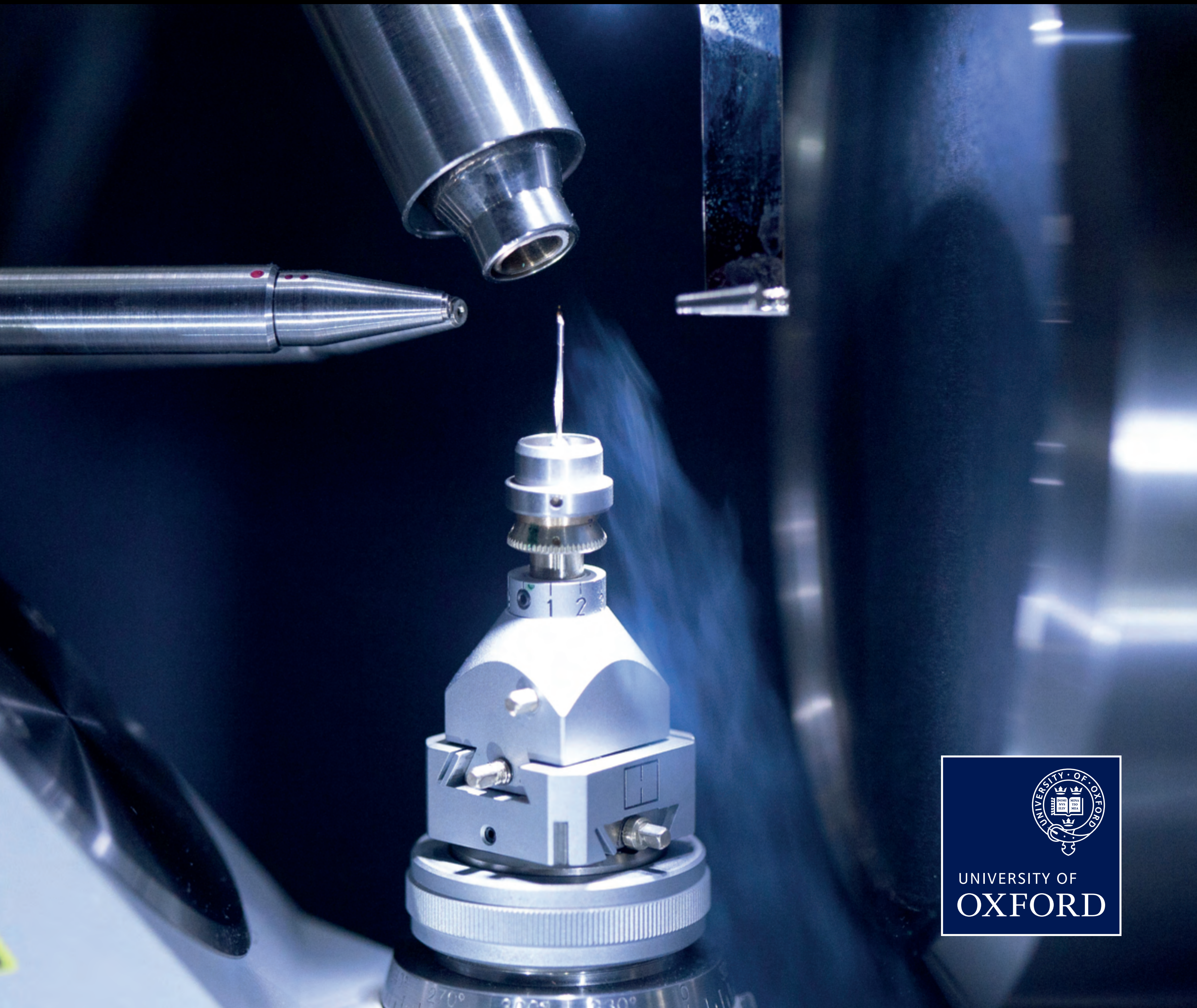
09

2021-2022

Periodic

The Magazine of the Department of Chemistry



UNIVERSITY OF OXFORD

From the Head of Department

Professor Mark Brouard

Welcome to the ninth edition of Periodic magazine. 2021 has been another extraordinary year with continuing challenges, one of which has been the lack of opportunity to meet in person with alumni and friends of the Department. As normal life gradually resumes I hope that situation will change soon. These post-pandemic times have also brought opportunities for creative new ways of working, and I have been impressed by the adaptability and dedication of our students and my colleagues.

Oxford Chemistry has seen a number of changes in 2021 with the retirement of Professor Fraser Armstrong and Professor Peter Edwards, both of whom made invaluable contributions to the Department. At the beginning of Michaelmas Term we were delighted to welcome Dr Ludmilla Steier, who joins us as Associate Professor and Teaching Fellow at St Catherine's College. The Chemistry management team has seen some changes this year too as we welcomed Professor Steve Faulkner to the newly-created role of Associate Head of Department for People. Making sure that everyone involved in Oxford Chemistry is heard is particularly important in these times, and Steve talks in detail about his new role and plans for the future on page 14. In September, we welcomed Professor Ed Anderson as the new Head of Organic Chemistry. Ed takes over from Professor Chris Schofield, whose able leadership of the Organic section spanned from 2011 to 2021. We thank him for his service and congratulate him on his new role as Head of Chemistry at the new Ineos Oxford Institute for Antimicrobial Research.

The creation of the Ineos Oxford Institute, a collaboration between the University and one of the world's largest manufacturing companies, was one of the many exciting events of 2021 – bringing world-leading researchers together to tackle one of the world's greatest healthcare challenges. Another major new development of this year has been the establishment of the new Kavli Institute for Nanoscience Discovery. Led by Professor Dame Carol Robinson and supported by the US Kavli Foundation, the new interdisciplinary institute includes several groups from the Department and we are proud that Oxford chemists are at the forefront of transformative research that promises to tackle some of the most pressing issues of the day.

As we go to press, we have just witnessed the record-breaking flotation of Oxford Nanopore on the London Stock Exchange and I congratulate Professor Hagan Bayley on whose original research the company is based. Nanopore has created technology that can benefit our lives in a host of ways, including the identification and tracking of Covid-19 variants around the world. I believe that its phenomenal success truly shows the many benefits that investment in fundamental science can bring.

Our DPhil students continue to drive forward innovative research, and we are deeply grateful for the support that alumni and friends have given to our DPhil Centenary Campaign. I hope that, in the following pages, you enjoy reading about their progress, and some of the very many exciting new developments in research and teaching in the Department.

On the cover: Cover image shows a Supernova X-ray diffractometer with switchable microfocus copper and molybdenum sources. The instrument can collect single crystal diffraction between 90 and 500 K and is used for determination of the atomic structure of crystals ranging from those composed of organic and organometallic molecules to extended framework materials. Photograph by Dr Karl Harrison.

News & Achievements

A selection of recent highlights. More news can be found at **www.chem.ox.ac.uk**

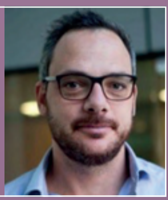

Professor Charlotte Williams OBE and Nobel Laureate and Oxford alumnus **Stanley Whittingham** were elected **Fellows of the Royal Society**.

The work of three Oxford chemists was recognised in the prestigious Royal Society of Chemistry (RSC) Awards, which celebrate outstanding work and achievements in advancing the chemical sciences.

Professor Fernanda Duarte won the **RSC Harrison-Meldola Memorial Award** for introducing multidisciplinary approaches to rationalise complex (bio)chemical reaction mechanisms, guiding rational molecular design.

Professor Andrew Goodwin received the **RSC Peter Day Award** for studies of structural complexity in framework materials.

Professor Charlotte Williams was awarded the **RSC Tilden Prize** for her contributions to sustainable polymer chemistry.



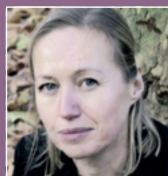
Professor Philipp Kukura was awarded the 2021 **Medal for Light Microscopy** from the Royal Microscopical Society.

Professor Kylie Vincent has been appointed as the University's first academic **Champion for Women in Entrepreneurship**. Read more about her role on page 18.

Professor Steve Davies received the 2021 **Royal Society Mullard Award** in recognition of his long and successful record in converting brilliant academic ideas to commercial successes with world impact in the biotech sector.

The Chemistry Teaching Laboratories Team were winners of the **Vice-Chancellor's Education Awards** in 2020 for the design, implementation and evaluation of a truly integrated chemistry practical course for undergraduates. They presented their work at the inaugural **Teaching and Learning Showcase**, a new biennial event for Oxford, held in Trinity Term 2021.

Dr Megan Midson, Course Developer and Demonstrator, joined four other members of the Teaching Labs Team (Drs Malcolm Stewart, Andrew Worrall, Zoe Smallwood and Sam Cahill) in being awarded **Fellowship of the Higher Education Academy**.



Professor Véronique Gouverneur received the 2022 **ACS Arthur C. Cope Award**, one of the highest honours bestowed by the American Chemical Society. The award recognises outstanding achievement in the field of organic chemistry.

Dr Weston Struwe received an award from the UK Research and Innovation Future Leaders Fellowship scheme, which helps universities to recruit, develop and retain world-class researchers.

Professor Sir Christopher M. Dobson
FRS FMedSci FRSC

Professor Sir Christopher M. Dobson, FRS FMedSci FRSC

Many Oxford chemists will recall Chris Dobson in his many guises as chemistry tutor, lecturer in the Inorganic Chemistry Laboratory, supervisor, colleague or founding member of the Oxford Centre for Molecular Sciences. We are aware that the news of his untimely death in September 2019, whilst reported in *The Times* and *The Guardian*, may not have reached all Oxford alumni, especially given the ensuing Covid outbreak.

Despite his numerous prestigious awards and the knighthood conferred in the 2018 Queen's Birthday Honours List for his contributions to Science and Higher Education, Chris remained "Chris" to the many who had the privilege of working alongside him. In addition to the kindness and genuine interest he showed to all he met, he will be remembered for his pioneering research into the chemical processes that disrupt the production of healthy proteins, resulting instead in the formation of toxic amyloid deposits.

Chris had a long association with Oxford from 1967 to 2001. After attending Abingdon School, he read Chemistry at Keble and moved to Merton for his DPhil on early studies to determine the structure and dynamics of proteins in solution using nuclear magnetic resonance (NMR) spectroscopy, with the late Professor R.J.P. Williams. After research fellowships at Merton and Linacre, he was appointed Assistant Professor of Chemistry at Harvard University in 1977. Chris returned to Oxford in 1980, as a University Lecturer in the Chemistry Department and a Fellow of Lady Margaret Hall (LMH).

Chris's research interests then ranged from topics as diverse as the folding mechanism of proteins (including lysozymes and other amyloid forming proteins), the hydration and silicate polymerisation of cements, to the dynamics of crystalline penicillins. These studies all relied on state-of-the art solution and solid-state NMR spectroscopy. Chris was fascinated by so much: if an experiment had not produced the expected results, he always wondered what this might mean - and would send the student or postdoc back to the lab to look into this further. He was a true optimist and great thinker 'outside-the-box'. In 1981, Chris was awarded the Corday–Morgan Medal and Prize, by the Royal Society of Chemistry, for the most meritorious contributions to experimental chemistry, the first of over 40 academic honours he went on to receive.

Chris was a founding member of the Oxford Centre for Molecular Sciences (OCMS), an interdisciplinary research centre established in 1988, which pioneered a multidisciplinary and collaborative approach to the study of important problems in chemistry, biochemistry and chemical biology. He served as co-Director of OCMS from 1988 and then as Director from 1998. Chris's interests in protein folding and misfolding, and their importance in disease, continued to develop during this period. Chris was promoted to Professor of Chemistry in 1996, the same year he was elected a Fellow of the Royal Society.

After 21 years as a chemistry professor and Fellow in Oxford, Chris moved to the University of Cambridge in 2001 as the John Humphrey Plummer Professor of Chemical and Structural Biology and then, in 2007, was appointed Master of St John's College, Cambridge - a role he thoroughly enjoyed. In 2012, he founded the Cambridge Centre for Misfolding Diseases and, in 2016, co-founded a biotech start-up company with the aim to find new therapeutics for Alzheimer's and Parkinson's Diseases. Sadly, Chris's remarkable scientific career was cut short by a diagnosis of cancer early in 2019, and he died in the Royal Marsden Hospital that September.

Many tributes have been paid to Chris, a caring friend and wonderful colleague, all emphasising his warmth, good humour and time for everyone. He published over 850 papers during his career and supervised more than 40 Oxford DPhil students and numerous post-docs from all over the world. Chris is survived by his wife Mary (née Schove), a historian of medicine and former Director of the Oxford Wellcome Unit for the History of Medicine, and their sons, Richard and William.

A symposium in Oxford in the spring of 2022 (unavoidably delayed due to COVID restrictions) is currently being planned to celebrate Chris's research and scientific legacy. If you would be interested in receiving more details of this, please contact **christina.redfield@bioch.ox.ac.uk** or **development@lmh.ox.ac.uk**.

