

Institution: University of Birmingham

Unit of Assessment: Uo8, Chemistry

1. Unit context and structure, research and impact strategy

1.1. Context

UoA8 (School of Chemistry) has a bold vision to maximise academic and end-user impacts of its research. Part of the College of Engineering and Physical Sciences at the University of Birmingham (UoB), UoA8 has seen significant investment, renewal and growth since REF2014 (**Figure 1.1**), affording a vibrant and outstanding research environment. Ahead of moving to the new Molecular Sciences Building (MSB) in 2023 (**Figure 1.2**), strategic recruitment has led to new opportunities and increased emphasis on challenge-led research, closely aligned with UoB's Strategic Framework (**REF5a-2.4**).

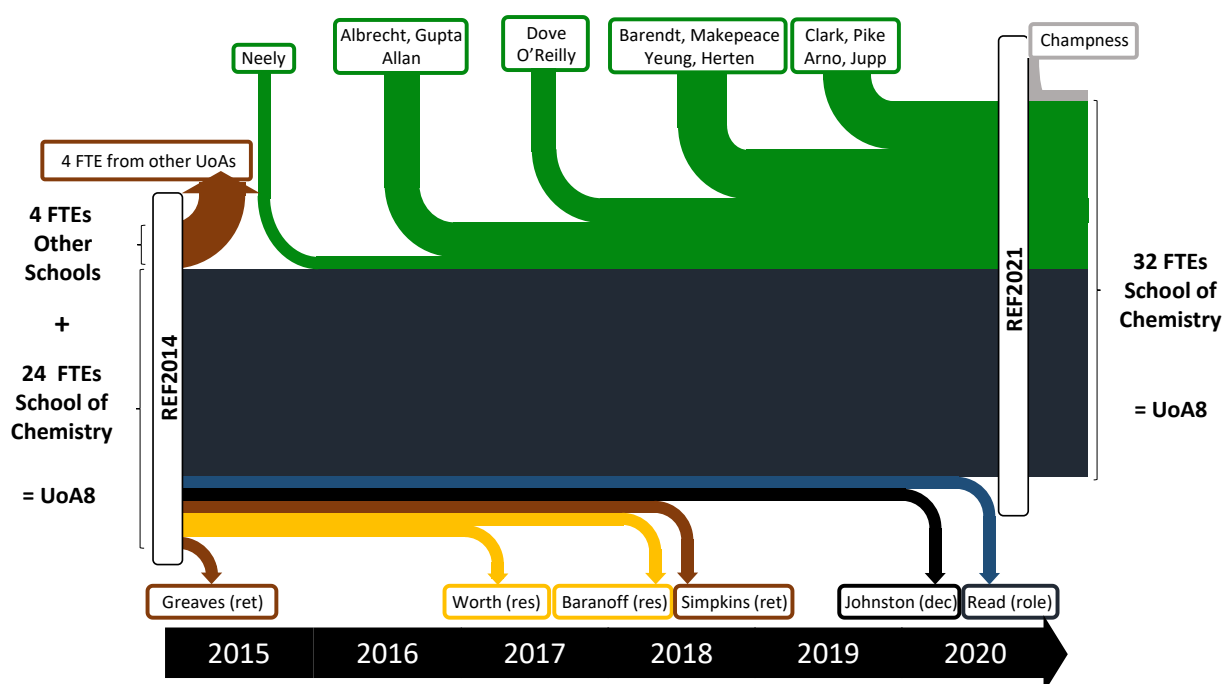


Figure 1.1-Evolution of UoA8. [ret-retired; res-resigned; dec-deceased; role-non-research role]

Since REF2014, investment in people and infrastructure has transformed UoA8's ambition and culture, evidenced by:

- **14 new appointments**, with sustained investment beyond REF2021 (Champness, Haworth Chair, 01/2021),
- **grant capture doubling**,
- **significant diversification in research income**, spanning Horizon2020, UKRI, Faraday Institution, charities and industry,
- **4 new UoB spin-outs**, demonstrating increased translational activity,
- **11 granted patents** (further 14 filed) from 8 academics and **9 licensing agreements** with a growing list of commercial partners,
- **£11M investment in research equipment and infrastructure**,
- **sustained growth in PDRA** (215% increase) and **postgraduate** (74% increase) numbers,

Unit-level environment template (REF5b)

- a **strong pipeline of outstanding early-career researchers**, including 2 Future Leaders Fellows (FLFs) and 1 Royal Society University Research Fellow (URF) since 2019,
- **£80M** committed by UoB to the new **MSB** (groundworks commenced, [REF5a-4.2.1](#)).



