

UNIVERSITY OF CAMBRIDGE

Yusuf Hamied Department of Chemistry

Postgraduate Virtual Open Day 2026



Welcome to the Yusuf Hamied Department of Chemistry's postgraduate open day and thank you for joining us. In order to provide you with an easy-access current snapshot of the breadth and depth of groundbreaking research taking place here right now, our academics have all contributed to this booklet.

Our reputation as a leading centre of academic excellence is reflected in state-of-the-art facilities, excellent professional services staff, our world-leading faculty and postdocs; and crucially our diverse community of postgraduates. We pride ourselves on providing a safe and supportive environment in which creative students from all backgrounds can conduct the most exciting, rigorous, and transformative research imaginable.

We are certain you will find something here to interest and inspire you. Please take a close look, enjoy the opportunities to interact today, explore the web pages, and do follow up with academics or our postgraduate team if you need further information.

We sincerely look forward to receiving your application to study with us,

Professors Deborah Longbottom and Stephen Jenkins,
Co-Heads of Department



Postgraduate Virtual Open Day Schedule

Yusuf Hamied Department of Chemistry, University of Cambridge

Thursday 5th November 2026

14.00 – 14.25 **Postgraduate Team Presentation**
14.25 – 14.45 **Postgraduate Team Q&A**

Acknowledgements

Organisers *Tessa Blackman and Olivia Hamlet*
Photography *Nathan Pitt and Michael Webb*
Design *Richard Shaw*

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The Yusuf Hamied Department of Chemistry

University of Cambridge

The Yusuf Hamied Department of Chemistry is consistently ranked as the leading Chemistry department in the UK and among the top five worldwide. Our community brings together around 60 academic staff, over 200 postdoctoral researchers and more than 250 postgraduate students. Each year, we welcome approximately 80 new postgraduates from more than 500 applications. We offer two postgraduate degrees:

- **MPhil in Chemistry** (by research)
- **PhD in Chemistry**

Research in the Department spans nine collaborative **Research Interest Groups**, covering areas from biological chemistry and materials to theory and spectroscopy. This breadth provides students with an exceptional environment to engage in cross-disciplinary work.

Our facilities include world-class laboratories and research centres, including our **Chemistry of Health Building**, which houses the Centre for Protein Misfolding Diseases, the Molecular Production and Characterisation Centre, and the Cambridge Centre for Chemical Synthesis.

We are proud to hold an **Athena SWAN Silver Award** and remain strongly committed to improving equality, diversity and inclusion in science. Women scientists make up over a third of our postdoctoral researchers and nearly half of our postgraduate students.

Postgraduate students are fully supported by dedicated administrative staff, a team of pastoral tutors, and well-established student and academic mentoring systems, ensuring an outstanding and supportive research environment.



How To Apply

The Route into Cambridge

Successful applications come from people who have researched what they want to study and with whom. That is our experience. While success in the process cannot be guaranteed, a well-researched and thoroughly written application is the expectation. We encourage you to correspond directly with potential supervisors in advance of submitting your application.

To be considered for Departmental funding (as well as the University scholarship competitions) your application must be submitted by 8th December 2026. Submit your application using the University Postgraduate Admissions online Applicant Portal. Checking documents requirements early on is advised to avoid delays or automatic rejection and submitting early is desirable.

The Department has minimum entry requirements which are higher than some other departments across the University:

MPhil 2.1 Honours degree
PhD 2.1 MSci or MChem

Please check here for international equivalencies and if you are still unsure, contact the Chemistry Postgraduate Admissions Team.

University Postgraduate Admissions
For application submissions, scholarship searching and more, please click here.

Chemistry Postgraduate Admissions
For details on how to apply, application guidance, funding options and links, please click here.



Postgraduate Education

Our Researcher Development Programme

The Yusuf Hamied Department of Chemistry is committed to providing an excellent postgraduate experience through comprehensive training, career development and a strong social network.

Postgraduate students take part in **research-level lectures, workshops and peer-to-peer presentations** throughout their studies. Our structured **Researcher Development Programme** offers training in transferable skills, presentation and communication, and career planning. In-house careers sessions are complemented by close links with the University Careers Service, providing guidance on both academic and non-academic pathways.

Opportunities to gain teaching experience are an integral part of postgraduate education. Students can contribute to the University's renowned supervision system, working with undergraduates in small-group tutorials organised by the Colleges. Within the Department, PhD and MPhil students are encouraged to **demonstrate in undergraduate laboratories**, supporting practical classes, explaining experimental techniques, and assessing written reports. Both supervising and demonstrating provide valuable professional skills while offering an additional source of income.

The Department also organises annual events such as **Showcase Week**, where students present their research to peers and academics, and maintains robust feedback and reporting systems to support progress.

Through this combination of high-level research training, professional development, and teaching opportunities, we aim to provide every postgraduate with the skills, confidence and experience needed for a successful career in science and beyond.



Materials Chemistry

Our Dark and Light-Responsive Materials

The technological devices we depend on, from aeroplanes to mobile phones, rely upon ever-increasing structural complexity for their function. Designing complex materials for these devices through the art of chemical synthesis brings challenges and opportunities.

Members of the Materials RIG invent new materials in view of potential applications. Modern materials chemistry is a wide ranging topic and includes surfaces, interfaces, polymers, nanoparticles and nanoporous materials, self assembly, and biomaterials, with applications relevant to oil recovery and separation, catalysis, photovoltaics, fuel cells and batteries, crystallisation and pharmaceutical formulation, gas sorption, energy, functional materials, biocompatible materials, computer memory, and sensors.

If you are keen to work on a project in one of our groups, contact the group leader directly and discuss your application with them in advance of submitting your application to the University.

The Materials Chemistry research groups accepting postgraduate students (PhD and MPhil) for entry in October 2027 are:

Prof. Hugo Bronstein

Prof. Melinda Duer

Prof. Alex Forse

Prof. Dame Clare Grey FRS

Dr Svetlana Menkin

Prof. Jonathan Nitschke

Prof. Erwin Reisner (PhD only)

Prof. Oren Scherman

Prof. Andrew Wheatley

Prof. Dominic Wright

Prof. Jenny Zhang



Professor Hugo Bronstein | click here for video

Organic Materials for Energy Applications

Research in our group is centred on the organic synthesis of conjugated polymers and molecules for a range next generation plastic electronic technologies.

Key challenges are the development of flexible solar panels and light emitting diodes which are flexible, efficient and sustainable. We also research many other aspects of functional organic materials such as bio-electronics, flexible lasers and field-effect transistors.

We work closely with physicists and materials scientists to understand the underlying photophysical processes in our materials and test them as a new generation of plastic electronic devices.

Relevant Papers

Synthesis of model heterojunction interfaces reveals molecular-configuration-dependent photoinduced charge transfer. *Nature Chemistry*, **2024**, 16, 1453–1461.

Suppression of Dexter transfer by covalent encapsulation for efficient matrix-free narrowband deep blue hyperfluorescent OLEDs. *Nature Materials*, **2024**, 23, 519–526.

Exploiting Excited-State Aromaticity To Design Highly Stable Singlet Fission Materials. ***J. Am. Chem. Soc.***, **2019**, 141, 13867–13876.

Highly Luminescent Encapsulated Narrow Bandgap Polymers Based on Diketopyrrolopyrrole. ***J. Am. Chem. Soc.***, **2018**, 140, 1622–1626.

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Professor Melinda Duer | click here for video

Understanding How Materials Direct Cell Behaviour

We use solid-state NMR, electron microscopy and a range of optical imaging techniques to understand the key molecular structural and dynamics aspects of the extracellular matrix and biomaterials that drive cell behaviour.

The extracellular matrix (ECM) is a complex 3D architecture of proteins and sugar polymers. It forms the bulk of our structural tissues and provides them with their particular mechanical properties but more intriguingly, at the molecular level, it provides the communication system between the cells in the tissue and the signals that drives the individual behaviour of cells. The ECM is particularly important in degenerative diseases, such as osteoporosis, osteoarthritis, diabetes mellitus and neurodegenerative diseases, and in cancer, where. degradation of the ECM directs dysfunctional cell behaviour that progresses the disease. Our aim is to generate insight that leads to chemistry-based approaches to repairing damaged or aberrant ECM structures to restore cell, and hence organ, function.

Relevant Papers

Glycation changes molecular organization and charge distribution in type I collagen fibrils. Sneha Bansode, Uliana Bashtanova, Rui Li, Jonathan Clark, Karin H. Müller, Anna Puszkarska, Ieva Goldberga, Holly H. Chetwood, David G. Reid, Lucy J. Colwell, Jeremy N . Skepper, Catherine M. Shanahan, Georg Schitter, Patrick Mesquida, Melinda J. Duer*, *Scientific Reports*, 10 **(2020)** 3397-3410.

Collagen Structure–Function Relationships from Solid-State NMR Spectroscopy. Ieva Goldberga, Rui Li, and Melinda J. Duer*, *Acc. Chem. Res*. 51 **(2018)** 1621-1629.

Citrate bridges between mineral platelets in bone. E. Davies, K.H. Muller, W.C. Wong, C. J. Pickard, D.G. Reid, J.N. Skepper, M.J. Duer*, *Proc. Nat. Acad. Sci. USA* 111 **(2014)** E1354–E1363

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Professor Alex Forse | click here for video

Materials for Climate Change Mitigation

Our ultimate goal in the Forse Group is to design materials that can reduce greenhouse gas emissions and help tackle the climate crisis. Limiting global warming to 1.5 °C requires the rapid development and deployment of a range of greenhouse gas mitigation technologies.