We also wish to collect anecdotes from Chris's time in Oxford and your recollections of him, so please email them to **development@lmh.ox.ac.uk**.

LMH is establishing a Chris Dobson Research Fund to support DPhil students and post-docs undertaking research in the areas he was so passionate about, with the first awards to start in the autumn of 2022.

Karen Topping (LMH Chemistry, 1981-88) and Professor Christina Redfield (Dobson Group, 1980-2001)

Professor Tony Downs

In February 2021 the Department was saddened to announce the death of former colleague Professor Tony Downs at the age of 85.

Tony joined the Inorganic Chemistry Laboratory in 1966, first as a senior research officer, then as lecturer and latterly as Professor. He was also (for 37 years) a dedicated and inspirational tutor in inorganic chemistry at Jesus College, before retiring from both positions in 2003.

Tony was originally from Northampton, was educated at Lincoln School, and won an undergraduate scholarship to read natural sciences at St John's College Cambridge. He stayed in Cambridge to work for his doctoral degree, which he received in 1961 for work on perfluoroorgano compounds of sulphur, under the supervision of Profs Harry Emeléus and Evelyn Ebsworth. Prior to coming to Oxford, he held a Salters' Fellowship in Cambridge and a lecturer position at the University of Newcastle-upon-Tyne.

Tony's research interests in Oxford focussed primarily on fundamental studies of the reactivity of both main group and transition elements, including seminal work on both main group metal hydrides and the chemistry of xenon. His work was characterized, in particular, by the use of rigorous techniques to investigate very reactive molecular compounds, with the synthesis of digallane, finally achieved in 1989, being described at the time as a 'tour de force.'

Many of the compounds that interested Tony were highly reactive and/or potentially explosive, and research students of a particular vintage (ca. 1979) will recall an incident in the ICL that made the front pages of both the *Oxford Mail* and the student newspaper *'Cherwell.'* Following an accident in one of the top-floor laboratories, Tony calmly defused an explosive mixture of diborane and liquid oxygen (approximating to rocket fuel) while the fire brigade watched on. The newspaper headline 'Don defies bomb death...' contrasted with Tony's (typically) unflustered response: 'I'm used to this kind of thing...'

Aside from his calmness, members of Tony's former research group (and the wider University) also remember him warmly for his generosity, his hospitality, his unfailing good humour, and his unstinting support (and that of his wife Mary).

Away from the laboratory, Tony was very fond of travelling (including numerous trips to South America and a group trek to the Himalayas!), classical music, photography and cricket. He was a member of Hampshire County Cricket Club for more than 20 years and would entertain the team to dinner at Jesus College when they visited early in the season to play against the University in the Parks.

Professor Tony Downs

Professor Allen Hill FRS

In August the Department was sad to announce the death of Professor Allen Hill FRS. A graduate of Queen's University, Belfast, Allen came to the Department of Chemistry in 1962 and became a Fellow of The Queen's College, Oxford in 1965, retiring in 2004. He and his research group made seminal contributions to the electrochemistry of redox-active proteins. In particular, work carried out in the early 1980s paved the way for the development of electronic blood glucose sensors, which came to market in 1989 and have revolutionised the management of diabetes globally.

Fingerprick blood glucose testing allows people with type 1 diabetes to measure and understand the effect of food, exercise, illness and numerous other factors on their blood glucose levels, enabling them to reduce the risk of dangerous highs and lows, as well as serious long-term complications. Even with the advent of continuous glucose monitoring (via interstitial fluid) and closed loop insulin delivery systems, fingerprick blood glucose testing still enables essential calibration of these systems.

Allen was elected a Fellow of the Royal Society in 1990 and amongst many medals and awards from learned societies around the world he received the prestigious Royal Medal of the Royal Society in 2010 for his pioneering work on protein electrochemistry. The work on the glucose sensor, carried out in the Inorganic Chemistry Laboratory, was also recognised in 2012 as a National Chemical Landmark by the Royal Society of Chemistry. He was vigorous in successfully bringing the glucose sensor to market in the 1980s paving the way for many subsequent spin-outs from the Department of Chemistry.

Allen was an inspiring mentor to a number of researchers who have gone on to lead teams in academia and in industry. He will be remembered by those who knew him as a very warm, giving and humorous member of the Department and he will be sadly missed by many around the world.

Professor Allen Hill FRS

Dr Stephen Simpson

Dr Stephen Simpson

The Department was sad to announce the death of Dr Stephen Simpson in 2020. Stephen joined the Physical Chemistry Laboratory in 1969 and served as both lecturer in Physical Chemistry and Fellow at Wadham college for 28 years until his retirement in 1997. He was an inspiration to a large number of undergraduates, Part II and DPhil students and postdocs whom he taught or guided, and all will have their own fond memories of him.

Stephen was an undergraduate chemist at Oxford completing his Part II project with John Barltrop in the Dyson Perrins Laboratory before undertaking his DPhil studies in the area of molecular force fields under the supervision of Jack Linnett in the Inorganic Chemistry Laboratory. From there Stephen held post-doctoral positions with Don Hornig, first in Princeton and then at Brown University, before moving to Cambridge to work with R G W Norrish, and eventually to the National Physical Laboratory and finally Oxford.

The majority of Stephen's work in Oxford concerned the detailed measurements of energy transfer in small molecules, particularly carbon monoxide. He used shock tube techniques at high temperatures, and chemical laser excitation at lower temperatures in his extensive gas phase studies. In later years he showed his experimental skills in building instrumentation for the study of the photodissociative behaviour of adsorbed molecules on dielectric surfaces. Older members of the Department will remember his mountaineering skills, developed both in Europe and the Himalayas. Stephen inspired students with his infectious enthusiasm and he is remembered with great affection by his former tutees. He will be sadly missed by all those who knew him.

New Research

Karen Heathcote reports on new work from the Conway group, and Thomas Player reports on work by the Farrer, Langton and Ritchie groups.

Towards a new treatment for hypoxic tumours

The Conway group have collaborated with Ester Hammond's group in the Department of Oncology to develop and test a novel hypoxia-activated prodrug, which could have significant implications for cancer treatments.

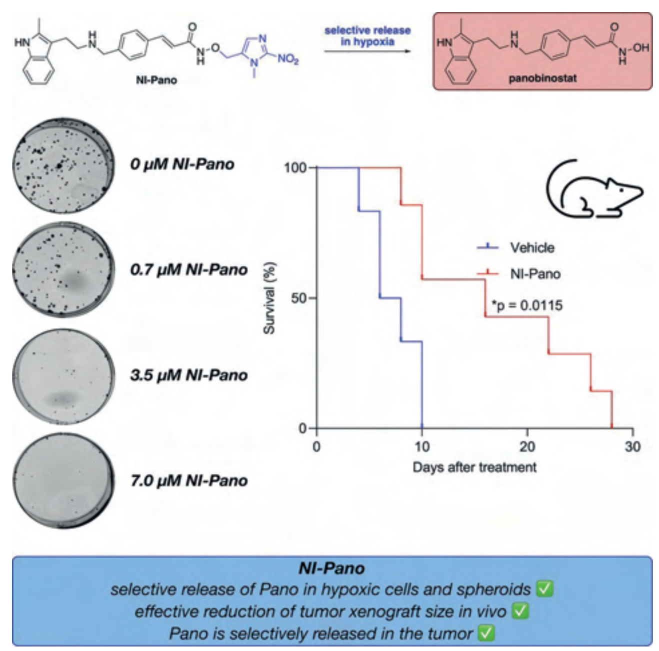
Tumours are often hypoxic (low O_2), due to increased O_2 consumption by rapidly proliferating cancer cells and decreased O_2 diffusion into tumours from existing blood vessels. This can lead to challenges in both radiotherapy and chemotherapy treatments for cancer patients. Hypoxia-activated prodrugs (HAPs) are one of the strategies employed to tackle the issue of tumour hypoxia. Prodrugs are molecules that only release the active drug compound after they are broken down inside the body. HAPs aren't active in cells with normal oxygen levels, but are selectively degraded in hypoxic cells to release the active drug molecule.

Since 2009, the Conway and Hamond groups have been collaborating on a project to develop molecularly targeted HAPs and first saw success with CH-01, a kinase inhibitor prodrug. This collaboration has been at the forefront of working on this new style of HAP. Other HAPs have focused on the release of non-specific toxic agents and have had limited success in clinical trials so far.

Around five years ago this collaboration turned their attention to HAPs that could target lysine deacetylase (KDAC) enzymes. KDAC enzymes are often implicated in cancers, with over-expression of some KDACs being observed in multiple cancer types. KDAC inhibitors are therefore commonly used in anti-cancer therapeutics. The activity and interactions of KDAC enzymes are also often altered in hypoxia, and molecules that selectively inhibit KDACs in hypoxia are expected to be useful for treatment of tumours without damaging non-cancerous cells. The work of these two research groups has culminated in an article published in *Cell Chemical Biology* this year, describing the development and testing of a new HAP using an active KDAC inhibitor called Panobinostat (Pano).

Members of the Conway group synthesised four different modified versions of Pano, with different bioreductive groups attached in a position that would block binding to the KDAC enzymes. These groups are reduced in hypoxia, releasing the active Pano drug, but should be stable when O_2 levels are normal. Testing in hypoxia and against KDAC enzymes *in vitro* led to selection of 1-methyl-2-nitroimidazole panobinostat (NI-Pano) as the best molecule for further experiments.

NI-Pano was therefore taken forward into *in vivo* studies. In cancer cells NI-Pano was shown to be converted into Pano under hypoxic, but not normoxic, conditions, and at < 0.1% O_2 was observed to increase acetylation of relevant proteins at doses as low as 0.05 µM, indicating KDAC inhibition. The most exciting results for the groups came when using mice with tumour xenografts. After injection of NI-Pano into mice, Pano was found in tumours (but not plasma or kidneys), tumour growth was delayed and survival of mice increased. These results were obtained at just the right time, as soon after the experiments were



New Research *continued*

completed the pandemic hit! This did mean that the studies in mice couldn't be extended as much as the team had hoped but they were still able to publish these impressive results.

After working on hypoxia-activated prodrugs for over 10 years, Stuart Conway said "This has been a big team effort and it's exciting to see HAPs working *in vivo*."

References: Skwarska et al., Development and pre-clinical testing of a novel hypoxia-activated KDAC inhibitor, *Cell Chemical Biology* (2021), https://doi.org/10.1016/j.chembiol.2021.04.004

Cazares-Körner, C. et al. CH-01 is a hypoxia-activated prodrug that sensitizes cells to hypoxia/reoxygenation through inhibition of Chk1 and aurora A. *ACS Chem. Biol*. **8**, 1451–1459 (2013).

Farrer Group
Metals in medicine

Around half of all chemotherapy treatments for cancer involve platinum compounds, such as the well-known cisplatin, despite the often-serious side effects of these highly reactive complexes. Platinum-based treatments form crosslinks with DNA and proteins in cancer cells, ultimately resulting in cell death.

Meanwhile, lanthanide-containing compounds are widely used in magnetic resonance imaging (MRI) for disease diagnosis. In MRI imaging a strong magnetic field interacts with the protons in water throughout the body, with the level of contrast in the MRI image strongly depending on the rate at which the nuclei's magnetization returns to normal. This relaxation rate can be affected by the magnetic properties of surrounding chemical compounds, and intravenously administered lanthanide metal complexes are commonly used as contrast agents, increasing the contrast in MRI imaging of blood vessels and helping to diagnose brain tumours where the blood–brain barrier has degraded.

In a joint study between the Farrer, Faulkner, and Baldwin research groups, a range of lanthanide–platinum compounds have been synthesised that were shown to permeate and accumulate inside cancer cells. The build-up of these compounds inside the cells was measured using magnetic resonance, and it was shown that a version of the compound without a platinum complex was not toxic to the cells, whereas the platinum-containing compound was. Depending on the oxidation state and bound ligands of the platinum complex, the initially low toxicity of some of the compounds increased over time as the oxidation state

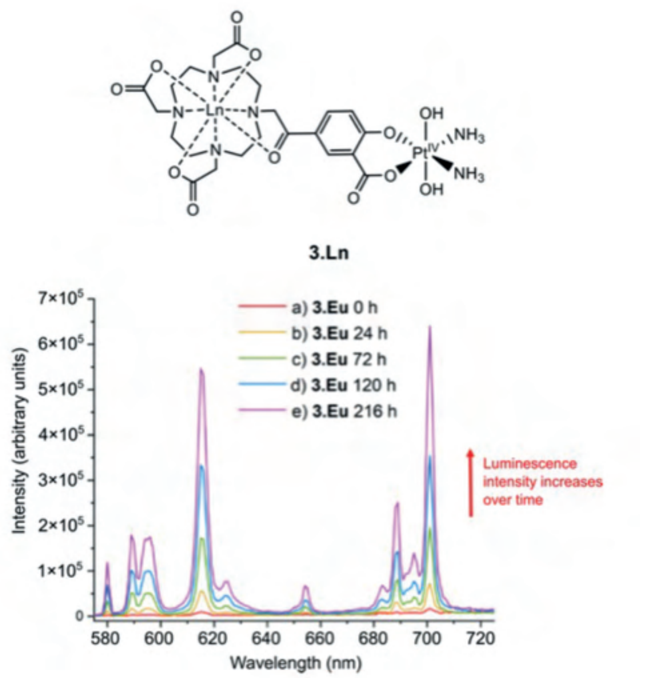


Figure: *An example of one of the lanthanide–platinum complexes synthesised in the study, labelled 3.Ln. The luminescence intensity of the complex increases after the addition of ascorbic acid, shown by the coloured lines over a period of nine days (216 hours) for the case when the lanthanide chosen is europium (3.Eu). The ascorbic acid reduces the platinum from Pt(IV) to Pt(II) in an example of "switch-on" luminescence.*

of the platinum complex was reduced from +4 to +2 inside the cell – this activation in the cell is an attractive feature for targeted chemotherapy that will hopefully reduce unwanted damage to non-cancerous cells.