Figure 1.2-MSB, UoA8's new research building. Completion 2023.

1.1.1. Structure

Research activity is structured to break traditional inorganic/organic/physical chemistry boundaries. Our tiered approach enables us to lead on important fundamental and applied research, and respond to emerging opportunities and challenges (**Figure 1.3**).

Three subject-specific **Research Sections**, Materials, Molecular Synthesis and Biological Chemistry (MSBC), and Interactions, Interfaces and Sensors (I2S), focus on training and development, and provide our organisational framework. Research Sections contain the skills and expertise to generate new knowledge for application and impact generation through three challenge-led **Research Themes** (**Sections 1.3&1.4**).

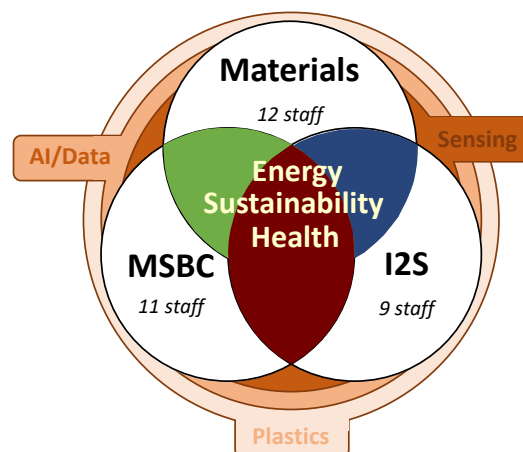


Figure 1.3-UoA8's Structure: Sections intersect to create Themes; Interest Groups span all research areas.

Themes align with national priorities, enabling significant grant capture, e.g.:

- **Energy:** **Faraday-funded CATMAT** (Slater, £2.7M), developing next-generation cathode materials for increasing Li-ion battery performance; **UKRI-FLF** (Makepeace, £1.2M) developing non-hydrocarbon fuels.
- **Health:** **EPSRC-CDT Sci-Phy-4-Health** (Hannon, £3.5M), training 49 PhDs (25F/24M), tackling healthcare challenges in ageing, trauma and cardiovascular disease; **EU-funded EID-ITN**, **IDESIGN** (Cox, £0.6M), partnering postgraduates with EU-based industry to develop compound libraries for drug discovery.
- **Sustainability:** **EU-funded ERC, RISE and ITN programmes** (O'Reilly, Dove, Britton, Tucker, £2.4M) focusing on sustainable chemistry and plastics recycling; **Faraday-funded ReLiB** (Anderson, £10.1M, with £4.8M renewal, 2021) focusing on Li-ion battery materials recycling.

To expand our research ecosystem, we launched **Interest Groups** in 2019 to provide flexible, inclusive and unrestricted testbeds for exploring emerging research areas and informing new research directions/innovations. To date, we have founded three Groups: **Plastics**, which rapidly evolved into the campus-wide **Birmingham Plastics Network**; **Data and Machine Intelligence**, which aligns with the Turing and UoB's Data Science Institutes; and **Sensing**, which provides a platform for collaboration with Physics (Quantum Sensing) and Medicine.

1.2. Research Strategy

Research that matters drives our research- and impact-generating strategy (**Section 1.3**), unites our research objectives and ensures our strategic goals align with UoB's Strategic Framework ([REF5a-2.1&2.4](#)). Strategy is set by tensioning a bottom-up approach, empowering individuals to pursue research excellence, with top-down strategic steering by our **Research Committee**. Our

Director of Research (Albrecht), supported by Section Heads, monitors our grant pipeline and works closely with the **Impact Lead** (Preece) to ensure timely and tailored support for translational activities.

UoA8's REF2014 strategy and objectives sought to develop research under the banner of '*Chemistry for Health and Sustainability*' through 3 outward-facing Research Themes: Chemical Biology and Drug Discovery, Imaging in Chemistry and Biomedicine, and Materials Chemistry and Energy. Significant progress against our REF2014 objectives was made by:

1. strengthening our research base in **Health** and **Sustainability**,
2. increasing cross-disciplinary interaction by establishing and growing a new **Energy** Research Theme and cross-College appointments,
3. sustained institutional investment in academic leadership and strategic appointments, which has increased Category-A FTE by 33%, added £3.2M infrastructure investment, and driven a cultural shift towards more challenge-led, collaborative research.

Driven by horizon-scanning, funder priorities and industry/stakeholder engagement, this strategy has developed throughout this REF period and been informed by five principles (**Table 1.1**).