We are exploring new materials for carbon dioxide capture and electrochemical energy storage, both of which can help mitigate greenhouse gas emission. For example, we are developing new batteries that can capture carbon dioxide pollution when charged. We are also developing improved fast charging supercapacitor energy storage devices.

We specialise in the application of nuclear magnetic resonance (NMR) spectroscopy techniques that are complemented by electrochemistry, synthetic chemistry and computational chemistry.

Relevant Papers

Capturing Carbon Dioxide from Air with Charged Sorbents, ***Nature***, **2024**, 630, 654

Structural Disorder Determines Capacitance in Nanoporous Carbons, ***Science***, **2024**, 384 (6693), 321

Enhancing Electrochemical CO2 Capture with Supercapacitors, ***Nature Comm.*** **2024**, 15, 7851

Revealing Ion Adsorption and Charging Mechanisms in Layered Metal-Organic Framework Supercapacitors with Solid-State Nuclear Magnetic Resonance, ***J. Am. Chem. Soc.***, **2024**, 146, 33, 23171

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Professor Dame Clare P. Grey FRS

Structure and Dynamics in Batteries and Supercapacitors

We use a wide range of techniques, including solid state NMR spectroscopy and diffraction, to investigate local structure and dynamics and the role that this plays in controlling the physical properties of technologically important, but disordered materials. A particular focus of the group is on understanding how the materials that are found in rechargeable batteries – such as those found in laptops, mobile phones and electric vehicles - function. For example, if we can determine how Li-ions move in and out of the battery electrode materials, as the batteries are cycled, then we could design materials that could sustain even faster cycling or may last longer. Battery materials operate outside their thermodynamic stability windows and will react over time to form more stable structures, resulting in battery degradation. Our work focusses on understanding and mitigating these processes – with a particular emphasis on developing new characterization methods to follow these processes often in real time. With magnetic resonance methods we can watch, for example, Li plating and help provide insight into why this process (which can lead to serious safety incidents) occurs.

Relevant Papers

Niobium tungsten oxides for high-rate lithium-ion energy storage, ***Nature***, **2018**, ***559***, 556.
Materials' methods: NMR in battery research, ***Chem. Mater.***, **2017**, 29, 213-242.

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Dr Svetlana Menkin | click here for video

Fundamental studies of Electrified Interfaces and Electrodeposition enable Sustainable Batteries.

Our research aims to provide a fundamental understanding of localised interface activity and use the insights to enable sustainable, reliable, and affordable energy storage solutions for climate change mitigation. We look at metal electrodeposition mechanisms by investigating how a charge is transported across interfaces, one of the remaining fundamental questions in Electrochemistry. Using scanning electrochemical microscopy to focus on localised electrochemical reactions on the surface and electrochemical impedance spectroscopy to track charge passage routes through the solid-liquid interface, we gain new insights into how interface structure and dynamics drive bulk activity. We explore new strategies for plating the most promising, albeit challenging, multivalent metals (e.g., calcium, zinc, and aluminium) that are still considered (almost) impossible to plate. At the same time, we are investigating lithium and sodium metal plating and corrosion using an alternative bottom-up methodology to realise safer and more energy-dense anode-free batteries.

Relevant Papers

Simon, J. T.; Gunnarsdóttir, A. B.; Gray, E. L.; Tripathy, D.; Sayed, F. N.; Chhowalla, M.; Clarke, S. M.; Grey, C. P.; Menkin, S. *Separating Hydrogen Evolution From Electroplating in Zn Metal Batteries Using Scanning Electrochemical Microscopy* ***Advanced Energy Materials.*** DOI: 10.1002/aenm.71398

Wiśniewska, E.; Shi, X.; Newitt, R.; Sanyal, V.; Palanisamy, K.; Menkin, S. Role of Tin Seed Layers in SEI Evolution and Lithium Electrodeposition. **Faraday Discussions (2026).** DOI: 10.1039/D6FD00048G

Menkin, S.; Ayerbe, E.; Gunnarsdóttir, A. B.; del Olmo, D.; López-Aranguren, P.; Rafique, A.; Rikarte, J.; Chauque, S.; Shi, X.; Guillon, O.; Dominko, R.; Schlee, P.; Finsterbusch, M.; Kvasha, A.; Fattakhova-Rohlfing, D. Anode-Free Cell Concepts: Critical Analysis and Development of Practical Batteries. **Small (2026).** DOI: 10.1002/smll.202513633

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Professor Jonathan Nitschke | click here for video

Strange Cages for Chemical Beasts

Simple organic subcomponents can come together around metal-ion templates to produce intricate hollow capsules.[1] The Nitschke group explores the design and uses of some of these three-dimensional architectures, along with the use of the same construction principles to produce interlocked structures – catenanes[2] and knots[3] – and double-helical metallopolymers with useful optoelectronic properties.[4] Some of the structures that we have explored include a tetrahedral cage that encapsulates white phosphorus,[5] an antiaromatic-walled cage,[6] and a large capsule isomorphous to ferritin.[7] Current work targets the preparation of dodecahedral capsules that will be large enough to encapsulate proteins, along with flexible capsules woven together from macrocyclic strands.

Relevant Papers

[1] D. Zhang, T. K. Ronson, J. R. Nitschke, ***Acc. Chem. Res.*** **2018**, 51, 2423-2436.

[2] C. S. Wood, T. K. Ronson, A. M. Belenguer, J. J. Holstein, J. R. Nitschke, ***Nature Chem.*** **2015**, 7, 354-358.

[3] J. P. Carpenter, C. T. McTernan, J. L. Greenfield, R. Lavendomme, T. K. Ronson, J. R. Nitschke, ***Chem*** **2021**, 7, 1534-1543.

[4] J. L. Greenfield, D. Di Nuzzo, E. W. Evans, S. P. Senanayak, S. Schott, J. T. Deacon, A. Peugeot, W. K. Myers, H. Sirringhaus, R. H. Friend, J. R. Nitschke, ***Adv. Mater.*** **2021**, 33, 2100403.

[5] P. Mal, B. Breiner, K. Rissanen, J. R. Nitschke, ***Science*** **2009**, 324, 1697-1699.

[6] M. Yamashina, Y. Tanaka, R. Lavendomme, T. K. Ronson, M. Pittelkow, J. R. Nitschke, ***Nature*** **2019**, 574, 511-515.

[7] J. A. Davies, T. K. Ronson, J. R. Nitschke, ***Chem*** **2022**, https://doi.org/10.1016/j.chempr.2022.1001.1003

[8] J. L. Greenfield, F. J. Rizzuto, I. Goldberga, J. Nitschke, ***Angew. Chem., Int. Ed.*** **2017**, 56, 7541-7545.

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Professor Erwin Reisner (PhD only) | click here for video

Sustainable Energy and Circular Chemistry

Our research team creates novel ideas and concepts, assembles innovative prototype devices and develops emerging technologies for the solar-powered conversion of waste, water and air into sustainable fuels and chemicals. A long-standing strength of our team is commitment to collaborative and cross-disciplinary science, with chemists, physicists, materials and nano-scientists, chemical biologists, synthetic biologists, engineers and entrepreneurs working together in our laboratory. We currently focus on solar-powered technologies for the upcycling of plastic and biomass waste as well as the valorisation of the greenhouse gas carbon dioxide to produce green fuels and chemicals and ultimately enable solar circular chemical industries.

Relevant Papers

Direct air capture of CO_2 for solar fuel production in flow, ***Nature Energy***, **2025,** 10, 448–459 (link https://www.nature.com/articles/s41560-025-01714-y)

Solar reforming as an emerging technology for circular chemical industries, ***Nature Energy,*** **2025**, 10, 448–459 (link https://www.nature.com/articles/s41570-023-00567-x)

Hybrid photothermal–photocatalyst sheets for solar-driven overall water splitting coupled to water purification, ***Nature Water***, **2023**, 1, 952–960 (link https://www.nature.com/articles/s44221-023-00139-9)

Solar-driven liquid multi-carbon fuel production using a standalone perovskite–BiVO4 artificial leaf, ***Nature Energy,*** **2023**, 8, 629

Floating perovskite-BiVO4 devices for scalable solar fuel production, ***Nature***, **2022**, 608, 518.

Photoelectrochemical CO2-to-fuel conversion with simultaneous plastic reforming, ***Nature Synthesis***, **2022**, 2, 182

Bacteria–photocatalyst sheet for sustainable carbon dioxide utilization, ***Nature Catalysis***, **2022**, 5, 633

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Professor Oren A. Scherman | click here for video

Dynamic Supramolecular Materials for Healthcare and Sustainable Technologies

We design molecules and soft materials that assemble, adapt and respond to their environment. Using selective non-covalent interactions (often based on host-guest recognition with cucurbit[n] urils) we programme material mechanics, dynamics, responsiveness and biological performance. Our work spans supramolecular chemistry, polymer science, materials engineering and healthcare, translating molecular design into functional technologies.

Healthcare and biomaterials: We develop dynamic hydrogels for regenerative medicine, biosensing and drug delivery. A major focus is pH-responsive materials for osteoarthritis, including injectable systems tailored to adapt to conditions in diseased joints. We also create cartilage-inspired biomaterials that combine strength, flexibility, toughness and resilience, while enabling stress relaxation, self-recovery and remodelling. These materials support durable clinical technologies and help reveal how cells respond to dynamic environments.

Relevant Papers: *Adv. Mater.*, **2026**, 38, e23440; *Adv. Mater.*, **2025**, 37, 2415687; *J. Am. Chem. Soc.*, **2025**, 147, 33337; *Nat. Mater.*, **2022**, 21, 103.