The results of the study, recently published in the journal *Dalton Transactions*, suggest that the novel gadolinium- and europium-containing compounds have significant potential for development, both as an imaging probe that can permeate inside

New Research *continued*

cancer cells, and as a method of studying real-time accumulation of platinum prodrugs (compounds with little or no pharmacological activity that are chemically transformed into an active form in the body). In the long term, the hope is that this may lead to the development of novel targeted anti-cancer drugs.

Dr Farrer said: "Switch-on lanthanide luminescence following the reduction of a platinum(IV) anti-cancer prodrug is really exciting. It will enable us to visualise the reduction of the compounds at a sub-cellular level, and help us to understand more about their mechanisms of action."

@Farrer_group
farrer.chem.ox.ac.uk

Reference: Yao, K. *et al.*, Cell-permeable lanthanide–platinum(IV) anti-cancer prodrugs, *Dalton Transactions* **50** 8761 (2021), doi.org/10.1039/d1dt01688a

Langton Group

Controlling cell membrane transport with light

How can interactions between molecules be controlled when they are confined within a cell membrane? This highly biologically relevant question is one of those being considered by Matthew Langton's research group, established in the Chemistry Department in 2018.

All biological cells are separated from their environment by the cell membrane, a wall-like structure made up of two layers of fatty molecules. This structure, known as a lipid bilayer, and the proteins embedded within it, regulate what can enter or exit the cell's interior.

Understanding and controlling the flow of molecules or ions across this membrane may help in developing new treatments for diseases such as cystic fibrosis, whereby a protein that controls the flow of chloride ions across the cell membrane is not functioning correctly in the body. As well as its relevance to pure biological research, supramolecular chemistry in cell membranes has applications in catalysis. If a catalyst can be embedded into a membrane then reactions could be performed in an artificial cell and controlled by chemical signalling – for a review of supramolecular chemistry in bilayer membranes see the references below.

Transport across cell membranes in biology is controlled by proteins that respond to a stimulus, be it chemical or physical. In a recent study, Langton and DPhil student Aidan Kerckhoffs designed, synthesised, and characterised an artificial chloride ion transporter that can be controlled using visible light. A specially designed linear molecule undergoes a reversible isomerization under red light to a curved form, which can bind very effectively to a single chloride ion using hydrogen bonds (see figure). The curved form can then be transformed back into the less efficiently binding linear form using blue light.

It was recently demonstrated that when the transporter molecule is incorporated into a lipid bilayer, the reversible photoswitching can be used to reliably accelerate and decelerate the rate of chloride ion

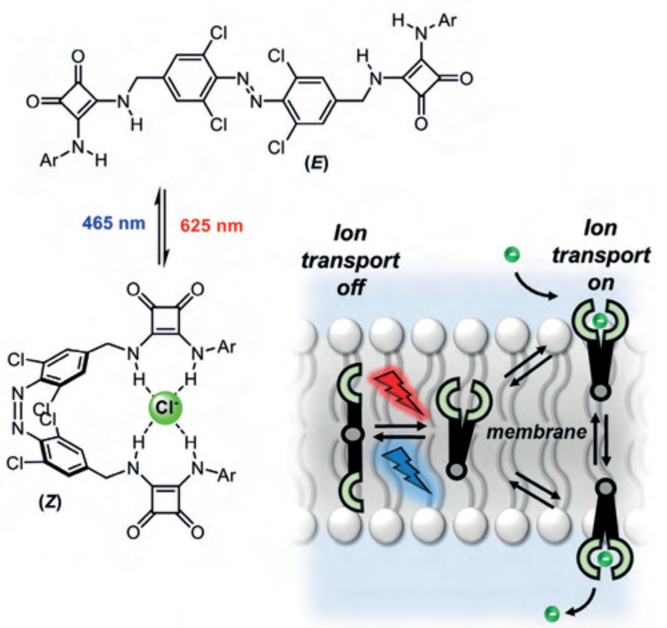


Figure: *A specially designed artificial chloride ion transporter undergoes an isomerization between linear and curved forms under red light, which is reversed by blue light. The curved form transports chloride ions across the lipid bilayer much more effectively than the linear form, meaning light can be used to control the rate of chloride ion flow across the membrane.*

transport across the membrane. As well as increasing the rate with red light, it can also be slowed back down by applying blue light, which forces the molecule back into its linear form. Previous studies have used ultraviolet (UV) light to activate ion transporters, but not in this reversible way. Visible light also presents advantages over UV for potential therapeutic applications because it can penetrate into the tissue more effectively and does not cause collateral damage to cells.

"Supramolecular chemistry in general is very collaborative," says Matthew Langton, "it stretches from material science and molecular machines through to chemical biology and everything in-between". Ultimately, research of this kind may lead to the use of cell-like compartments as small reaction vessels, by controlling how reactants, catalysts, and products enter and exit the interior of the cell, opening up a world of biologically inspired reactions that can be performed and controlled on the nanoscale.

@ChemLangton
langton.chem.ox.ac.uk

References:

L. E. Bickerton, T. G. Johnson, A. Kerckhoffs and M. J. Langton, Supramolecular chemistry in lipid bilayer membranes, Chemical Science (2021), **12**, 11252-11274. doi.org/10.1039/D1SC03545B

Aidan Kerckhoffs and Matthew J. Langton, Reversible photo-control over transmembrane anion transport using visible-light responsive supramolecular carriers, *Chemical Science* **24**, 6325–6332 (2020) doi.org/10.1039/d0sc02745f

Ritchie Group

Spectroscopy to diagnose lung disease

Each time you breathe in and out your lungs process a mixture of gases: oxygen is consumed to fuel the body, while carbon dioxide and water are produced. Tracking the levels of these gases as a patient breathes would allow clinicians to accurately assess how efficiently the lungs are functioning, which is important when diagnosing and treating diseases from asthma and chronic obstructive pulmonary disease (COPD) to COVID-19.

The Ritchie group have been collaborating with colleagues in the Department of Physiology, Anatomy, and Genetics to develop a laser gas analyser, which non-invasively measures the concentrations of these gases at the mouth.

Using laser absorption spectroscopy, the analyser records the concentrations of O_2, H_2O, and CO_2 100 times a second with an unprecedented level of accuracy while a patient sits and breathes into the device. By also measuring the temperature and pressure, the perfect gas law can be used to infer the amount of nitrogen,

Figure 1: *The laser gas analyser in use, demonstrated by Dr Nick Smith, one of the chemists who developed it. The device is housed in the black box, which is breathed into by the subject using a mouthpiece and noseclip to ensure that all inhaled and exhaled gases enter the device.*

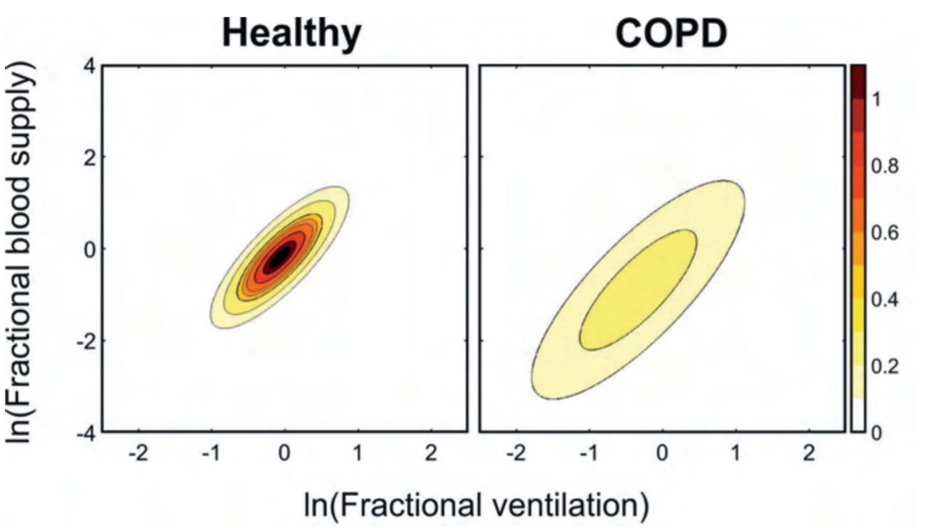


Figure 2: *The distributions of both blood supply (vertical axis) and ventilation (horizontal axis) across the lung are found to be significantly wider for COPD patients (right) than for young healthy individuals (left).*

since these four gases make up over 99% of the air around us.

Direct absorption spectroscopy, probing vibrational transitions in the near-infrared spectral region, is used to detect the H_2O and CO_2. For O_2 the more sensitive technique of cavity-enhanced absorption spectroscopy (CEAS) is used to probe an electronic transition. In CEAS the laser light is trapped between a pair of mirrors and passes through the sample many times - before being detected, greatly increasing the sensitivity.

The gas concentrations are combined with flow measurements to generate highly precise profiles of gas being taken in or produced by the lungs. Using a custom mechanistic model of the lung it is possible to calculate clinically valuable parameters such as the variation in the ventilation and blood supply of gas exchange compartments within the lung. A healthy lung should show a narrow distribution of these quantities, since the alveoli within the lungs should all work relatively well, whereas a lung with reduced function will show a wider variation, indicating that many of the alveoli have deteriorated.

It has been demonstrated that this gas analyser can be used to measure variation in lung function between groups of young, old, and COPD-diagnosed individuals. Differences in clinically relevant parameters were found between all three groups, with significantly wider distributions for the patients with COPD. A further study has also shown that the laser gas analyser can provide measures that are more sensitive than current clinical tools at assessing deterioration in lung function associated with badly controlled asthma. Faster diagnosis and more accurate assessments of these respiratory diseases would allow more effective interventions and, the hope is, better clinical outcomes.

This newly developed technique is currently being used to assess the lung function of patients who have been hospitalized with COVID-19, testing the hypothesis that the long-term effects of the disease, sometimes known as "long COVID", may involve a breakdown in the lung's ability to divert blood away from damaged regions.

ritchie.chem.ox.ac.uk

References:

Mountain, J. E. *et al*., Potential for noninvasive assessment of lung inhomogeneity using highly precise, highly time-resolved measurements of gas exchange, *J Appl Physiol* (1985), **124** 3 (2018). doi.org/10.1152/japplphysiol.00745.2017

Smith, N. M. J. *et al*., Novel measure of lung function for assessing disease activity in asthma. *BMJ Open Resp Res*, **7** e000531 (2020). doi:10.1136/bmjresp-2019-000531

Clean Green Tech

Hannah Fowler reports on some of the Department's cutting-edge research that could lead to a more sustainable future.

Awareness of the climate crisis and sustainability issues is an unavoidable part of modern life. It is astonishing to think that one three-atom molecule can have such devastating effects, but the increasing levels of CO_2 in the atmosphere have led to acceleration of the greenhouse gas effect. When coupled with other problems like the unsustainable use (and disposal) of single-use plastics, it is easy to determine the sources of a lot of the climate change and ecological problems we are now experiencing, and we urgently need to find ways to tackle these problems. Local, individual actions like cycling or walking rather than driving, reusing and recycling as much as possible, and growing our own fruit and vegetables are all important but alone they are not enough. However, researchers in the Department of Chemistry are carrying out essential work to tackle these problems in a more 'global' way – by working towards clean technology that can help forge a more sustainable future.

'Catalyst' is possibly one of the most well-known words in chemistry. Catalysts are used to formulate a new chemical process that runs quicker than its un-catalysed counterpart and they are fundamental in many industrial (and biological) processes. However, many industrial catalysts use heavy metals as their reaction centre, which comes with an environmental cost. Whilst there is now stringent regulation on the disposal of these compounds, environmental and ethical problems remain with obtaining them. Furthermore, if they are accidentally released into the environment then this can have devastating effects on, for instance, nearby water supplies. Researchers in Oxford have been tackling this problem with the intention of replacing heavy metal catalysts with biological ones – which is where the newly incorporated company HydRegen came from. Dr Holly Reeve and Professor Kylie Vincent have worked to create systems that use biological catalysts (enzymes) to carry out hydrogenation of reactants (such as ketones) into products (alcohols) by the (biological) splitting of a H_2 molecule, and combining the resultant H ions with the reagents to make a hydrogenated product (this is the overall process, there are intermediate steps). Whilst traditional catalysts can often be 'poisoned', which is a common problem for catalytic converters in cars and means the catalyst cannot always be fully recovered, HydRegen's method of preparing the enzymes allows recovery of the whole catalyst by adhering it to carbon beads. This makes the enzymes easy to separate from the products – another in a long list of benefits to using this method. HydRegen officially launched at the end of 2020, and it will be very exciting to see their (and others') developments in this area.

Another famous term in chemistry classrooms and departments is the Haber-Bosch process and researchers here are interested in making this greener. This highly useful reaction provides essential ammonia (NH_3) for uses in the agricultural industry, as well as for household items such as cleaning products. However, this versatile compound comes at a high price: its manufacture accounts for 1.4% of all CO_2 emissions and uses 1% of energy generated in the world (as of 2019).* It is clear, therefore, that research into making this a greener process is essential and that is a task that Professor Edman Tsang's group has taken up, in collaboration with the company Siemens.

One of the reasons this process produces so much CO_2 is due to the extremely high temperatures and pressures that nitrogen and hydrogen need to produce ammonia, making it a very energy-intensive process. The Tsang-Siemens collaboration has been looking into electrifying the process which would remove the need to use fossil fuels and could instead use renewable sources, such as wind power. They also intend to supply the hydrogen by electrolysis of water, removing the need to use a combustion process to source it, which is very eco-unfriendly. A successful modification to this process would represent a huge leap forward to significantly reducing global CO_2 output levels, whilst still supplying essential and widely used ammonia.

A further process that substantially contributes to CO_2 output is the collective use of fossil fuel powered vehicles, and there has been a significant push in recent years to switch to electric cars, with the idea that 0% carbon emissions could be achieved if the electricity were gathered entirely via renewable sources. One of the researchers in this area is Professor Michael Hayward, who explains that to use energy from renewable sources like wind and solar, '[We] need to have good ways of storing energy in a convenient form… [and] the simplest way of doing that is charging up a battery'. Professor Hayward continues to explain that there are many challenges involved in this, '[We] want a battery to last more than 10 minutes, but we also need to think about recycling those batteries, how we're going to make them and scale them up, the manufacturing… The Faraday Institution covers all those areas'.

The Faraday Institution is a large consortium of universities and researchers who contribute to solving problems around batteries and their use, with the intention of 'powering Britain's battery revolution'. As part of this, professors Michael Hayward, Simon Clarke and Andrew Goodwin, are members of the FutureCat consortium within The Faraday Institution. Professor Hayward explains that his group and the Clarke group are focussed on 'making new materials and getting away from using cobalt'. Current Li-ion batteries contain NMC (Nickel, Manganese and Cobalt) materials, which produce a range of problems. For example, as well as being expensive and in short supply, cobalt is one of a number of toxic heavy metals that pose health risks, and its mining raises serious ethical issues. So researchers are looking to replace materials like cobalt with more widely available ones. Professor Hayward said, 'we took the view four or five years ago that, if we were going to get rid of cobalt, what were our choices? If we're going to make a transition metal system which is not limited by metal availability there are only two [suitable candidates], one of is titanium and the other is iron. Titanium is not good for batteries, so we're focussed on making iron cathodes and materials based on iron'. As such, the Hayward and Clarke groups continue their work into iron-based cathode materials, so that, 'the next generation [of batteries] will, ideally, not contain cobalt and be at least as good as current materials'.

The next problem to address with batteries is their capacity. Batteries storing energy on the National Grid do not need to be mobile, so can be made very large in order to increase their energy storage capacity. Batteries in cars, however, need to be small, light, and still highly efficient. As Michael explains, 'what you need for electric cars is a better [battery], not just a physically bigger one'. Until recently, electric car batteries needed very frequent recharging and so a lot of research has been going into designing longer-lasting ones.. This issue has become time-sensitive in the UK with the recent government announcement that the sale of all new petrol and diesel cars will end by 2030. But Professor Hayward is optimistic, explaining that, previously, cars could only go about 100 miles before needing a recharge, but that now, 'you can go out and buy an electric car and drive the best part of 300 miles without [needing to recharge the battery], so things are really moving on quite a lot'.

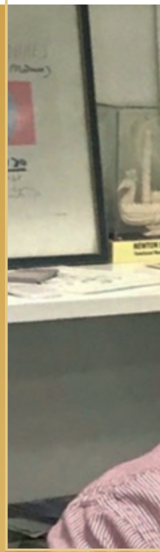
Another large contributor to our carbon footprint, is plastics, particularly single-use ones. Researchers in the group led by Professor Charlotte Williams are working on the development of methods to prepare, re-use and recycle polymers as products from bio-refining, industrial wastes and biomass so as to improve sustainability. Professor Williams's contribution toward this goal was recently recognised when she was presented with Unilever's Clean Future Award, alongside professors Matthew Rosseinsky and Andrew Cooper from the University of Liverpool, for their work that aims to use only renewable or recycled carbon in Unilever's 'home care' brands by 2030. Hopefully this idea can trickle into other areas and help to avoid the unnecessary use of single-use plastics.

Researchers at the University of Oxford are tackling sustainability research from several directions that cover a diverse variety of approaches, from no-waste catalysts in an industrial setting to the development and disposal of more eco-friendly plastics in our own homes. Work such as this is vital in helping to pave the way toward a brighter, more sustainable, and environmentally friendly future.

Reference: *M. Capdevila-Cortada, *Nature Catalysis*, 2019, **2**, 1055.

The People Person

Professor Steve Faulkner, recently appointed to the new role of Associate Head of Department (People), talks to *Periodic*.



How do you see your new role?

My role is to make sure that everyone in the Department of Chemistry has a voice. That's a broad range of people, because as well as the ones that everybody thinks about – like students, postdocs and academics – there's a whole range of technical, professional and support staff who make the place function. There's also a range of people whose interests meet the Department – all of them together make Chemistry what it is, and they all have different perspectives on what we need. Some of what I do is to balance those needs, and to make sure that people get a chance to be represented. We need methods that we can use to help people to achieve their best.

How does your role fit in with the Athena SWAN agenda?

It's much broader than the Athena SWAN agenda. That's something where we've made great steps in the last 10 years to ensure equality of opportunity at work and ensure that we encourage people to stay in the system, and to work towards a system that people feel comfortable being in and staying in, regardless of their background and what is going on in the rest of their lives. Within Chemistry gender is a still an obvious issue, and though things are still far from perfect, they are getting better. As we continue to address this, we are moving as fast as we can to address the needs of all in an inclusive department. My role also encompasses other things, and this kind of role has been developing across the University recently. There is now an Associate Head of Division for People in MPLS for example. It's commonly acknowledged that people are our main product – the people that we train and develop create the future of chemistry. In practical terms that's been acknowledged much less than the function of what we're doing to develop them. As time moves on, those things are starting to overlap a lot more.

What are the main challenges?

Chemistry is a large department of almost 1000 people. The thing that has struck me most since I started is that we don't all know each other. While we all meet regularly within our teams, we tend to move in our own spheres.

Finding a mechanism that helps people to make connections and friends beyond their immediate work environment is a challenge. It's something we need to work on, but through the pandemic we've had to operate in circumstances where it's been almost impossible to do anything social, and it has been hard for people to make connections in the Department with colleagues who can support them outside their immediate interest. I suspect that reopening the world again is going to create some challenges and some opportunities. It's clear that over the last 18 months we have made up a wholly new way of working on the hoof. It will be good if we can take some lessons from the new ways of working that we can use to improve the old ways of working.

What have you been doing so far?

What I have been doing isn't what any of us ever envisaged, which is to start picking up some of the threads from a year and a half in lockdown. We recognise that as we have been through this turbulent time, everyone has been under very dramatic but

Steve Faulkner is Professor of Inorganic Chemistry and Associate Head of Department (People). Steve has been in Oxford since 2008. Before that, he was Professor of Inorganic Chemistry at the University of Manchester (where he was previously a Lecturer and Reader in Inorganic Chemistry). From 1998-2001 he was a Lecturer in Chemistry at the University of Surrey, having been an Addison Wheeler Fellow in Durham from 1993. Steve did his undergraduate degree in Oxford, followed by a DPhil on cell calcium in the Oxford Centre for Molecular Sciences. He grew up in the Lake District near Keswick and now lives with his family in a much flatter but equally rural part of West Oxfordshire.

very different pressures – from people who've had to come in to work every day because they've had to keep the buildings safe, to people who've had to work in isolation in a small space. But everyone has gone through something. Collectively, we must ensure that no one comes out of this worse than they would have done otherwise.

So we're listening to people, finding out about their experiences, and there are various ways of doing that. Surveys and forums have a place, and committees can often be used as a sounding board. But these methods don't reach everybody, so as and when we can, a major part of reaching people is going to be walking round and knocking on doors and saying hello. It is always good to talk to more people. I worry that we tend to hear the voices of the very content and the very unhappy, but we need to know more about those in between, the people who aren't always on our radar. You can only hit a target that you can see.

Have you had a good response, and what have you learned so far?

Yes! So far I have been pleasantly surprised. Coming to the role earlier this year when we were in a second lockdown and morale was low, I didn't have high expectations, but everyone I have spoken to has engaged positively.

There's been lots of discussion of communication. In particular, people want to be able to express their feelings as well as to have a system that tells them what's happening. The nature of meetings in a large department is that they can become briefings, and what we need is a genuinely two-way process. I can provide a route in, and I suspect that my real role is to be a feedback loop!

What do you hope to have achieved by the end of your time in office?

I would like to achieve a tangible benefit, knowing that as we come back from the pandemic and all of the constraints that have been imposed upon Chemistry. I'd like to have started to build a system which has real differences and which makes people happy to be here, wanting to be here, and wanting to carry on in the job.

I want to see a system in which the Department is able to support people, and where people are prepared to ask for that support. I'm always slightly cynical about how you can turn the whole of a plan into reality; I think our plans have to be moulded by how they work when they are tried out.

Are you enjoying the job?

I don't know – ask me afterwards! I'm quite odd in that I really do like people, even though I am an introvert. Going back to my childhood, I once asked my dad – who was deeply anti-war – why he hadn't been a conscientious objector in the Second World War. And he said: 'Well, my problem was that once I made up my mind that somebody ought to be doing it, there's no way it couldn't be me.' And that is a philosophy that applies to this as well – if we are going to have a structure, then it is our responsibility to play a part.

Nobel Prize Centenary for Oxford Chemistry

First awarded 120 years ago from the fortune of Alfred Nobel – a weapons manufacturer who wanted to ensure that his legacy was not simply as the inventor of dynamite – the Nobel Prize in Chemistry has been received by 185 scientists. Around 10% have been associated with Oxford Chemistry as either a researcher or visitor (see timeline), nine of them as doctoral students or professors (bold names). The interconnected stories of these scientists remain an inspiration for the chemists studying and working in Oxford today.

In 1921, **Frederick Soddy** became the first Oxford academic to be awarded the Nobel Prize in Chemistry, for work developing the theory of isotopes. Soddy was an early advocate of centralised labs for undergraduate teaching and as well as chemistry he wrote extensively on economics, with a perspective rooted in the laws of thermodynamics. His view that exponentially growing world economies were based on exhaustible stocks of fossil fuels was both reassuringly chemical and eerily prescient.

Next was **Robert Robinson**, who won in 1947 for investigations into biologically important plant products. Robinson's synthesis of tropinone – an alkaloid molecule in the same class as cocaine – is a now-classic example of biomimetic synthesis, which uses lab-based techniques to mimic those in nature. Many of his contributions to the written language of chemistry – the symbol for benzene with a circle in the middle, curly arrows to represent the movement of an electron pair – remain familiar to students today.

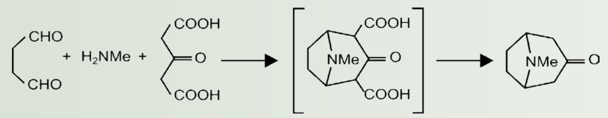


Figure 1: Robinson's biomimetic synthesis of tropinone – a tandem reaction between a dialdehyde, amine, and a dicarboxylic acid in a one-pot synthesis – is a classic in total synthesis.

Robinson was also a keen chess player, representing Oxford against Bletchley Park during the Second World War. His DPhil student John Cornforth, who would go on to win a Nobel Prize himself for work on the stereochemistry of enzyme-catalysed reactions, was also on the (losing) Oxford team.

Sir John Cornforth and Rita Harradence met at the University of Sydney and emigrated to the UK as the Second World War broke out, working on their DPhils at Oxford under Robinson's supervision. Both studied the synthesis of hormone-related molecules and received their doctorates in 1941; they were married the same year.