Energy and sustainability: We design adaptive systems for efficient electron and energy transfer in energy storage, catalysis and soft bioelectronics. We also develop scalable routes to robust, self-healing colloidal photonic films. These recyclable, reconfigurable materials could support photovoltaics, wearable sensors, robotics and autonomous power sources.

Relevant Papers: *Science*, **2026**, 393, 1009-1013; *Sci. Adv.*, **2024**, 10, eadn5142; *Nature*, **2023**, 103, 949-955; *Nat. Nanotechnol.*, **2021**, 16, 1121.

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Professor Andrew Wheatley | click here for video

Exploiting synergy in multiscale systems

My group is interested in generating new functionality by the multiscale integration of different chemical motifs. A track-record in organometallics enables us to combine enhanced chemical reactivity with molecular cluster and nanocatalyst design. We seek to harness the potential of synergic activity in multimetallic nanomaterials by developing both compositional and morphological control during synthesis. Our focus is on independently varying these two characteristics to allow new efficiencies in applications like oxygen and CO_2 reduction. We employ molecular control to manipulate crystal faceting, nanoparticle growth, and intermetal electronic effects. We also work on the synthesis of photoresponsive heterometallic molecular clusters capable of facile deposition on surfaces for the frequency modulation of light. Combining scales, we also work on hosting molecules and nanomaterials in composites that combine the properties of the guest with those of a support matrix. The latter is typically a self-shaping metal-organic framework. New ways of constructing these monolithic systems allow us to combine excellent mechanical properties with tuneable porosity. The introduction of additional functionality is possible my modifying either the support or guest. Applications are being explored in nonlinear optics, catalyst recycling, and fuel synthesis and storage.

Relevant Papers

Understanding metal-organic framework densification: solvent effects and the growth of colloidal primary nanoparticles in monolithic ZIF-8, ***Small,*** **2025**, 21, 2500510.

Luminescent alkylaluminium anthranilates reaching unity quantum yield in the condensed phase, ***Angew. Chem. Int. Ed.,*** **2025**, 64, e202501985.

Anisotropic heterobimetallic nanomaterials with controlled composition for efficient oxygen reduction at ultralow loading, ***Adv. Funct. Mater.***, **2024**, 2411006.

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Professor Dominic Wright | click here for video

From Molecules to Materials

Making new inorganic molecules and materials is fundamentally important to future developments in energy storage and catalysis. Our group is interested in broad aspects of synthetic inorganic chemistry, spanning main group elements and transition metals. The focus is on the development of systematic synthetic methods in inorganic synthesis, which parallel the type of synthetic approaches used in organic chemistry. Using these approaches we are exploring new strategies to molecular and extended materials, with applications in pollution control, water splitting, new-generation batteries and sustainable catalysis involving non-transition metals.

Relevant Papers

Single-Source Bismuth (Transition Metal) Polyoxovanadate Precursors for the Scalable Synthesis of Doped BiVO4 Photoanodes, ***Adv. Mater.***, **2018**, ***30***, 1804033.

Theory and Practice: Bulk Synthesis of C_3B and its H_2- and Li-Storage Capacity, ***Angew. Chem. Int. Ed.,*** **2015**, ***54***, 5919.

Dipole-Induced Band-Gap Reduction in an Inorganic Cage, ***Angew. Chem. Int. Ed.***, **2014**, ***53***, 1934.

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Professor Jenny Zhang | click here for video

Biological and Artificial Photosynthesis

We love working at the intersections of science and are currently blending together materials science, engineering, electrochemistry, biophysics and chemical biology to understand how to better exchange energy/electrons with living systems. One part of our group develops toolsets to probe deep into the fascinating light-driven redox chemistry that underlies natural photosynthesis. Another part aims to re-wire photosynthesis using electrodes, molecular and colloidal electron shuttles to enhance its efficiency or to extract bioelectricity. We are also getting more inventive with ways in which we can apply our toolsets for manipulating the bioenergetics of living systems – the sky is the limit to what we can use these for.

Relevant Papers

Photosynthesis re-wired on the pico-second timescale, ***Nature***, **2023**, 615, 836

3D-printed hierarchical pillar array electrodes for high-performance semi-artificial photosynthesis, ***Nature Materials***, **2022**, 21, 811

Advancing photosystem II photoelectrochemistry for semi-artificial photosynthesis, ***Nat. Rev. Chem.***, **2020**, 4, 6

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Synthetic Chemistry

Delivering diverse and pioneering synthesis methods

The Department's Synthetic Chemistry research is focussed on developing innovative new methods to make and use molecules of function.

Our interests range from innovative catalytic strategies to the synthesis of small molecules and beyond, to supramolecular assemblies or the total synthesis of biologically important compounds and natural products.

Our research is diverse, pioneering and internationally leading. The dynamic environment created by our research groups, working at the cutting edge of the field, makes postgraduate research at Cambridge the best place for outstanding and motivated students.

If you are keen to work on a project in one of the Synthetic Chemistry groups, contact the group leader directly. Discuss your application with them in advance of submitting your formal application form to the University.

The Synthetic Chemistry research groups accepting postgraduate students (PhD and MPhil unless otherwise indicated) for entry in October 2027 are:

Dr Pawel Dydio

Prof. Matthew Gaunt

Prof. Jonathan Goodman

Prof. Chris Hunter

Prof. Robert Phipps (PhD only)

Prof. David Spring

Dr Ruth Webster



Dr Pawel Dydio | click here for video

Beyond Conventional Catalysis

The most exciting opportunities in catalysis emerge when we learn to control the reaction landscape rather than forcing chemistry down a single pathway. What if the most interesting chemistry begins where a single catalytic cycle ends? In the Dydio Lab, we explore catalytic systems in which multiple pathways intertwine, compete and cooperate — and harness this complexity to create new reactivity and selectivity. Our research operates at the interface of catalyst design, reaction discovery and chemical systems thinking: we build multicatalytic networks, uncover new modes of molecular activation and transformation, and dissect the origins of selectivity so that reactions can be redesigned rather than merely optimised. From carbonylation and C–H functionalisation to molecular editing, late-stage modification and catalytic reaction networks, we integrate synthetic and organometallic chemistry with mechanistic experiments, kinetics, computation and data-driven analysis to expose the hidden logic of catalytic systems and turn that understanding into new chemical capability.

Relevant papers

Regio- and Enantioselective Alkoxycarbonylation of Unactivated Terminal Alkenes under Palladium–Bromide–Monophosphine Catalysis. *J. Am. Chem. Soc.* **2026**, 148, 26960–26969.

Dehomologative C–C Borylation of Aldehydes and Alcohols via a Rh-Catalyzed Dehydroformylation–Borylation Relay. *J. Am. Chem. Soc.* **2025**, 147, 16735–16741.

A Merger of Relay Catalysis with Dynamic Kinetic Resolution Enables Enantioselective β-C(sp^3)–H Arylation of Alcohols. *Angew. Chem. Int. Ed.* **2024**, 63, e202408418.

Multi-Stimuli-Responsive Network of Multicatalytic Reactions Using a Single Palladium/Platinum Catalyst. *Angew. Chem. Int. Ed.* **2024**, 63, e202404684.

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Professor Matthew Gaunt | video here

New Chemistry for Synthesis, Biology and Medicine

Our research is driven by the discovery of new reactions and new ways to make and remodel molecules. Projects range from fundamental catalysis, reaction discovery and complex molecule synthesis to molecular remodelling, medicinal chemistry and the selective modification of peptides, proteins and nucleic acids. We are particularly interested in chemistry that opens new molecular space and creates opportunities to explore biological function and drug discovery. Students receive a rigorous training in modern synthetic organic chemistry, while individual projects can provide experience in high-throughput experimentation, chemical biology, medicinal chemistry and other techniques through collaborations with academic and industrial scientists. Projects are ambitious and often evolve in unexpected directions as the science develops. We want students who are curious, creative and adventurous, and encourage them to develop their own ideas and become increasingly independent scientists. Our aim is to provide the scientific training, opportunities and supportive environment needed for each student to pursue their ambitions, whether in academia, the pharmaceutical and biotechnology industries, or beyond.

Relevant Papers

Programmable remodelling of C–N connectivity in amines. *Nature* **2026**, *in press.* (doi.org/10.1038/s41586-026-11009-1).

One-carbon homologation of alkenes. *Nature* **2025**, 643, 130.

Multicomponent alkene azido-arylation by anion-mediated dual catalysis. *Nature* **2021**, 598, 597.

A general carbonyl alkylative amination for tertiary amine synthesis. *Nature* **2020**, 581, 415.

Selective Chemical Functionalization at N6-Methyladenosine Residues in DNA Enabled by Visible-Light-Mediated Photoredox Catalysis. *J. Am. Chem. Soc.* **2020**, 142, 51.

Nature **2018**, 561, 522. Multicomponent synthesis of tertiary alkylamines by photocatalytic olefin-hydroaminoalkylation.

Nature **2018**, 562, 568. A Protein Functionalization Platform Based on Selective Reactions at Methionine Residues.

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Professor Jonathan Goodman | click here for video

Molecular Challenges

In order to make molecules effectively, we need to be able to understand reactivity and selectivity, get the maximum possible information from analytical data, be able to predict adverse effects, and handle chemical data effectively. We address all of these issues, using machine learning and computational methods to improve our knowledge of chemistry.