During the 1940s they worked on the purification of penicillin, which would later be significant in the career of fellow Nobel laureate Dorothy Hodgkin. It was at this time that they moved to the Medical Research Council (MRC), continuing work on the synthesis of molecules like cholesterol in collaboration with Robinson.

In 1975, Cornforth used his Nobel acceptance speech to thank his wife, calling her his "most constant collaborator" and saying that "her experimental skill made major contributions to the work; she has eased for me beyond measure the difficulties of communication that accompany deafness [Cornforth suffered from profound hearing loss from an early age]; her encouragement and fortitude have been my strongest support".

Some six decades earlier, while working on the decomposition of solid explosives during the First World War, **Sir Cyril Hinshelwood's** early interest in the mechanism of chemical change began. Hinshelwood played a large part in the development of science at Oxford, and his particular focus on the molecular mechanisms of chemical reactions led to discoveries such as branching in chain reactions. He received the Nobel Prize in 1956 alongside Nikolay N. Semenov for this work, later applying these principles to the bacterial cell, which was fundamental in research on antibiotics.

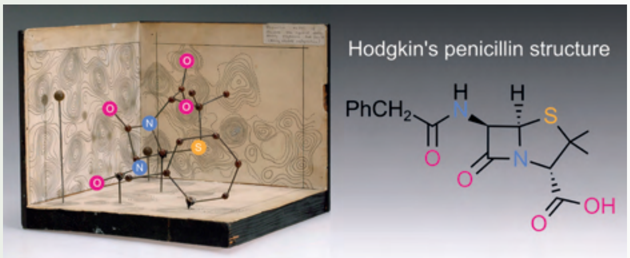


Figure 2: *Molecular structure of penicillin, determined by X-ray diffraction. On the left is Hodgkin's original molecular model from c. 1945 set against the electron density plots, with atomic labels of the atoms other than carbon added for clarity. Photograph courtesy of Wikimedia Commons.*

It was said that Hinshelwood learnt a new language each Long Vacation, and could speak at least five other than English. Despite this, he fought to remove the university's entrance exams in Latin and Greek, the latter a compulsory subject that he had once crammed to take up a place at Oxford.

Biochemist **Alexander Todd** worked with Robinson on anthocyanin dyes during his studies at Oxford, and for much of his later career at Cambridge he focused on the structure and synthesis of biologically relevant molecules, from nucleosides – the structural units that make up nucleic acids DNA and RNA – to vitamins B1, E, and B12. Todd was part of the team that extracted and purified the last of these, and it was for this and related work that Todd received the Nobel Prize in 1957.

In total five scientists have received Nobel Prizes for discoveries relating to vitamin B12, the most recent for **Dorothy Crowfoot Hodgkin** in 1964. Fascinated by geometric patterns of crystals since childhood, her life's work was using X-ray crystallography to uncover the structure of biological molecules – one of the most important techniques in this field today. She built on Todd's work to uncover the chemical structure of vitamin B12; in 1945 she confirmed the proposed structure of penicillin; and her work on the structure of insulin, which spanned her entire career, was instrumental in developing treatments for diabetes.

In 1932, Hodgkin became only the third woman to graduate from Oxford with a first class honours degree in Chemistry. Coincidentally, she was also the third woman to win the Nobel Prize in Chemistry in a field that is, to this day, often dominated by men. The next female winner of the Nobel Prize in Chemistry was not until 2009, and since then four further women have won – hopefully an indication that this gender imbalance may be changing.

22 years separate Cornforth's 1975 prize from the next to be awarded to an Oxford chemist: **John E. Walker**. Working at the MRC in Cambridge since the 1970s, his crystallographic studies of the protein that synthesizes adenosine triphosphate (ATP, a molecule that provides the energy for processes in cells) led to his share of the Nobel Prize in 1997. Today Walker is Emeritus Director of the Mitochondrial Biology Unit of the MRC, which aims to understand the most fundamental processes happening in mitochondria, the part of the cell that produces ATP.

A further 22 years divides Walker's prize and that from 2019, which was jointly awarded to **M. Stanley Whittingham** and **John B. Goodenough** (alongside Akira Yoshino) for their work on lithium-ion batteries. Whittingham studied at Oxford before working in the US on a lithium battery system with a metallic anode and a layered solid cathode. Goodenough, head of the Inorganic Chemistry Laboratory during the 1970s and 1980s, expanded on Whittingham's work to show that Li_xCoO_2 could be used as a lightweight cathode material, eventually leading to the ubiquitous use of rechargeable lithium-ion batteries we see today. Both Nobel laureates remain involved in battery research, aiming to reduce our dependence on fossil fuels and increase the efficiency of electric vehicles.

In 2019 Goodenough became the oldest ever Nobel laureate, at 97 years old. Over the past century the Nobel Prize has recognised some of the most fundamental discoveries in all aspects of chemistry, many of which began in Oxford, and the next 100 years surely holds greater advances still from an ever more diverse and broad field.

1900 First Nobel Prize in Chemistry awarded

1910

1920 **Frederick Soddy**

1930 Harold Urey

1940 **Robert Robinson**

1950 Linus Pauling; **Cyril Hinshelwood**; **Alexander Todd**

1960 Melvin Calvin; **Dorothy Hodgkin**; Robert Mulliken

1970 **John Cornforth**

1980 Jean-Marie Lehn

1990 Rudolph Marcus; Paul Crutzen; **John E. Walker**

2000 Ahmed Zewail; Robert H. Grubbs

2010 Martin Karplus; Stefan Hell; **M. Stanley Wittingham**, **John B. Goodenough**

2020

A Champion for Women in Entrepreneurship

Hannah Fowler talks with Professor Kylie Vincent about her new role as Academic Champion for Women in Entrepreneurship

Professor Kylie Vincent is a familiar face in and around the Department of Chemistry. Her research interests are in inorganic chemistry; specifically, the roles of metals in enzymes that are found in bacteria, and of particular interest are bacteria that can live on hydrogen gas as an energy source. Kylie explains: "when I set up my group, we were really interested in very fundamental studies of how bacteria can use metal containing enzymes to be able to very efficiently use hydrogen as a food source, or produce hydrogen as a waste [material], and whether we can learn from that, perhaps to inspire energy technologies".

Professor Kylie Vincent

This research interest was clearly an important one as in December 2020 Kylie and a previous group member, Dr Holly Reeve, 'spun-out' their company, HydRegen, supported by the University and external investors. The company carries out industrially common hydrogenation reactions (e.g. ketones to alcohols) with enzymes that can be used in place of more traditional catalysts, which use expensive and toxic heavy metals as their reaction centre. Kylie says: "I'd always had an interest in the interface between academic research and commercialisation of research ideas". She was prepared for such an endeavour, having previously attended entrepreneurship courses during her time as a post-doc, and, since starting her own group, by keeping an eye out for applications of research that might suit 'real-world' problems. Kylie explains that the search for applications has since expanded, saying: "my group is split fairly evenly between working on very fundamental aspects of understanding bio-inorganic chemistry and working out ways that we can apply that in technologies towards cleaner synthesis of chemicals" . She says that the two often link together and that when a discovery about a mechanism, for example, is understood, it can lead the group to investigate new areas of innovation, the research of which can send them back to exploring fundamentals again. "It's a nice interplay between the two".

With this knowledge base and experience, it is very fitting that Kylie was recently appointed to the new role of Academic Champion for Women in Entrepreneurship. She will be working closely with Chas Bountra, Pro-Vice Chancellor for Innovation, and Leah Thompson, Senior Knowledge Exchange Officer for Enterprising Oxford and IDEA (Increasing Diversity in Enterprising Activities), which is a University of Oxford initiative that addresses inequalities in entrepreneurship.

When asked about the appointment, Kylie said, "it's a new role the University has created, realising it would be helpful to have some academic backing for all of the work that's already going on through the IDEA initiative". This position will create a bridge between these initiatives and the academic community. As it is new, this allows Kylie and her colleagues to start from the beginning of the process by understanding the breakdown of female diversity as it stands currently - such as how many women are starting companies

"I think we know relatively little about what some of the benefits are in having more diversity on boards. There's an understanding that having diverse boards is helpful but what are some of those benefits? I'm looking forward to seeing, as we do start increasing diversity, the benefits of that to the culture of spin-out companies, the way we build them, and the speed at which they grow".

"…for scientists who have any kind of interest in entrepreneurial activities, it's worth going to some courses and training early on… because there's a whole world of language out there, like "venture capitalists and angels" to "exit strategies" and it can be quite impenetrable without training".

or filing patents – and allows them to gather a more complete image of the situation. Kylie says "we don't have a full picture of that at the moment". This new position will initially look to increase female participation in entrepreneurship activities, and will then aim to look more broadly across all areas of diversity: "it's a two-year role … [and] I'm interested to see where we are at the moment, then working to set targets for what we'd like to see, where we'd like to go, and what we should be aiming to see in the next couple of years".

Within this role, Kylie would like to help increase visibility and awareness of opportunities such as entrepreneurial training programs, and then see how diversity increases as a result. This is something she has experience with, as her previous student, Dr Holly Reeve, was able to take some training modules through the Saïd Business School, which helped her to be able to demonstrate she would be a viable project manager and CEO for HydRegen. However, this endeavour does not apply only to scientists. Kylie says: "we'd like to expand knowledge and uptake of [these types of courses] and increase awareness of enterprise activities throughout all the divisions of the university". Kylie would also like to increase visibility in other areas, such as highlighting seminar programs, increasing discussion about enterprise, ensuring there are mentoring programs available for people trying to expand these kinds of initiatives, and putting together an advisory board for the University that draws upon expertise inside and outside the institution about how to increase diversity, an undertaking which, Kylie happily notes, has had very enthusiastic responses so far.

At the beginning of our discussion, Kylie mentioned that starting up a company was "a steep learning curve". Asked if she had any advice for others looking to do that same, Kylie said, "for scientists who have any kind of interest in entrepreneurial activities, it's worth going to some courses and training early on… because there's a whole world of language out there, like "venture capitalists and angels" to "exit strategies" and it can be quite impenetrable without training".

Kylie also explains it is useful to have awareness about how to protect intellectual property and how to file patents through the University. Whilst the Oxford University Innovation (OUI) team are there to support everyone in the University, it can be helpful if you can understand the business 'language' early on. She also explains that there are a lot of resources within the University to help develop an idea further, such as the EPSRC Impact Acceleration Account that funds small projects to determine, for example, if an idea has a suitable market.

Whilst this role is about championing other women, when asked what she would like to learn from the experience, Kylie says: "I'm really looking forward to finding out a bit more about what's going on right across the spread of the University, as we have more of a STEM perspective in Chemistry. There are a lot of really interesting social enterprises going on in other departments, particularly in the social sciences and humanities departments". She also mentions that the University is filled with people who are passionate about supporting entrepreneurship across the university and that she is excited to connect with them and learn about initiatives that are already happening.

Kylie says she is also looking forward to finding out more about the benefits of increasing diversity. "I think we know relatively little about what some of the benefits are in having more diversity on boards. There's an understanding that having diverse boards is helpful but what are some of those benefits? I'm looking forward to seeing, as we do start increasing diversity, the benefits of that to the culture of spin-out companies, the way we build them, and the speed at which they grow".

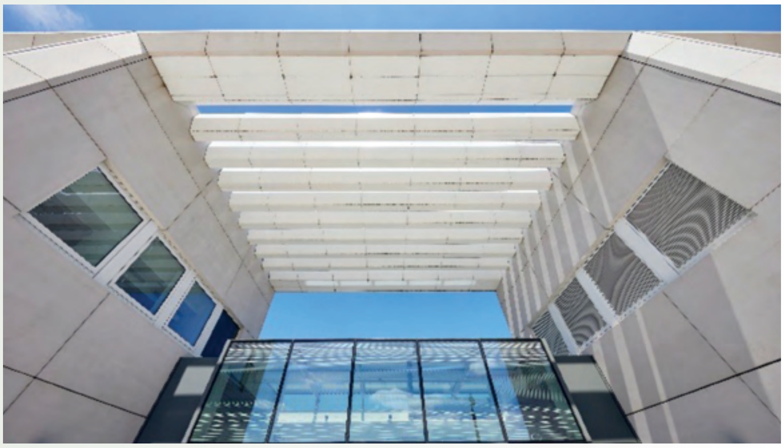
Kylie will be spending two days a month on this new role that will engage with current students, as well as alumni, from across the university. It will be very interesting to see how the engagement of women with entrepreneurship activities changes as a result, and hopefully this will be the start to seeing more spin-out companies led by women. We wish Kylie and her colleagues all the best with this important endeavour.