Projects in our group include the development of new reactions (what are the limits of the possible?), the automated analysis of analytical data (have we have made what we think we have made?) and the prediction of properties (will a new molecule be safe and stable for as long as we need it to be?) Underlying all of this we are developing ways to enable people to store and analyse molecular data more consistently in order to maximise the impact of research.

Relevant Papers

Leveraging Language Model Multitasking To Predict C–H Borylation Selectivity, ***J. Chem. Inf. Model.*** 2024, **64**, 4286-4297.

Reaction dynamics as the missing puzzle piece: the origin of selectivity in oxazaborolidinium ion-catalysed reactions, ***Chemical Science***, 2023, **14**, 12355-12365.

The DP5 Probability, Quantification and Visualisation of Structural Uncertainty in Single Molecules, ***Chemical Science,*** 2022, **13**, 3507-3518.

InChI version 1.06: now more than 99.99% reliable, ***J. Cheminformatics***, 2021, **13**, 40.

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Professor Chris Hunter

Organic Chemistry

Our research is based on the design and synthesis of organic molecules to learn fundamental rules that govern the complex relationship between chemical structure and functional properties. Current projects are focused on synthetic oligomers equipped with a range of different side chains that determine properties: folding into sequence-defined three-dimensional structures; copying sequence information from parent to daughter strands using template-directed synthesis; protein binding for diagnosis and treatment of misfolding diseases. Projects may involve a range of different techniques and approaches including supramolecular chemistry, organic synthesis, physical organic chemistry, computational modelling, analytical chemistry and chemical biology.

Relevant Papers

Selective Duplex Formation in Mixed Sequence Libraries of Synthetic Polymers, *J Am Chem Soc* **2024**, 146, 9326.

Ligand Profiling as a Diagnostic Tool to Differentiate Patient-Derived α-Synuclein Polymorphs, *ACS Chem Neurosci* **2024**, 15, 2080.

Length and Sequence-Selective Polymer Synthesis Templated by a Combination of Covalent and Noncovalent Base-Pairing Interactions, *J. Am. Chem. Soc.*, **2024**, 146, 32837.

Template-Directed Synthesis of Recognition-Encoded Melamine Oligomers Using a Base-Filling Strategy, *J. Am. Chem. Soc.*, **2025**, 147, 18284.

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Professor Robert Phipps | click here for video

Exploiting Non-covalent Interactions for Control in Catalysis

Our primary focus is on the design and development of new catalysts that employ non-covalent interactions (such as hydrogen bonds, ion pairs) to control various aspects of selectivity. These aspects include regioselectivity, site-selectivity and enantioselectivity, all of which are crucial elements that need to be carefully controlled for a useful synthetic process.

Non-covalent interactions are used extensively by enzymes in biological catalysis and also by supramolecular chemists to assemble fantastic macromolecular structures. Harnessing non-covalent interactions in the context of small molecule catalysts to advance the field of synthetic organic chemistry has fantastic potential and this is our group's main interest.

A range of projects encompass reactivity through transition metals as well as free radicals and we have a number of studentship collaborations with the pharmaceutical industry.

Relevant Papers

A Chiral Hydrogen Atom Abstraction Catalyst for the Enantioselective Epimerization of Meso Diols. ***Science*** **2024**, 386, 42.

Enantioselective Nitrene Transfer to Hydrocinnamyl Alcohols and Allylic Alcohols Enabled by Systematic Exploration of the Structure of Ion-Paired Rhodium Catalysts ***J. Am. Chem. Soc.*** **2024**, 146, 22629

sSPhos: A General Ligand for Enantioselective Arylative Phenol Dearomatization via Electrostatically-Directed Palladium Catalysis ***J. Am. Chem. Soc.*** **2023**, 145, 25553

"The Discovery and Development of the Enantioselective Minisci Reaction" ***Acc. Chem. Res.*** **2023**, 56, 2037

Strategies That Utilize Ion Pairing Interactions to Exert Selectivity Control in the Functionalization of C-H Bonds ***J. Am. Chem. Soc.***, **2022**, 144. 18195

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Professor David Spring | click here for video

Chemistry at the interface with Biology and Medicine

Our research interests use organic synthesis to make molecules, which can be utilised to understand and exploit biological systems. Our current projects include improved designs for antibody-drug conjugates, next generation peptide therapeutics, synthetic methodology, and the discovery of new antibiotics. We collaborate with many chemical companies and academic groups around the world. The scientific education of our group members in organic synthesis is given a high priority. All of our postgraduate students are encouraged also to learn new techniques relating to their projects with our industrial and academic collaborators.

Every effort is made so that group members achieve their career ambitions, usually jobs in academia or the chemical industries.

Relevant Papers

MMP-cleavable linker platform for tumour-responsive homo- and heterobivalent antibody-drug conjugates, A. J. Counsell, S. J. Walsh, N. Ashman, M. Park, F. M. Dannheim, T. A. King, T. Wharton, J. S. Carroll, D. R. Spring, *Chem. Sci.* **2026**, 17, 2722-2731. https://doi.org/10.1039/D5SC06664F

On-resin assembly of cysteine-reactive linkers for controlled site-selective antibody bioconjugation, S. Krajčovičová, T. Wharton, D. R. Spring, *Nature Protoc.* **2026**, 21, s41596-026-01376-4. https://doi.org/10.1038/s41596-026-01376-4

Multicomponent Stapling of Glucagon-like Peptide-1 Enables Receptor-Guided PROTAC Delivery, J. L. Venne, S. Krajčovičová, G. Davies, H. Bolt, J. Revell, D. R. Spring, *Angew. Chem. Int. Ed.* **2026,** 65, e9595531. https://doi.org/10.1002/anie.9595531

Peptide Marriages: Modular Assembly of Multi-Agonist Therapeutics, K. A. Kostadinova, J. L. Venne, S. Krajčovičová, J. Dodgson, W. F. J. Hogendorf, T. E. Nielsen, D. Hymel, H. Bolt, A. Collinson, J. Revell, D. R. Spring, *Chem. Eur. J.* **2026**, 32, e71280. https://doi.org/10.1002/chem.71280

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Dr Ruth Webster | click here for video

Homogeneous catalysis, organometallic and coordination chemistry

Research in the Webster group sits at the boundary between organic and inorganic synthesis. We employ earth abundant metals in catalysis, with a specific focus on using designed iron catalysts in atom economic transformations. The complexities of iron catalysis require us to employ a range of different techniques, and work with collaborators with expertise in complimentary areas (such as DFT, EPR and advanced mass spectrometry techniques), to gain understanding of novel bond breaking and bond making processes.

We have a particular interest in the chemistry of phosphorus, and often couple this with iron catalysis to develop new transformations.

Relevant Papers

Synthetic and Mechanistic Studies into the Reductive Functionalization of Nitro Compounds Catalyzed by an Iron(salen) Complex, ***J. Am. Chem. Soc.*** **2024**, 146, 19839.

Synthesis and Characterization of a Terminal Iron(II)-PH_2 Complex and a Series of Iron(II)-PH_3 Complexes, ***Inorg. Chem.*** **2024**, 63, 6998.

The Complex Reactivity of $[(salen)Fe]_2(\mu\text{-}O)$ with HBpin and Its Implications in Catalysis, *ACS Catal.* **2023**, 13, 11841.

Taming PH_3: State of the Art and Future Directions in Synthesis, *J. Am. Chem. Soc.* **2022**, 144, 16684.

An Iron-Catalyzed Route to Dewar 1,3,5-triphosphabenzene and Subsequent Reactivity, ***Angew. Chem. Int. Ed.*** **2022**, 61, 10.1002/anie.202208663.

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Physical Chemistry

Turning Phenomena into Quantitative Science

Physical Chemistry at Cambridge has two broad but overlapping aims.

One is to understand the properties of molecular systems in terms of physical principles. This work underpins many developing technological applications that affect us all, such as nanotechnology, sensors and molecular medicine.

The other is Atmospheric Chemistry (AC) where the interactions between chemical composition, climate and health are studied using a range of computer modelling and experiment based approaches. Together these two areas form a richly interdisciplinary subject spanning the full range of scientific methodologies: experimental, theoretical and computational. It is the research area with something for everyone.

If you are keen to work on a project in one of the Physical Chemistry groups, contact the group leader directly. Discuss your application with them in advance of submitting your formal application form to the University. The Physical Chemistry research groups accepting postgraduate students (PhD and MPhil) October 2027 are:

Prof. Alex Archibald

Prof. Chiara Giorio

Prof. Stephen Jenkins

Prof. Sir David Klenerman FRS

Prof. Tuomas Knowles

Prof. Steven Lee

Dr Raj Pandya



Professor Alex Archibald | click here for video

Modelling the Chemistry of the Atmosphere

In our team we study the chemistry of the gases and particles present in the air around us. We are concerned with understanding what is causing these compounds to change in their abundance and constitution and what are the impacts of these changes for human health, weather and climate. This interdisciplinary work requires chemists and physical scientists from a range of backgrounds to come together to help tackle some of these grand challenges. The bulk of the work in our team focusses on the use of numerical simulations using high performance computers (super computers). We are home to the UK National Centre for Atmospheric Sciences global model development team and provide bespoke support to our postgraduate students in running and analysing global model simulations. Postgraduates from the group have gone on to work in a wide range of jobs in academia and industry, increasingly in the software/technology area.

Relevant papers:

Staniaszek, Z., Griffiths, P.T., Folberth, G.A., O'Connor, F.M., Abraham, N.L. and Archibald, A.T., The role of future anthropogenic methane emissions in air quality and climate. ***npj Climate and Atmospheric Science,*** **2022**, 5(1), pp.1-8.