To learn more about Enterprising Oxford and IDEA, please visit: https://eship.ox.ac.uk/

Practical Chemistry in a Time of

We had been planning for a long time. The Chemistry Teaching Laboratory (CTL) was already going to be closed from the end of Hilary Term 2020 as a consequence of the plans for the Life and Mind Building. It had been decided some time ago that our brand new building had to be partially demolished and re-modelled. We were to lose the end of two prep rooms and have the entrance moved to a different side. We would gain an internal staircase to allow student movement between the two floors (without passing through the "clean" reception area) and we would end up being a separate, self-sufficient building, no longer an extension to the rapidly disappearing Tinbergen Building. We knew that we would lose Trinity Term and therefore we had put in place a number of online exercises for the undergraduates. We were to teach them some coding, hone their writing skills and give them some exercises on experimental design skills – all great preparation for when they resumed their practical courses or began their Part II projects in Michaelmas Term. This was all pre-Covid. Very soon it became clear that this temporary hiatus in our teaching programme was to be something much more major.

The teaching of practical chemistry in universities across the world was placed on hold for over a year. The advent of a global pandemic meant that HE teachers had their plans and routines thrown into chaos, leaving the community wondering how it might be possible to teach skills relevant to practical chemistry without access to laboratories. In an attempt to spark discussion and collaboration, DrMalcolm Stewart - together with members of the CTL team in Oxford - set up a discussion forum, which we christened #DryLabs20. This network of teaching professionals met remotely every two weeks to discuss what could be achieved and to share ideas. Very soon, the delegate list for these meeting numbered over 100 and the participants were spread not only throughout the UK, but mainland Europe, North America and Australasia.



There were visitations from those at the RSC concerned with accreditation of UK degrees, and representatives from A-level awarding bodies worried about a breakdown in the school/university transition. Very soon, teachers from other disciplines heard about #DryLabs20 and set up their own subject-specific groups - such as DryLabsRealScience (Biology) and the Physics-LTHE group - and the inevitable time-difference problems for our colleagues on the other side of the globe led to the formation of DryLabsDownUnder. We all became very adept at using Teams and Zoom, breakout rooms and the whole new armoury of remote working.

Meanwhile, the CTL team developed and refined a whole raft of exercises aimed at everyone from incoming first-year students (who had not been in a school lab since halfway through Year 13), to those looking to embark upon research careers – and everyone in between. In summer 2020, the ACS Journal of Chemical Education announced a special issue: Insights Gained While Teaching Chemistry in the time of Covid-19. We rapidly wrote up our thoughts to date and published a series of papers for this issue. These covered our work on teaching Mathematica remotely, advanced data handling using Excel, a paper examining the success of the #DryLabs20 forum and a collaboration with colleagues in the Department

Dr Malcolm Stewart, Director of the Chemistry Teaching Laboratory

COVID (with apologies to Gabriel García Márquez)

of Biochemistry on using enzyme kinetic simulations to teach experimental design – and there are more to come!

These, and many other, activities kept the students thinking about practical chemistry throughout the lockdown periods until they began to filter back into the labs – a period that ran from March 2020 until February 2021. As soon as a skeleton staff was allowed back into the CTL in November 2020, we set about planning what we might offer returning students, in socially distanced labs. The whole experience would be different to usual – we would be working in bubbles of 10-15 students with two members of staff; there would be no post-graduate demonstrators allowed in the building; the skill-level of the students would be, at best, a little rusty. It was decided to allow the new first year students into the CTL for 4 sessions in the second half of Hilary Term 2021 and so - to try and introduce them in advance to the labs and new techniques - we made a series of videos that we put on Canvas, the online learning environment. These showed the type of equipment and experiments that they might be doing when they came back. These have proven immensely popular with the students and we have seen a rise in confidence amongst those who watch the videos in advance of attending lab sessions.

There are, of course, many commercial versions of lab-based videos available, but we believe that giving the students a preview of the actual situation they will encounter rather than an alternative filmed somewhere else (or, worst of all, a cartoon) results in a marked improvement in their lab performance. We will surely keep these videos for future use!

And so, Trinity Term 2021 saw both first and second year students come to labs and begin to (re)learn some important lab skills. Neither year group has done much practical lab work since March 2020, and those starting their Part II year in October will not have been in the lab for 18 months. But what did we learn from this "Time of Covid"? Firstly – most students really missed their time in the lab. The enthusiasm that the returning students

Dr Andrew Worrall, Deputy Director of the Chemistry Teaching Laboratory

showed for their practical work was an absolute delight to see. It is, of course, a challenge to us to keep this enthusiasm going when life begins to return to normality. We have produced some really useful material that we will definitely keep in the lab course in the future - in particular the coding skills and the use of programs such as ChemDraw and MNova will be kept.

We think we have begun to improve the standard of the students' writing when it comes to lab reports and we hope that this will feed into an easier thesis-writing experience at the end of the 4th year – we will certainly continue to work on this. The biggest learning experience for us all has been just how important labs are to chemistry students. Not only do they teach skills that cannot be learned in other environments, they have a key pastoral and social role to play in the life of an undergraduate.

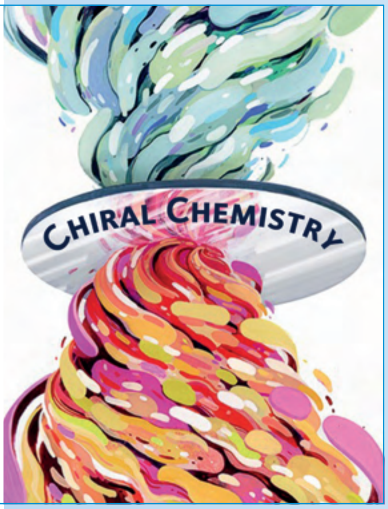
They might not always relish spending 6 hours at a time in the chemistry labs, but they certainly missed it when they couldn't have it!

Opportunity to Change

The pandemic has brought about unanticipated changes to our outreach programmes, many of which are here to stay.

As a practical subject, the vast majority of our chemistry outreach prior to March 2020 consisted of highly enjoyable hands-on practical workshops both in school and the Chemistry Teaching Laboratory (CTL), exciting lecture-demonstrations, residential summer schools, a smattering of career and research talks and a number of MPLS-wide in-person activities. All of this changed when face-to-face outreach was suspended back in 2020.

The shift to online working has provided an opportunity for reflection as well as the development of new forms of outreach that will form part of our staple diet going forward.



A productive area has been the development of online **interactive workshops** that showcase the Department's research. The first, a Chiral Chemistry workshop, created with members from the TMCS CDT, includes the work on the main protease of COVID-19.

Two further workshops, one for 14-16 yrs and another for 9-10 yrs, highlight the work of the Williams Group on sustainable polymers. There has also been an opportunity for Undergraduate Outreach Developers to work on new workshops for use in Colleges, namely an interactive session on fullerenes for 14-16 yrs, showcasing six different research groups and including VR, as well as two puzzle-based microscale practical challenges, one for 14-16 yrs, the other for 16-19 yrs.

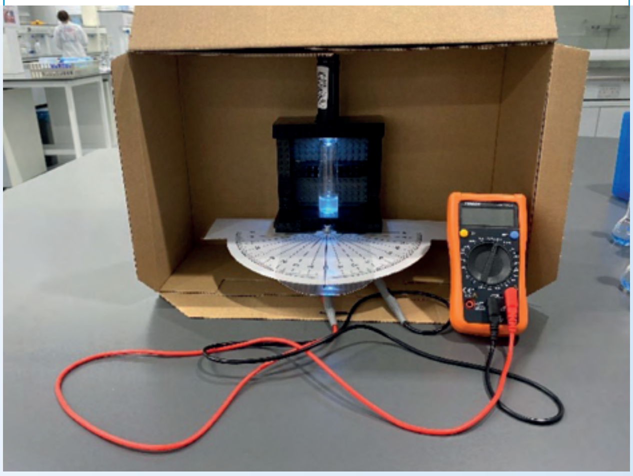
'The work we completed over the course of five weeks was so fulfilling as the team pushed ourselves to make resources that were challenging, engaging and enjoyable for students. It was a privilege to channel my passion for chemistry into teaching, especially with the full support of the CTL team. I highly recommend all with an enthusiasm for the subject to partake in outreach opportunities; it is important and rewarding work!'
Madeline Buffett, Undergraduate, Hertford

As we have embraced technology as a means to communicate with one another digitally, so we took the opportunity to move our career and research talks online. We kicked off with an **Autumn Chemistry Conference** in September, which attracted nearly 2,500 registrations from across the globe. Prof. Angie Russell and DPhil student Wouter Lindeboom (Williams Group) gave talks, and Prof. Dudley Shallcross, who completed his DPhil at Oxford Chemistry, was our guest speaker, alongside his colleague Tim Harrison, both now at the University of Bristol.

We launched a new super-curricular series 'Explore Chemistry' for students aged 16-19 yrs and their teachers. To date, 11 DPhils and PDRAs have recorded talks and then held live Q&As. This series will continue online next academic year.

Our **UNIQ summer school** also moved online for a second year in a row. However, this year's offering was far more interactive, with live Q&As with our six lecturers, three 90-minute small groups tutorials and each participant received a practical box of equipment to allow them to investigate kinetics and polarimetry using LEGO based instruments. We also included two panel events, one with students, the other with tutors.

'I am extremely grateful to have been given the opportunity to participate. I don't know what else to say to be honest. It was all round amazing and just further fuelled my Chemistry obsession.'
UNIQ Participant



In 2020, the CTL was awarded a Vice-Chancellor's Education Award for its innovative integrated practical course. In light of this, we have taken time during the pandemic to update our UNIQ summer school CTL based practicals. A Part II student worked on a series of interconnected practicals focused on the curcuminoids found in the spice turmeric. Curcuminoid chemistry is fascinating - it is used as a food colouring and is currently being actively investigated as a treatment for Alzheimer's disease. The practical programme includes extraction, separation and kinetics. Future work will focus on chelation and antibacterial properties. The work also produced resources suitable for school use, to support the delivery of the A level (or equivalent) curriculum.

An all-age **'Ask a Chemist'** series designed to support careers advice in schools began during the pandemic. A simple format allows any questions during a 1-hour slot. Our favourite response came from Dr Weston Struwe, who would be running a bike shop by the ocean if he wasn't a highly successful chemist!

As ever, we have collaborated with colleges for their events, providing panel guests and talks for various online sessions held throughout the year.

Collaboration across colleges and departments led to a series of **Remote Interview Workshops** for all courses, not just Chemistry. This new initiative, led by Chemistry, saw just over 2,000 applicants benefit from the support, the majority being from widening participation backgrounds.

We have also led on a collaboration with six other Higher Education Institutions to create an online project designed to highlight the women working in the chemical sciences to tackle issues of societal importance, such as air and plastic pollution, healthcare, and battery technology. The project, part-funded by the RSC, is designed for 10-14 yr olds and their supporters of any age. It includes practical challenges, alongside resources explaining the research and profiles of the women involved. The project site can be accessed at https://bit.ly/womeninchem.

Inspired by the 2019 Nobel Prize for the development of lithium-ion batteries, the **Oxford Chemistry 'Power UP!'** resources challenged participants to make DIY batteries with materials they had at home, and model novel solid electrolytes for use in batteries. One of our Undergraduate Outreach Developers has worked on an adaption for Girl Guides, which will be piloted in 2021-22.

'It's been an amazing experience to work with so many wonderful women and get such positive feedback from participants! I'm incredibly excited for the future of this project and adapting it to be used more widely across the country (and maybe the world!). '

Megan Bell, Undergraduate, Trinity

The pandemic has also allowed us time to write articles for use in schools. New articles include a summary of the retrosynthetic work of the Robertson Group and a GCSE-friendly article on waste water adapted from a publication by the O'Hare group. Alumnus Alan Tyldesley (Trinity, 1974) contributed a piece on the explosive nature of ammonium nitrate.

Showcasing the work of the Department is a great way to inspire the next generation of chemists, and the work of the Harry Anderson Group on molecular engineering was the focus of our contribution to this year's **Salters' Festival of Chemistry South-East**. The Festival consisted of recorded videos of mini-talks about the research, practical experiments, lab and college tours, and live Q&A events.

We are delighted to have a brand-new schools' section on the Department's website, which makes our events, activities and programmes more visible and includes a filter function for ease of use by our visitors. Please do find out more at **www.chem.ox.ac.uk/schools**

Dr Fay Probert

Dr Fay Probert joined the Department of Chemistry in January 2021 as the new Dorothy Hodgkin Career Development Fellow.

Dr Fay Probert

The Dorothy Hodgkin Fellowship was conceived by Somerville College and the Department of Chemistry to mark the 50th anniversary of the award of the Nobel Prize to Dorothy Hodgkin, whose pioneering work in X-ray crystallography led to the elucidation of the structures of important biomolecules, including penicillin, insulin and Vitamin B12. Her career paved the way for subsequent generations of women in science as she worked to support other women in her lab, even donating some of her Nobel prize winnings to help establish a college nursery. Sadly, Dorothy Hodgkin remains the only British woman to have received a Nobel Prize in science, and women remain underrepresented, particularly at senior levels. With the generous support of Somerville and Chemistry alumni, the five-year Dorothy Hodgkin Career Development Fellowship was created to support an outstanding early-career scientist for five years. We were delighted to welcome Dr Fay Probert to the role.

Fay's career began at the University of Warwick, where she graduated with a degree in mathematics. She moved to the Department of Chemistry to pursue an MSc in mathematical biology and biophysical chemistry and went on to complete a PhD in analytical chemical biology. After completing her doctoral studies, Fay worked at Bruker UK and the Medical Research Council at Harwell. She joined the Department of Pharmacology at Oxford in October 2015 as a senior postdoctoral researcher and was a Junior Research Fellow at Somerville before becoming Dorothy Hodgkin Career Development Fellow.

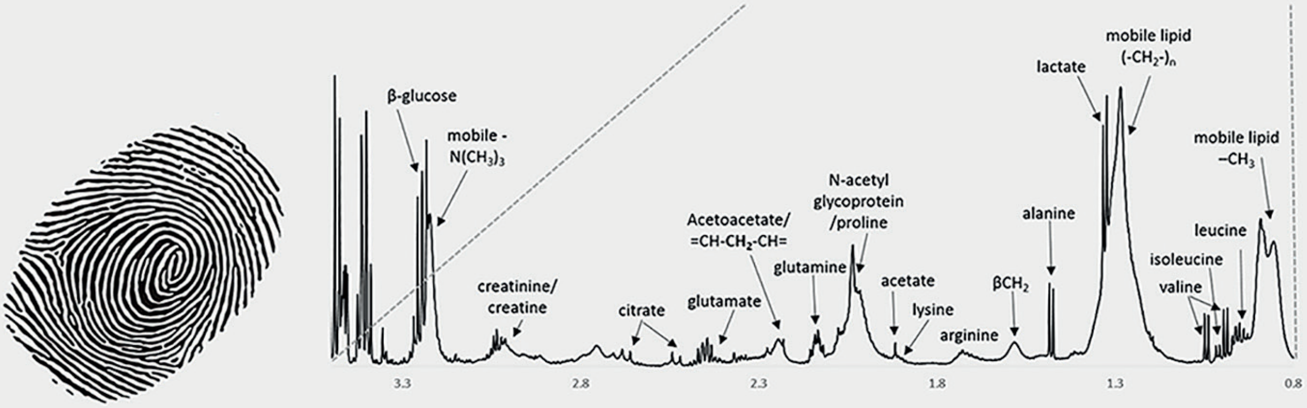
Fay's research uses a multidisciplinary combination of analytical chemistry, mathematics and biology techniques to understand the chemistry of small molecule pathways associated with disease. She is particularly interested in understanding the chemistry of brain inflammation, with the overall aim of identifying novel drug targets, developing therapeutics, and improving diagnostics for neurodegenerative diseases.

Neurodegenerative diseases, including Alzheimer's disease and Multiple Sclerosis (MS), are the leading cause of disability and second leading cause of death worldwide. Although chronic inflammation is a hallmark of such diseases, the mechanisms by which inflammation contributes to cell death are not understood. Fay's work has shown that inflammation in the brain generates profound changes in blood molecules that are consistent with significantly compromised energy metabolism.

Fay's work in the rapidly evolving field of metabolomics uses analytical chemistry methods and advanced statistical analysis to characterise small molecules (metabolites) in biological samples with the aim of better understanding the chemistry associated with disease in complex biological systems, identifying novel biomarkers, and discovering novel drug targets.

Fay is also examining the viability of using nuclear magnetic resonance (NMR) analysis of blood as a cost effective, non-invasive and rapid method of

Each NMR spectrum provides a metabolic fingerprint of an individual at a particular point in time.



diagnosing and monitoring disease progression. NMR is a highly reproducible technique that requires minimal sample preparation and allows analysis of blood samples in under 10 minutes. The intrinsically quantitative and non-selective nature of NMR allows every molecule in a blood sample (above a sensitivity threshold) to be measured simultaneously. While the basic molecules that make up blood remain the same across individuals, the relative quantities of the metabolites differ and produce a distinctive pattern that is unique. Thus, a single NMR experiment provides a huge amount of information within a molecular ‘fingerprint’, which is representative of the blood sample. As a result, NMR provides significant advantages over other techniques that can only quantify a single molecule at a time and, by analysing the fingerprint of metabolites in combination, can provide a more powerful means of diagnosis.

NMR is information-rich and lends itself to the use of advanced statistical techniques, which Fay is using to extract the molecular patterns that relate disease stage and prognosis. These statistical tools build complex equations able to distinguish NMR spectra of blood samples from different groups of patients. Once these equations have been calculated and independently tested on a large cohort, they can be used to classify new blood samples. This not only provides a means of diagnosing disease but, by interrogating the metabolites responsible for the discrimination, provides clues into the underlying pathology of the disease.

For the future, Fay hopes that her work will help enable the generation of detailed maps of an individual’s metabolic processes, which could facilitate the development of personalised medicine and better management of autoimmune diseases. Fay says: “I am delighted that this Fellowship has provided me with the support and resources to develop and continue my research in this exciting and rapidly-developing field.”

Supporting students and researchers for 45 years

Tina Jackson retired from the Chemistry Department this summer having spent 45 years as a technician in the NMR facility. Over that time, she recorded many thousands of spectra and trained many hundreds of chemists in the use of NMR spectrometers, including Part II and DPhil students, and post-doctoral researchers.

After leaving school Tina worked as a banking assistant for 6 months, after which she left and joined the Organic Chemistry Department in 1976, working in the Dyson Perrins laboratory, then headed by Sir Ewart Jones, before moving across South Parks Road to the newly-built Chemistry Research Laboratory in 2004 when the facility was relocated. Tina worked in the NMR facility for the whole of her time in Chemistry, firstly with the formidable Lady Eva Richards (wife of the pioneering NMR spectroscopist Sir Rex Richards) and subsequently with Andy Derome and then Tim Claridge.

When Tina started, the laboratory state-of-the-art instruments operated in continuous-wave mode at proton frequencies of 100 MHz, and the first 2D COSY spectrum had only just been published in *J. Chem. Phys.*. As technology progressed, magnets moved from immensely heavy solid state and water-cooled devices to the era of superconducting magnets, Tina became responsible for the regular cryogenic filling of these and arguably the most valuable member of the NMR team (nowadays, the top-end commercial NMR magnets have reached 1.2 GHz).

The introduction of robotic sample changers in the early 1990s presented an initial cause for concern (would she be replaced?) but Tina came to recognise the valuable role these could play in a busy laboratory environment. Of less concern was a move away from troublesome flatbed plotters and A3 paper outputs of spectra, with the eventual retirement of the last HP7550 plotters in the early 2000s and a complete move to digital media.

Tina Jackson

Of the many significant departmental changes over the years, Tina recalls the times when the Dyson Perrins tea room was available only to academic staff and the technicians would congregate where they could in the department for tea breaks (unlimited smoking included). Fortunately, the department is now far more inclusive! In addition to her role as technician, Tina was one of the founders of the annual Dyson Perrins Christmas Disco, traditionally housed in the original (but long since demolished) Mansfield Road club. A popular event for staff and students alike, this has now been superseded by more student-led events such as the Catalyst Society.

Having resonated for many years in Chemistry, we wish Tina a very happy, well-deserved and, of course, relaxing retirement!

Professor Dame Carol Robinson leads new Kavli Institute for Nanoscience Discovery

Professor Dame Carol Robinson is Director of the new Kavli Institute for Nanoscience Discovery (Kavli INSD).

The new Institute brings together world-leading researchers in biochemistry, structural biology, chemistry, pathology, physics, physiology and engineering and is based in a new building at the heart of the Oxford Science Area.

Supported by the US-based Kavli Foundation, the Kavli INSD will house over 40 academics, including Professor Robinson and five other research leaders from the Department of Chemistry, as well as 400 students and postdoctoral researchers.

Professor Dame Carol Robinson

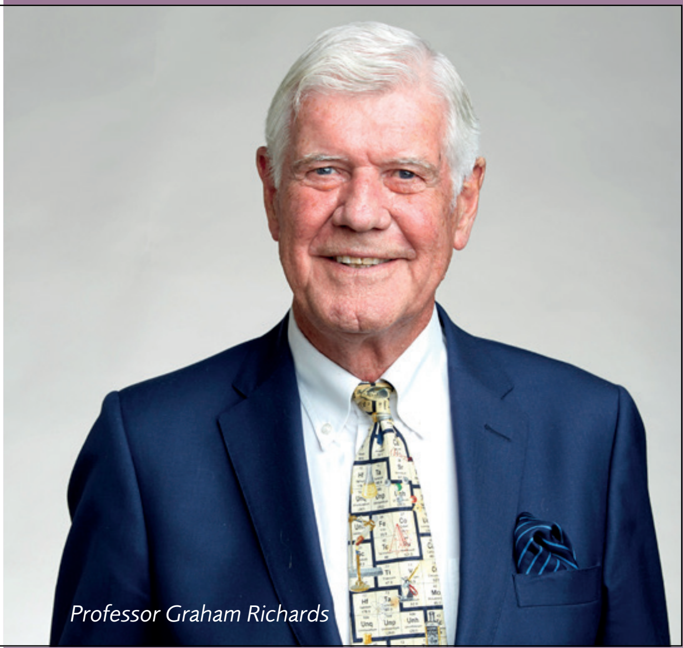
Professor Robinson and her group moved into the new Institute in June and her work is already underway on applying mass spectrometry to understand protein complexes in health and disease. Other groups from the Department of Chemistry include the Kukura, Baldwin, Benesch and Rauschenbach groups as well as a recently appointed Future Leadership Fellow, Weston Struwe.

Professor Robinson said: "I am delighted to be the founding Director of the Kavli Institute for Nanoscience Discovery with its mission of bringing the physical sciences into the cell. The opportunity to shape this new interdisciplinary centre where the outcomes are not determined in advance, but discovered through experiment, is something that resonates very strongly with me.

"Scientific research increasingly involves collaboration between different disciplines due to the complexity of cutting-edge work. By bringing multiple disciplines together under the same roof to advance scientific research the new Kavli Institute will create an environment that encourages the cross-pollination of ideas and interdisciplinary cooperation."

A Scientific Life

Professor Graham Richards CBE FRS shares the remarkable story of his life and career in a new book.


Professor Graham Richards

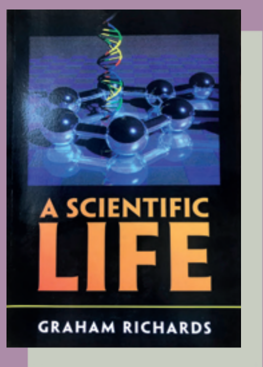
Graham Richards begins his new book with the question "Why would anyone be interested in my life?" It is difficult to imagine why anyone with even the slightest interest in science and scientists would not be interested in such an extraordinary life.

Born at the outbreak of World War II to a mother whose schooling finished at age 11, and having suffered from polio as a child, Graham's background would not have been typical of the young men who went up to Brasenose College in 1958. But he thrived at Oxford and stayed to take a doctorate, during which time he became one of the earliest chemists to use a computer. With characteristic modesty he attributes his initiative to luck, writing "I realised, perhaps out of laziness, that there was this newfangled thing called a computer which could do integrals numerically.." Graham went on to become a pioneer in the field of computer-aided molecular design and drug discovery, and he recounts the story of some of his most significant work, including the implementation of the groundbreaking Screensaver Lifesaver project, in *A Scientific Life*.

Graham's account of Oxford life and politics over half a century is fascinating – from conducting night time promenades in full academic regalia as a pro-proctor tasked with keeping student discipline in the turbulent years of 1969-70, to serving as chair of the University and Industry committee during the Wilson years of 'white hot technological revolution', becoming a member of Council, and eventually serving as the first head of the newly-unified Department of Chemistry from 1997. During this time Graham's highly innovative ways of raising funds enabled the building of the Chemistry Research Laboratory, which was opened by HM the Queen in 2004.

Graham tells the story of how he became a pioneer in the commercialisation of academic science, playing an instrumental part in the creation and management of technology transfer company Oxford University Innovation, which went on to generate tens of millions of pounds for the University. He also founded his own companies including Oxford Molecular, a scientific software company that at its peak was worth £450m. Graham's honest and amusing account of the highs and lows of his entrepreneurial activities will surely be essential reading for any would-be academic entrepreneur, and to this day he remains a strong advocate of the benefits of commercialisation for both academia and the wider economy.

***A Scientific Life* was published by AuthorHouse in January of this year.**
ISBN: 978-1-6655-8443-2



A New In stitute to tackle Antimicrobial Resistance

Ineos, one of the one of the world's largest manufacturing companies, and the University of Oxford are launching a new institute to tackle the growing worldwide problem of antimicrobial resistance. The Ineos Oxford Institute (IOI), funded by a £100 million donation from Ineos, will link the Departments of Chemistry and Zoology to create a cross-disciplinary institute for research and drug discovery that will tackle one of the most pressing issues of our time. Antimicrobial resistance (AMR), which is caused by misuse and overuse of antibiotics, currently contributes to an estimated 1.5 million excess deaths each year and could lead to over 10m deaths per year by 2050.