Hickman, S.H., Trajković, I., Kaltenborn, J., Pelletier, F., Archibald, A., Gurwicz, Y., Nowack, P., Rolnick, D. and Boussard, J., . Causal climate emulation with bayesian filtering. *Advances in Neural Information Processing Systems*, **2026**, 38, pp.89418-89461.

Jacob, L.S., Harvey, B.E., Giorio, C. and Archibald, A.T., Determining the key sources of uncertainty in dimethyl sulfide and methanethiol oxidation under tropical, temperate, and polar marine conditions. *Atmospheric Chemistry and Physics*, **2026**, 26(5), pp.3567-3587.

Bodnar, C., Bruinsma, W.P., Lucic, A., Stanley, M., Allen, A., Brandstetter, J., Garvan, P., Riechert, M., Weyn, J.A., Dong, H., Gupta, J.K., et al (inc A. Archibald). A foundation model for the Earth system. *Nature*, **2025**, 641(8065), pp.1180-1187.

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Professor Chiara Giorio | click here for video

Air pollution, ice cores, and the Earth's climate

The atmosphere is a complex multiphase environment where gases, particles (aerosols), and cloud droplets constantly interact. We explore how atmospheric chemistry shapes air quality, human health, and global climate.

Our research investigates the molecular-level mechanisms driving particle formation, cloud processing, and aerosol toxicity across indoor, urban, and remote environments. Additionally, we analyse organic biomarkers trapped in polar and glacier ice cores to reconstruct past atmospheric chemistry and evaluate Earth's climate feedbacks over long timescales.

By combining advanced high-resolution mass spectrometry, laboratory simulation chamber experiments, and field observations, we bridge microscopic chemical processes with global environmental impacts. We work at the intersection of atmospheric chemistry, analytical science, and climate science within a supportive, diverse research environment.

Relevant Papers

Physicochemical and Toxicological Characterization of Airborne Brake Wear Particles Reveals Oxidative Stress–Mediated DNA Damage, *Environmental Science & Technology,* **2026**, 60, 4955–4965.

Exposures in Indoor Air Affecting Health, *Allergy*, **2026**, 81, 1–20.

Metal speciation of volcanic aerosols from Mt. Etna at varying aerosol water content and pH obtained by different thermodynamic models, *Environmental Science: Atmospheres*, **2025**, 5, 8–24.

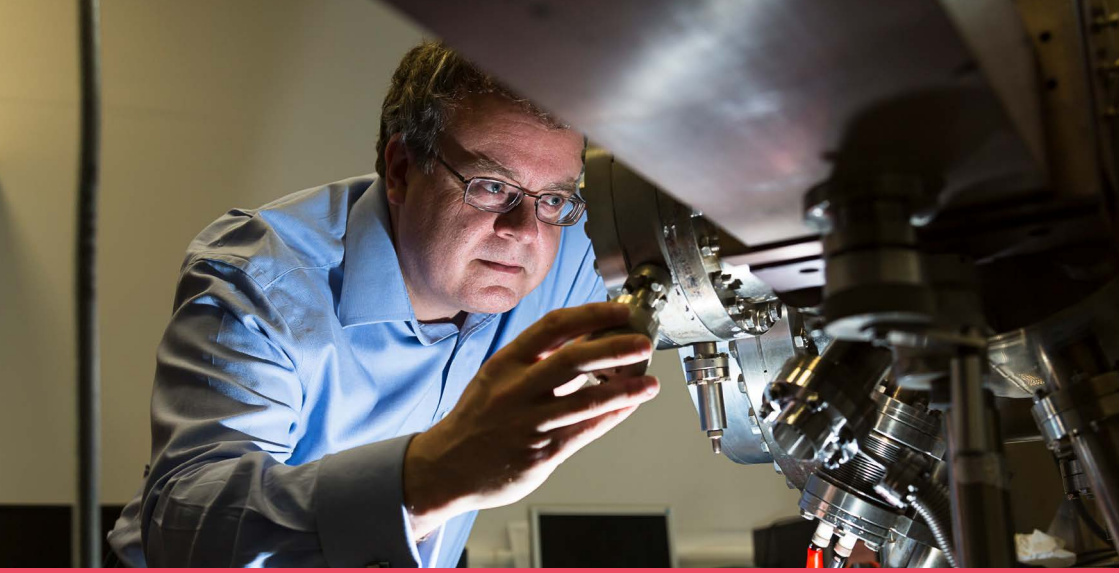
Prospects for reconstructing paleoenvironmental conditions from organic compounds in polar snow and ice *Quaternary Science Reviews*, **2018**, 183, 1-22.

Cloud processing of secondary organic aerosol from isoprene and methacrolein photooxidation. *Journal of Physical Chemistry A*, **2017**, 121, 7641–7654.

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Professor Stephen Jenkins | click here for video

Symmetry, Structure and Dynamics in Surface Chemistry

Modern surface science provides unprecedented insight into physical and chemical processes relevant to sensing, corrosion and heterogeneous catalysis.

My group makes extensive use of first-principles modelling (density functional theory) linked strongly with experimental work conducted here and elsewhere. In this way, we gain understanding at the level of individual adsorbed molecules and individual reaction events, relating these to the underlying physical properties of the surface.

One major focus of our work is on the propagation of chirality between molecules and surfaces; another is on the dynamic processes of bond making and breaking that occur upon adsorption, desorption or surface reaction. In either case, the interplay between symmetry and the low-dimensional surface environment is of paramount importance.

Relevant Papers

First-Principles Dynamics of Fluorine Adsorption on Clean and Monohydrogenated Si{001}, ***Langmuir***, **2022**, 38, 7256.

The Dehydrogenation of Butane on Metal-Free Graphene, ***J. Colloid Interface Sci.***, **2022**, 619, 377.

Surface Chirality Influences Molecular Rotation upon Desorption, ***Phys. Rev. Lett.***, **2021**, 126, 166101.

Comparative Study of Single-Atom Gold and Iridium on CeO2{111}, ***J. Chem. Phys.***, **2021**, 54, 164703.

2D Constraint Modifies Packing Behaviour: A Halobenzene Monolayer with X3 Halogen-Bonding Motif, ***Mol. Phys.***, **2021**, 119, e1900940

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Professor Sir David Klenerman FRS | click here for video

Watching Molecules in Action

The development of quantitative methods to directly observe individual molecules in solution, attached to surfaces, in the membrane of live cells or more recently inside live cells using fluorescence microscopy, has been a major advance in the last two decades. We can now study how individual cellular components interact to initiate cellular signalling and how this can go awry in disease.

My group (and collaborators) has focused on developing these methods and applying them to biological/biomedical problems difficult or impossible to solve using conventional methods. Our focus is on the molecular mechanism of the early events of the innate and adaptive immune response and how neurodegenerative diseases are initiated and spread through the brain. We are also actively exploring how our ultra-sensitive methods to detect protein aggregates can also be used for early diagnosis of diseases.

Relevant Papers

Detecting the Undetectable: Advances in Methods for Identifying Small Tau Aggregates in Neurodegenerative Diseases. ***ChemBioChem*** **2025** 26, e202400877

Single-Molecule Characterization and Super-Resolution Imaging of Alzheimer's Disease-Relevant Tau Aggregates in Human Samples, ***Angewandte Chemie International Edition*** **2024** 136, e202317756

Antibody agonists trigger immune receptor signaling through local exclusion of receptor-type protein tyrosine phosphatases. ***Immunity*** **2024** 57, 256

Cerebral organoids with chromosome 21 trisomy secrete Alzheimer's disease-related soluble aggregates detectable by single-molecule-fluorescence and super-resolution microscopy. ***Molecular psychiatry*** **2023** 29, 369

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Professor Tuomas Knowles | click here for video

Biophysical Chemistry of Proteins

In order to be functional, most proteins have to associate with other proteins to form complexes, the molecular machinery of life. Moreover, incorrectly formed complexes are associated with a range of disorders, including Alzheimer's and Parkinson's diseases.

This supra-molecular behaviour of proteins is thus increasingly viewed as a key new frontier in biophysical chemistry, but one which is challenging to probe using conventional methods.

Current work includes the development and application of new biophysical methods for the study of protein behaviour. Physical chemistry can make a significant contribution to protein science, both through the development of novel measurement and analysis approaches.

Relevant Papers

T.C.T. Michaels, A. Šaric, S. Curk, K. Bernfur, P. Arosio, G. Meisl, A.J. Dear, S.I.A. Cohen, C.M. Dobson, M. Vendruscolo, S. Linse, T.P.J. Knowles, Dynamics of oligomer populations formed during the aggregation of Alzheimer's Aβ42 peptide, *Nature Chemistry,* 12, 445 **(2020).**

Y. Shen, F.S. Ruggeri, D. Vigolo, A. Kamada, S. Qamar, A. Levin, C. Iserman, S. Alberti, P.S. George-Hyslop, T.P.J. Knowles. Biomolecular condensates undergo a generic shear-mediated liquid-to-solid transition. ***Nat Nanotechnol.*** 15, 841–847 **(2020)**.

Arter WE, Qi R, Erkamp NA, Krainer G, Didi K, Welsh TJ, Acker J, Nixon-Abell J, Qamar S, Guillén-Boixet J, Franzmann TM, Kuster D, Hyman AA, Borodavka A, George-Hyslop PS, Alberti S, Knowles TPJ. Biomolecular condensate phase diagrams with a combinatorial microdroplet platform. ***Nat Commun.*** 2022 Dec 21;13(1):7845.

Liu, C., Wu, K., Choi, H. *et al.* Diffusing protein binders to intrinsically disordered proteins. ***Nature*** 644, 809–817 **(2025)**.

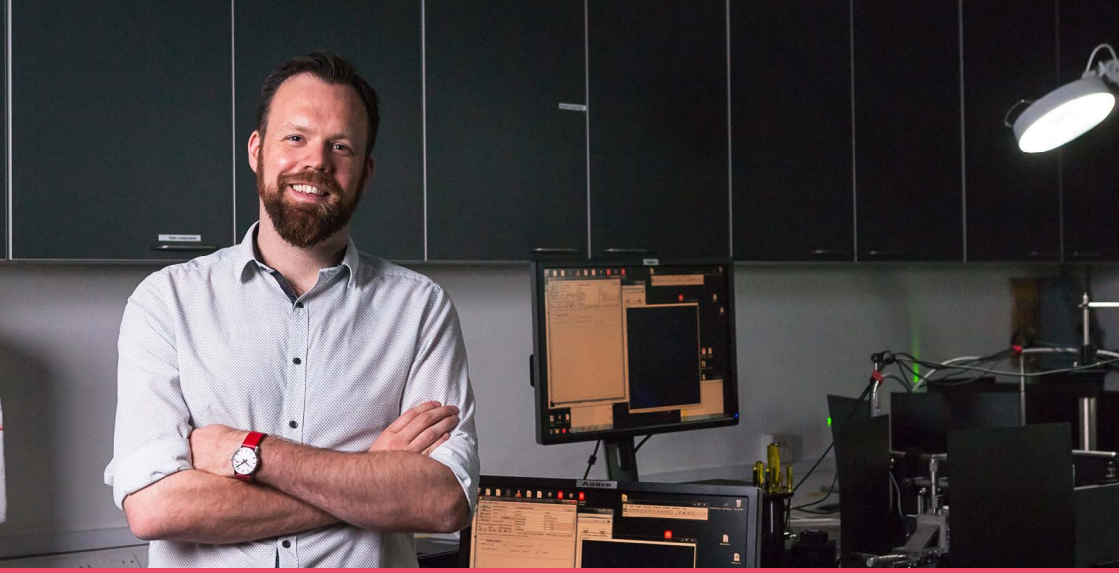
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Professor Steven Lee | click here for video

Building New Tools to Study Single Molecules

Our research centres on building new tools to study single biomolecules using a variety of advanced ultrasensitive optical techniques, primarily through single-molecule fluorescence and super-resolution imaging techniques.

This requires an interdisciplinary combination of research skills including chemistry, physics, engineering and computational methods that synergistically come together to help answer 'real world' biological problems by directly visualising biological processes inside living cells as they unfold.

New projects include the technology of our newest 3D microscope, which works via a "double helix point spread function", the application of it to human immune cells, developing new dye molecules which will enable us to answer more challenging problems in the future, and imaging human brain for protein aggregates in Parkinson's disease.

Relevant Papers

Structure-specific amyloid precipitation in biofluids, ***Nat Chem*** **(2022)** doi: 10.1038/s41557-022-00976-3.

vLUME: 3D virtual reality for single-molecule localization microscopy, ***Nature Methods*** **(2020)** 17, 1097–1099

Multi-dimensional super-resolution imaging enables surface hydrophobicity mapping. Nature Communications (2016) 7, 13544

3D Structures of Individual Mammalian Genomes Studied by Single-cell Hi-C, ***Nature***, **(2017)**, 544

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Dr Raj Pandya

Watching Chemistry Happen: Ultrafast and Quantum Spectroscopy

Our group develops new ways of using light to understand how molecules and materials work on their most fundamental length and time scales. We are particularly interested in processes that are difficult to observe directly: electrons moving during chemical reactions, ions hopping through battery materials, fluctuations in liquids and solids, and the quantum states that underpin energy and charge transport. To study these processes, we develop advanced laser spectroscopy and microscopy spanning visible and infrared light, terahertz radiation and X-rays. A major part of our research is therefore not simply applying existing spectroscopy, but inventing new measurement tools – combining nonlinear optics, ultrafast lasers, quantum light, computational imaging and signal processing to access information that conventional experiments cannot see. This reflects the group's current Cambridge research programme, which includes ion motion in energy materials, quantum-light spectroscopy and femtosecond electron-transfer dynamics in non-light-driven chemistry.

Our research is deliberately interdisciplinary. Current applications range from batteries and electrocatalysis to molecular and quantum materials, and students can work across physical chemistry, optics, materials science, computation and instrument development. Projects can range from fundamental questions about molecular dynamics to building entirely new forms of spectroscopy.

Relevant Papers

Magnetically and optically active edges in phosphorene nanoribbons. *Nature*, **2025**, 639, 348–353.

Three-dimensional operando optical imaging of particle and electrolyte heterogeneities inside Li-ion batteries. *Nature Nanotechnology*, **2023**, 18, 1185–1194.

Adaptive optical imaging with entangled photons. *Science*, **2024**, 383, 1142–1147.

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Theoretical Chemistry

New Insights from Theory and Simulation

Theoretical chemistry is now one of the most thriving and exciting areas of chemistry. Our research covers a range of length and time scales, including active development of new theoretical and computational tools. Applications include high-res spectroscopy, atomic and molecular clusters, biophysics, surface science and condensed matter, complementing experimental research in the department.

We develop new tools for quantum and classical simulations and informatics, and investigate molecules using descriptions that range from atomic detail to coarse-grained models of mesoscopic matter. This work often begins with analytical theory, which is developed into new computer programs, applied to molecules and materials of contemporary interest, and ultimately compared with experiment.

If you are keen to work on a project in one of the Theoretical Chemistry groups, contact the group leader directly. Discuss your application with them in advance of submitting your formal application form to the University.

The Theoretical Chemistry research groups accepting postgraduate students (PhD and MPhil) for entry in October 2027 are:

Prof. Stuart Althorpe

Prof. Rosana Collepardo

Prof. Robert Jack

Dr Seán Kavanagh

Prof. Angelos Michaelides FRS

Dr Aleks Reinhardt

Prof. Mariana Rossi

Prof. Alexander Thom

Prof. David Wales FRS



Professor Stuart Althorpe | click here for video

Quantum Dynamics in Chemistry

Our research focusses on simulations of quantum dynamics (QD), i.e. quantum effects in the motion of atomic nuclei. These effects are challenging to simulate on the computer because they typically occur in the cross-over zone between quantum and classical mechanics (CM).

If the nuclei are heavy, one can get away with CM. But if they are light, the chemistry can be dominated by quantum effects e.g. quantum tunnelling can speed up rates of hydrogen-transfer reactions by orders of magnitude at rt, as can zero-point energy effects. Until recently, QD could only be done for very simple models, because solving the Schrödinger equation is otherwise impossible.

However, a number of recent breakthroughs now allow QD to be simulated in liquids and chemical reactions. The key is to exploit the near-classical behaviour of nuclei, by using techniques based on the Feynman description of quantum mechanics.

Relevant Papers

Concerted Hydrogen-bond Breaking by Quantum Tunneling in the Water, ***Hexamer Prism Science***, **2016**, *351*, 1310.

Which quantum statistics–classical dynamics method is best for water? R L Benson, G Trenins, and S C Althorpe *Faraday Discuss.* 221, 350-366 **(2020)**

Path-integral approximations to quantum dynamics. S C Althorpe. ***Eur. Phys. J. B.*** 94, 155 **(2021)** (17 pages)

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Professor Rosana Collepardo | click here for video

Multiscale Modelling of Genome Organization

One of the main challenges in genome biology is finding out how genomes function. Genomes have intricate 3D spatial organizations that are sensitive to the cell type and cell cycle stage, and that are intimately linked to function. By pushing the current limits of realistic computational modelling of chromatin and exploiting the advances in high-performance computing, our group is investigating a transformative new paradigm that suggests that nature uses the physical chemistry of phase separation – liquid-liquid phase separation – to control genome organisation and gene activity.

Our group develops multiscale models to investigate the unknown molecular mechanisms that dictate genome structure and dynamics, the role of liquid-liquid phase separation in genome organization, and the link between genome organization and function.

Relevant Papers

Emergence of Chromatin Hierarchical Loops from Protein Disorder and Nucleosome Asymmetry, ***PNAS***, **2020**, 117, 7216-7224.

Liquid-Network Connectivity Regulates the Stability and Composition of Biomolecular Condensates with Many Components, ***PNAS***, **2020**, 117, 13238-13247.

Oligonucleotides Can Act as Superscaffolds that Enhance Liquid-Liquid Phase Separation of Intracellular Mixtures, ***bioRxiv,*** **2020**: https://doi.org/10.1101/2020.01.24.916858

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Professor Robert Jack

Collective Behaviour in Soft Matter

Colloids, glasses, and gels are "soft matter"– in many cases, their properties lie somewhere between liquids and solids.

We aim to describe these materials using theory and computer simulation, concentrating on how the collective behaviour of many microscopic particles can give have unusual macroscopic consequences.

Examples include the spontaneous self-assembly of nano-scale structures and the formation of very stable glassy solids.

Relevant Papers

Statistical Mechanics of Dynamic Pathways to Self-assembly, ***Ann. Rev. Phys. Chem.***, **2015**, *66*, 143.
Investigating Amorphous Order in Stable Glasses by Random Pinning, ***Phys. Rev. Lett.,*** **2014**, *112*, 255701.