The IOI will be led by Professor Chris Schofield and Professor Tim Walsh, from the Departments of Chemistry and Zoology, respectively. Professor Schofield, Chemistry Academic Lead for the IOI, said: "Clinical practice has been maintained by common use of antibiotics. In fact there are very few classes of antibiotics, approximately half a dozen that are really important. All of those are compromised by resistance mechanisms now."

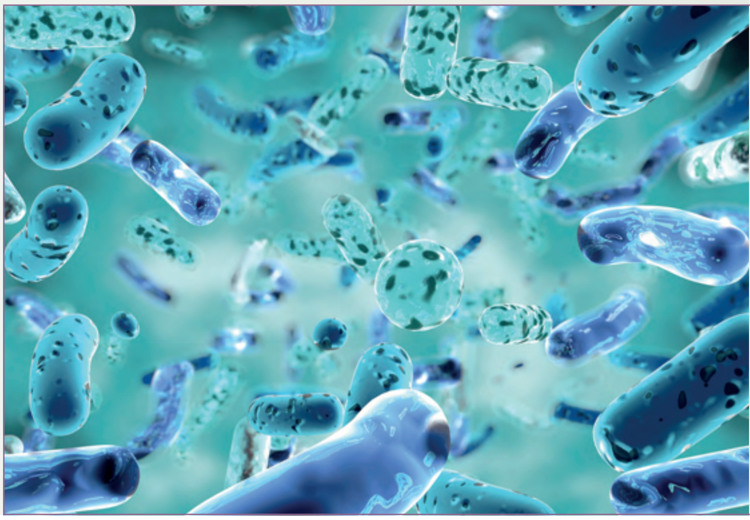
Surgeon David Sweetnam, advisor to the IOI, explained: "If antimicrobial resistance becomes widespread, we will return to what is only referred to as the pre-antibiotic era - where a simple urinary tract infection or a simple cut leads to death. I think it is our job to make sure the unthinkable doesn't become the inevitable."

To tackle this global threat, researchers at the IOI will work to design new drugs and find ways to better manage the use of existing ones. Most global antibiotic consumption by volume is in agriculture, and drug use in animals contributes significantly to decreasing antibiotic effectiveness in humans. The IOI will therefore focus on designing novel antimicrobials for animals, as well as exploring new drugs for humans. The Institute will also form partnerships with other global leaders in the field of antimicrobial resistance to raise awareness and promote responsible use of antimicrobial drugs and will seek to attract and train the brightest minds in science to tackle this 'silent pandemic'. The Institute will be based between two sites in Oxford - the Department of Chemistry and the Department of Zoology in the new Life and Mind building that is currently under construction.

Commenting on the £100m gift from Ineos, Professor Louise Richardson, Vice Chancellor, said: "This is a wonderfully generous gift for which we are very grateful. It is another example of a powerful partnership between public and private institutions to address global problems. Oxford played a crucial role in the early development of antibiotics so it is only appropriate that we take the lead in developing a solution to antimicrobial resistance."

Sir Jim Ratcliffe, founding donor and Chairman of Ineos, said: "Innovative collaboration between industry, academia and government is now crucial to fight against AMR. Ineos in its 22 years has become the largest private company in the UK, delivering large-scale, ambitious technical projects with impactful results. We are excited to partner with one of the world's leading research universities to accelerate progress in tackling this urgent global challenge."

The IOI is now beginning the process of recruiting core staff and academic researchers to ramp up its activities and take forward its crucial research.



DPhil Centenary Campaign

Our vibrant community of DPhil students has thrived over the past year, even with the challenges created by lab occupancy restrictions and other safety measures required by COVID-19. They continue to drive forward exciting research projects and take part in innovative training programs in partnership with industry. We are very thankful for all the support from alumni and friends that we have received as part of our Centenary Campaign to mark one century of the DPhil in Oxford Chemistry, especially given the changing landscape of research and student funding. Please read on for an update from the first research student supported as part of the Campaign.

Bryan Ng is in the second year of his DPhil in the Tsang group and is the recipient of the Oxford-Brilliant Education Chemistry Scholarship. Bryan spent part of the first year of his DPhil at the National Synchotron Radiation Research Center (NSRRC) in Taiwan to learn about data processing for X-ray absorption spectroscopy (XAS), a measurement technique used to determine the atomic structure and electronic state of matter. The NSRRC is home to one of the world's most advanced synchrotron facilities and draws scientists from around the world, eager to drive forward fundamental and applied reseach in areas such as chemistry, medicine, nanotechnology, environmental science and more. This experience enabled Bryan to develop the skills needed to provide the Tsang group with enhanced XAS capabilities. Bryan's knowledge will allow them to use the technique to reveal more information about the local environments of metals of interest for the development of novel catalysts, and in much greater detail than was previously possible.

Now that Bryan has completed his time at the NSRRC in Taiwan and has returned to Oxford, he is spending the second year of DPhil focusing more on his own research – the chemistry of metal-organic frameworks (MOFs). MOFs have enormous potential as heterogeneous catalysts and have a wide range of other valuable applications, for example in the areas of hydrogen storage and carbon capture. Even at this early stage in his DPhil, Bryan has already published a paper as second author, which has been submitted and is pending review. This academic year, he looks forward to continuing to progress his research and to a resumption of activities and events in College and across Oxford as and when they are deemed safe with the easing of COVID-19 restricitons.

Spotlight on: the Tsang Group

The Tsang group's research focuses on fundamental and applied aspects in catalysis and materials chemistry. Their work includes synthesis, testing and characterization of novel solid state materials for a wide range of applications, including in catalysis, sensors and medicine. The group also undertakes a breadth of research on new catalytic techniques for sustainable energy systems and solutions, for example photocatalytic solar cells, wind to ammonia conversion, hydrogen storage, and carbon dioxide activation, capture, storage, and conversion to useful products in a bid to reduce emissions and support net zero goals. The group is a global leader in green ammonia research, an area with enormous potential for reducing carbon emissions in the food industry and as a sustainable energy solution in the future.

Professor Edman Tsang said: "Bryan is a real asset to the group, and I am delighted that his outstanding research skills were recognized with the establishment of the Oxford-Brilliant Education Scholarship. His contributions to the group, both as a result of his time at the NSRRC and more generally, are enormously valuable. I have no doubt that he will continue to excel over the course of his DPhil, and look forward to seeing how his research career progresses in the future."

Bryan Ng

Centenary Scholars

We are delighted to report that the Centenary Scholars supported by alumni and other donors as part of the Centenary Campaign have just begun their DPhil studies this academic year. We look forward to sharing updates from some of them later this academic year. DPhil and Part II students are indispensable members of the Department, undertaking truly fundamental and challenge-driven applied research that pushes boundaries across the subject and supports the development of life-improving technologies, medicines and approaches. One of our central missions is to provide them with the best research and training experiences, and support of all kinds from alumni, industry and foundations helps make this a reality.

Head of Department Professor Mark Brouard said: "On behalf of the Department, I would like to extend my deepest thanks for the generous contributions of our community of alumni and friends, which are enabling us to support outstanding research students – something that is vitally important for our research programs. I hope that we can continue to build up the Centenary Fund to support more scholars in the future and can enhance our provision of internships, mentoring and so on for students. It really is a great privilege to be able to welcome so many brilliant young minds to the Department and provide them with all the skills, knowledge and experiences they need to succeed in their studies and beyond – thank you again for your continued support."

Will you make a gift to support outstanding students and their research in Oxford Chemistry, regardless of background or circumstance?

You can make a gift online at **development.chem.ox.ac.uk/centenary-campaign**, or get in touch using the details below.

You can also return the enclosed form, but please note with current safety restrictions there may be a delay in processing gifts made by mail.

We are extremely grateful for every donation of every size, all of which make a real difference to our students and the Department as a whole.

Could you support students in other ways?

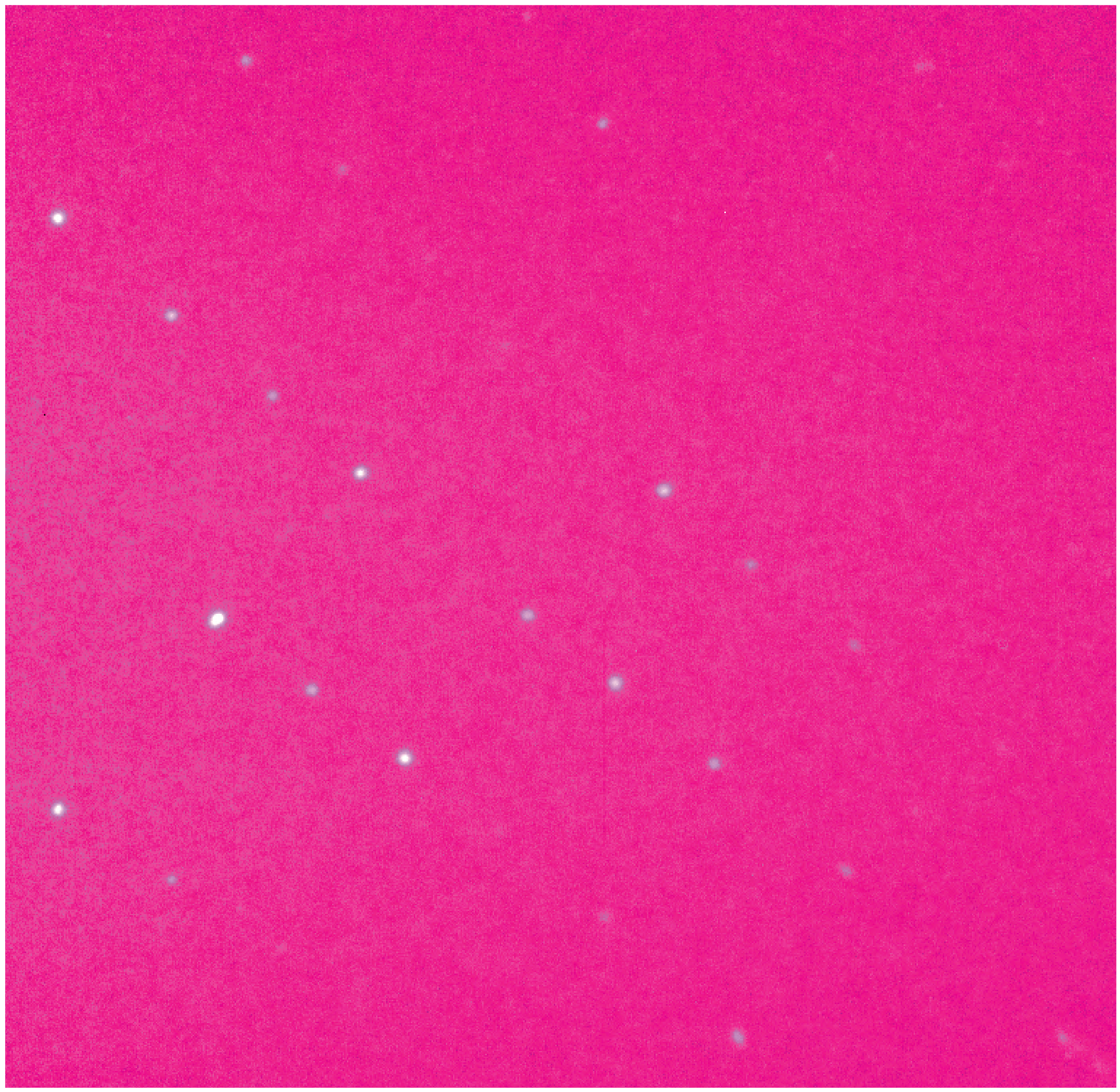
Perhaps you'd be interested in offering an internship, hosting a seminar, mentoring individuals or groups, or engaging with our students in another way. We would be delighted to discuss this in greater depth with you.

Do you have any stories to share?

We are building up our archives in the Department and are keen to hear stories and see any photos from your time as a student in Oxford Chemistry.

To support our students or share your memories and photos, please contact Susan Davis: susan.davis@chem.ox.ac.uk | Physical & Theoretical Chemistry Laboratory, South Parks Road, Oxford OX1 3QZ.

An X-ray diffraction image from a single crystal of a deoxycholic acid host-guest complex. Image courtesy of Professor Richard Cooper.



Contact us

www.chem.ox.ac.uk

Periodic magazine is published annually and distributed free to chemistry alumni, researchers, staff, students and friends of the Department. We are always delighted to hear from readers, and if you have any pictures you would be willing to share please do get in touch.

Contact: Susan Davis. Email: alumni@chem.ox.ac.uk

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

Editor: Susan Davis

Science writers: Hannah Fowler, Karen Heathcote, Thomas Player

Design: Joe Graham, Balancing Act Design

Distribution and printing: windrushgroup.co.uk

UNIVERSITY OF OXFORD

MIX
Paper from responsible sources
FSC® C013002
FSC www.fsc.org