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Dr Seán Kavanagh | click here for video

Advanced Material Simulations for Crucial Energy Challenges

We are a research team – the Simulation of Advanced Materials (SAM) lab – that uses state-of-the-art computational methods to design and develop next-generation materials; primarily targeting energy applications. The SAM lab works at the intersection of materials science, chemistry, physics and artificial intelligence (AI); developing and deploying techniques from quantum chemistry (e.g., DFT), solid-state physics and machine learning (primarily machine-learned interatomic potentials (MLIPs)) to understand and design the atomic-level properties of materials.

Topics include identification of performance-limiting bottlenecks in disordered solar cells and thermoelectrics – champion materials for which conventional modelling approaches fail, adapting machine-learned interatomic potentials for imperfect systems (defects, surfaces etc) to achieve transformative predictive accuracies across many functional material applications, and the development of high-quality computational research software to support these efforts.

We have a global collaborative network, including experimental and theoretical research groups as well as industry partners, with whom we combine our expertise to maximise the effectiveness of our research.

Relevant Papers

Fast and accurate foundation models for equivariant machine-learned interatomic potentials, *arXiv*, **2026** (Link: https://arxiv.org/abs/2607.28461)

Guidelines for robust and reproducible point defect simulations in crystals, *Nature Reviews Materials*, **2026** (Link: https://doi.org/10.1038/s41578-025-00879-y) — implemented in doped

Identifying the ground state structures of point defects in solids, *npj Computational Materials*, **2023** (Link: https://doi.org/10.1038/s41524-023-00973-1) — implemented in ShakeNBreak

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Professor Angelos Michaelides FRS | click here for video

Fundamental Theoretical Studies of Key Global Challenges

Our research aims at understanding important phenomena in surface-, materials-, and nano-science. Using concepts from quantum mechanics to statistical mechanics, we apply and develop methods and computer simulations to study, for instance, surfaces, interfaces, and processes of environmental relevance.

Topics under consideration at present – for which PhD projects are currently available – include studies aimed at obtaining a molecular level description of water at interfaces, the application of state-of-the-art electronic structure methods to fundamental problems at surfaces and in materials, the development of machine learning potentials and fundamental studies in heterogenous catalysis.

Research projects in our group are generally highly collaborative involving e.g. international groups in the field and access to and exploitation of some of the largest supercomputers in the world.

Relevant Papers

An accurate and efficient framework for modelling the surface chemistry of ionic materials, *Nature Chemistry*, **2025**, 11, 1688 (Link: https://www.nature.com/articles/s41557-025-01884-y)

The first-principles phase diagram of monolayer nano confined water, *Nature*, **2022**, 609, 512 (Link: https://www.nature.com/articles/s41586-022-05036-x)

Medium density amorphous ice, Science, 2023, 379, 474. (Link: https://www.science.org/doi/10.1126/science.abq2105)

First-principles design of a single-atom–alloy propane dehydrogenation catalyst, *Science*, **2021**, 372, 1444 (Link: https://www.science.org/doi/10.1126/science.abg8389)

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Dr Aleks Reinhardt | click here for video

Phase Behaviour of Materials

We are a computational chemistry group working in the broad field of statistical mechanics. We are interested in the behaviour of various materials, from atomic and molecular to soft condensed matter and biological systems. In particular, we are interested in phase behaviour, nucleation and self-assembly. Quantifying bulk phase behaviour requires extensive sampling of phase space, which would be prohibitively expensive using first-principles methods. At the same time, understanding the dynamics of a process from a microscopic perspective is often beyond the reach of experiment. As a result, clever simulation methods are required to be able to study such processes, and we are interested in developing suitable techniques to tackle different systems.

Relevant Papers

Phase diagrams — Why they matter and how to predict them, ***J. Chem. Phys.***, **2023**, 158, 030902. (Link: https://doi.org/10.1063/5.0131028)

Quantitative real-time in-cell imaging reveals heterogeneous clusters of proteins prior to condensation, ***Nat. Commun.***, **2023**, 14, 4831. (Link: https://doi.org/10.1038/s41467-023-40540-2)

Quantum-mechanical exploration of the phase diagram of water, ***Nat. Commun.***, **2021**, 12, 588. (Link: https://doi.org/10.1038/s41467-020-20821-w)

Direct observation and rational design of nucleation behaviour in addressable self-assembly, ***Proc. Natl Acad. Sci. USA,*** **2018**, 115, E5877. (Link: https://doi.org/10.1073/pnas.1806010115)

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Professor Mariana Rossi | click here for video

Simulations from Ab Initio Approaches

The central theme of the research in the group is the development of a deeper understanding of the impact of temperature and quantum nuclear motion on the structural and electronic properties of complex systems which are predominantly stabilized by weak interactions. In particular, we are interested in unraveling the chemistry and physics that govern the properties of interfaces between molecular liquids, flexible organic materials and inorganic solids.

This area of research requires that not only the electrons, but also the nuclei are treated within the first principles of quantum mechanics. The group develops and implements machine-learning and first-principles quantum mechanical methodologies that surpass previous limitations in addressing high-dimensional realistic systems, thus enabling the elucidation of new phenomena. We join density-functional theory and path-integral methods, aided by machine-learning models, to bridge new length- and timescales.

We also seek to improve the calculation of observables that can be directly probed experimentally, by taking particular care to account for nuclear motion.

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Professor Alexander Thom | click here for video

Developing New Methodologies in Electronic Structure Theory

My research group develops new theoretical and computational methods for calculating the electronic structure of molecules and materials. We are particularly interested in the challenging cases where standard electronic-structure methods fail, such as bond breaking and chemical reactions, electronically excited states, molecular magnets, and strongly correlated molecules and solids. A central theme of our research is how to obtain highly accurate solutions to these difficult quantum-mechanical problems without the prohibitive computational cost of conventional approaches. We develop stochastic approaches to high-accuracy methods such as coupled cluster and configuration interaction, together with new, computationally inexpensive methods for multireference electronic structure. Increasingly, we are also exploring what quantum computers might offer for quantum chemistry. Rather than simply translating existing classical algorithms onto quantum hardware, we are interested in designing algorithms that make effective use of the distinctive capabilities of quantum computers. This includes methods for ground and excited states, resource-efficient quantum circuits and measurements, and hybrid approaches in which classical electronic-structure calculations can guide quantum algorithms.

Relevant Papers

Folded Spectrum VQE: A Quantum Computing Method for the Calculation of Molecular Excited States. *J. Chem. Theory Comput.* **2024**, 20, 2491–2504 https://doi.org/10.1021/acs.jctc.3c01378

Non-unitary Trotter circuits for imaginary time evolution. *Quantum Sci. Technol.* **2024**, 9, 045007. https://doi.org/10.1088/2058-9565/ad53fb

A hybrid stochastic configuration interaction-coupled cluster approach for multireference systems. *J. Chem. Phys.* **2023**, 158, 184101. https://doi.org/10.1063/5.0145767

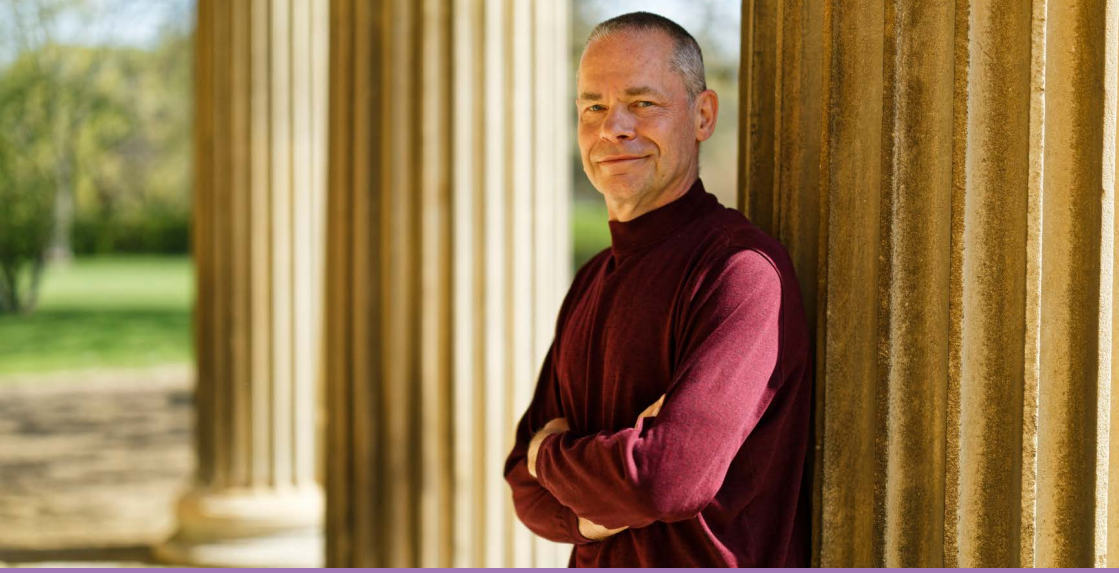
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Professor David Wales FRS

Energy Landscapes

Our research involves exploration of energy landscapes, with applications to chemical biology, spectroscopy, clusters, solids, surfaces, and machine learning. We develop new theory and simulation tools in three main areas. First is structure prediction based upon global optimisation. Second is enhanced sampling, to predict thermodynamic properties, and understand how the quantities measured in experiments are related to the structure encoded by the potential energy surface. Third is the development of new methods to treat rare event dynamics, where we characterise the transition states and pathways that connect local minima.

New horizons have been opened up by more efficient methodology and faster computer hardware, with recent results for protein folding and misfolding, RNA and DNA, analysis and design of mesoscopic structures and materials, and condensed matter, including glassy systems and energy storage. All these techniques have now been brought to bear to characterise the prediction landscapes generated in machine learning, with diverse applications ranging from patient outcomes in hospital to geometry optimisation.

Relevant Papers

Exploring Energy Landscapes, ***Annu. Rev. Phys. Chem.***, **2018**, *69*, 401.
Exploring biomolecular energy landscapes, ***Chem. Comm.***, **2017**, *53*, 6974.
Energy landscapes for machine learning, ***Physical chemistry chemical physics***, **2017**, *19*, 12585.

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Biological Chemistry

Life is in the Chemistry Inside Each of Us

Biological Chemistry research at Cambridge focusses on understanding the chemistry of life, both the physical processes occurring at the molecular level and the chemical reactions.

The major themes amongst the Biological Chemistry groups are biological polymers, proteins and nucleic acids – how they interact with each other and with small molecules. How do proteins fold to a defined structure and why do they sometimes not fold causing neurodegenerative diseases? How do proteins catalyse reactions? Can we make small molecules that inhibit these processes? What structures can nucleic acids adopt? How can we detect and what is the role of modifications of individual nucleotides? How can we target medicinally active compounds where they are needed?

If you are keen to work on a project in one of the Biological Chemistry groups, contact the group leader directly. Discuss your application with them in advance of submitting your formal application form to the University.

The Biological Chemistry research groups accepting postgraduate students (PhD and MPhil) for entry in October 2027 are:

Prof. Sir Shankar Balasubramanian FRS

Prof. Gonçalo Bernardes

Dr Mateo Sanchez Lopez

Dr Pietro Sormanni

Prof. Michele Vendruscolo

Dr Julian Willis



Prof. Sir Shankar Balasubramanian FRS | video here

The Dynamic Chemistry, Structure & Function of DNA

Our projects develop and use cutting edge technologies in chemical biology, molecular biophysics, structural biology and genomics to answer critical questions in genome function. Students will contribute to one or more of our primary research areas below:

A key interest is the structure and function of DNA secondary structures called G-quadruplexes (G4s). G4s are important in gene and chromatin regulation and our aims are to use chemical biology strategies to elucidate their role in genome biology and to develop small molecule-based intervention strategies for cancer [e.g. see *Genome Biology*, **2025**, *25*, 155; *Nature Chemistry*, **2025**, *17*, 875; *PNAS*, **2024**, *12(7)*, e2320240121; *Nature Communications*, **2022**, *13*:142; *Genome Biology*, **2021**, *22*, 117]

We are also developing techniques to map where small molecules bind to DNA and chromatin and to identify the proteins associated with their binding sites with a view to understanding therapeutic mechanisms [e.g. see *Nature Biotechnology*, **2023**, *41*, 1265]. Our aim is to characterise small molecule interactions with DNA, RNA and associated proteins and to enable the development of bifunctional small molecules that target the genome and chromatin-associated proteins to understand genome mechanisms and explore their therapeutic potential in diseases such as cancer. The design of bifunctional modalities will encompass new modalities of proximity-inducers that target contextual biology. A recent example being degraders that act at G-quadruplex locations in chromatin [e.g. see *Nature Chemistry*, **2026**, *18*, 1092]. Students are primarily based in the Balasubramanian lab at the Yusuf Hamied Department of Chemistry, but will build collaborative interactions with the group's sister lab at the CRUK Cambridge Institute.

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Professor Gonçalo Bernardes | click here for video

Translational Chemical Biology

A key aspect of my research group is the use of chemistry principles to develop molecules whose action is restricted to the tissue(s) where they should work to maximise therapeutic efficacy and reduce side-effects. Our 'bench to clinic' approach motivates us to work across disciplines, from organic chemistry to machine learning to immunology.

Recent examples of emerging areas in our group include the design of new chemistry for a) residue-specific modification of proteins and antibodies[1] and b) to bioorthogonally turn-on the activity of small-molecule drugs in vivo with methods based on metals and tetrazine-activation that expand the gamut of bond-cleavage reactions[2,3]. A key aspect of our research focuses on new drugs and targets. For example, we discovered that piperlongumine is an allosteric antagonist modulator of TRPV2 which leads to glioblastoma remissions in mice[4]. More recently, we reported RNA-degraders — a novel class of small molecules that degrade RNA[5], which we used to develop Click-Seq, a broad tool to edit and analyse known and unknown RNA modifications directly in cells.

The projects highlighted show how chemistry-driven approaches improve our understanding of complex biological phenomena that will inform the next generation of therapeutics.

Relevant papers:

[1]*J. Am. Chem. Soc.* **2018**, 140, 4004. [2]*J. Am. Chem. Soc.* **2020**, 142, 10869. [3]*Angew. Chem. Int. Ed.* **2020**, 59, 16023. [4]*ACS Cent. Sci.* **2021**, 7, 868. [5]*ACS Cent. Sci.* **2020**, 6, 2196.

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Dr Mateo Sanchez Lopez | click here for video

Developing new molecular tools for cell biology and neuroscience through chemical and synthetic biology

Having recently been awarded a Wellcome Trust Career Development Award to start an independent group in the department of chemistry at Cambridge in Oct 2023, our group works at the frontier between chemistry and biology. The research aims to apply the principles of chemistry in order to unlock our understanding of cell biology and using biology to create new chemistry. Specifically, we plan to develop new molecular tools leveraging optogenetics and protein engineering for cell biology and neuroscience. Another part of our research program will focus on the engineering of artificial metalloenzymes to catalyse new chemical reactions.

Relevant papers:

Sanchez MI, Wang W, Nguyen Q.-A, Soltesz I, Ting AY, ***PNAS***, **2020**, 117, 33186.

Sanchez MI, Ting AY, ***Nat. Methods,*** **2020**, 17, 167.

Sanchez MI, Rama G, Calo R, Ucar K, Lincoln P, Vázquez López M, Melle-Franco M, Mascareñas JL, Vázquez ME., ***Chem. Sci.,*** **2019**, 10, 8681.

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Professor Michele Vendruscolo | click here for video

Chemistry of Health: From bench to bedside

Our research is aimed at understanding the molecular origins of neurodegenerative disorders, including Alzheimer's and Parkinson's diseases, and at opening in this way novel opportunities for drug discovery to prevent, delay or treat these conditions. We have set up an interdisciplinary approach that brings together concepts and methods from chemistry, physics, engineering, genetics and medicine, using a combination of in silico, in vitro and in vivo approaches. This programme is based on the premise that physical and chemical sciences can provide relevant contributions to address biological questions to understand the normal and aberrant behaviours of proteins and their links with human disease. We are thus investigating the nature and consequences of the failure to maintain protein homeostasis, and its association with ageing and neurodegenerative disorders. We carry out this programme in the recently established Centre for Misfolding Diseases, which is hosted in the new Chemistry of Health building, which includes also the Chemistry of Health Incubator for translational research, and the Molecular Production and Characterisation Centre, a shared facility for research in chemical biology.

Relevant Papers

S. Zhang, D. Huo, R. I. Horne, Y. Qi, S. Pujalte Ojeda, A. Yan and M. Vendruscolo. Sequence-based virtual screening using transformers. *Nat. Comm.* **2025**, 16, 6925

Z. F. Brotzakis, S. Zhang, M. H. Murtada, M. Vendruscolo, AlphaFold prediction of structural ensembles of disordered proteins. *Nat. Comm.* **2025**, 16, 1632

R. I. Horne, E. Andrzejewska, P. Alam, Z. F. Brotzakis, A. Srivastava, A. Aubert, M. Nowinska, R. C. Gregory, R. Staats, A. Possenti, S. Chia, P. Sormanni, B. Ghetti, B. Caughey, T. P. J. Knowles and M. Vendruscolo. Discovery of potent inhibitors of α-synuclein aggregation using structure-based iterative learning. *Nat. Chem. Biol.* **2024**, 20, 634-645

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Synthetic Biology and Gene Editing

We are a new synthetic biology, molecular biology and biotechnology-focused research group. The common theme across our scientific work is exploring natural diversity to identify proteins with novel functions or properties, studying and characterising them, and finally engineering them to create new technologies.

Our main research focus is to study the DNA replication machinery of viruses and exploit them to develop new tools for gene editing and synthetic biology applications.

We study a fascinating and unusual class of viruses which use a unique mode of protein-primed DNA replication to replicate their linear DNA genomes. These represent one of the few known biological systems in which protein-DNA covalent bonds can be naturally found. This group of viruses are very understudied but hold great promise for exciting biotechnology applications. In particular, we are exploring how to repurpose these viral replication proteins to create innovative new tools for gene editing to treat human genetic disease.

Relevant Papers

Gene editing overview: AV Anzalone *et al.* (**2020**) Genome editing with CRISPR–Cas nucleases, base editors, transposases and prime editors. ***Nat Biotechnol.*** 38:824-844

Synthetic biology concepts: CC Liu *et al.* (**2018**) Toward an orthogonal central dogma. ***Nat Chem Biol.*** 14:103-106

Viral DNA replication system: M Salas *et al.* (**2016**) DNA-binding proteins essential for protein-primed bacteriophage Φ29 DNA replication. ***Front Mol Biosci.*** 3:37

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Group Lab Tour Videos

Yusuf Hamied Department of Chemistry, University of Cambridge

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BERNARDES	*Access here*	**PHIPPS**	*Access here*
DUER	*Access here*	**REISNER**	*Access here*
FORSE	*Access here*	**SCHERMAN**	*Access here*
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