Principles	Outcome	Exemplar Action & Resulting Impact
<p>Consolidate</p> <p>strengthen existing research excellence aligned with UoB priority/strategic areas and national research themes</p>	<p>research groupings with the infrastructure, leadership, skills set, breadth and depth to lead and direct the research agenda</p>	<p>4 appointments in solid-state materials delivering:</p> <ul style="list-style-type: none"> • strengthened research leadership • significant Faraday funding • strengthened links with Metallurgy & Materials, Physics • close alignment with UoB's Strategic Framework: Birmingham Energy Institute, Tyseley Energy Park
<p>Build</p> <p>invest in areas of strategic importance</p>		<p>3 appointments in soft materials/polymers delivering:</p> <ul style="list-style-type: none"> • strengthened academic leadership • spin-out: 4D-Medicine • new strand to Sustainability research • new links to Healthcare Technologies Institute, Medicine
<p>Connect</p> <p>establish mechanisms to connect research strands within UoA8, cross-campus and externally</p>	<p>enhanced inter- and multidisciplinary activity delivering impact</p>	<p>3 joint appointments with Medicine delivering:</p> <ul style="list-style-type: none"> • significant cross-disciplinary translational activity • breadth and depth in therapeutics & diagnostics • preparedness for Birmingham Health Innovation Campus
<p>Enable</p> <p>establish inclusive organisational structures</p>	<p>collaborative and collegiate environment, sustaining the highest quality research from <i>all</i> researchers</p>	<p>Deeply embedded EDI principles delivering:</p> <ul style="list-style-type: none"> • new policies for carers, returnees to work • flexible working • enhanced mentoring • an inclusive environment in the new MSB

<p>Distinguish give Birmingham Chemistry a distinctive identity</p>	<p>destination of choice for researchers working across our areas of excellence</p>	<p>Interest Groups delivering Birmingham Plastics Network New collaborative/interdisciplinary working principles embedded in the MSB</p>
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Table 1.1 Principles informing our Research Strategy.

Our aim is to sustain a thriving environment that empowers **all** individuals to deliver impactful, world-leading research. **Equality, Diversity and Inclusion (ED&I)** is therefore deeply embedded, informs how we support individuals to realise their potential and ensures all UoA8 members have contributed meaningfully to REF2021.

1.2.1. ENERGY: BATTERY TECHNOLOGIES & CLEANER FUELS

Solid-state materials research was a key strength in REF2014, with leading expertise in fuel cells, nuclear-waste storage and hydrogen storage materials. *Key objectives were to build our advanced materials characterisation and diversify the material class expertise.*

We addressed these objectives by strategic appointments in magnetic materials (Clark from Liverpool, 2020) and short-range order characterisation (Allan from Cambridge, 2017; Yeung from Oxford, 2019), supporting growing activity in new energy technologies. The Diamond-UoB collaboration was strengthened by Hrilijac's appointment at Diamond Light Source (retaining 0.2FTE, UoB), introducing staff to more diverse synchrotron techniques and strengthening networks, especially for our early-career appointees. The Theme has further advanced through equipment investment (£3M), new and deepening campus-wide and regional collaborations (e.g., with Birmingham Energy Institute, Tyseley Energy Park, **REF5a-2.1.7**), staff/student exchange and access to state-of-the-art instrumentation/expertise (collaboration agreement with BAM, Federal Institute for Materials Research and Testing, Germany).

Our strategy has positioned us to respond to significant funding and research opportunities (Faraday Institution), establishing leadership in battery technology, and enabled emerging strengths in cleaner fuels. Building on established expertise in hydrogen storage and fuel-cell materials (Anderson PI, UK Sustainable Hydrogen Energy Consortium; Slater/Anderson Co-Is, CDT in Hydrogen, Fuel Cells and Their Applications), research capacity has grown with the appointment of Makepeace (from Oxford, 2019, subsequent FLF) through his work on ammonia as an alternative hydrogen fuel source. We are driving the clean-energy agenda through involvement in the International Energy Agency Hydrogen Technology Collaboration Programme on hydrogen storage.

Research breadth in cleaner fuels is demonstrated by electrocatalysis research and more sustainable methods of ammonia production (Rodriguez), and leadership in nuclear technologies through EPSRC-funded consortia (Hrilijac, Read; TRANSCEND and DISTINCTIVE, 2020 RSC Industry-Academia Collaboration Award). Capitalising on University-wide investments in energy, establishing the Chemistry-led Birmingham Centre for Strategic Elements and Critical Materials (co-director Anderson) has advanced collaborations and secured projects worth >£35M.

Our technology and impact reach extends into organic materials. Spin-out company Irresistible Materials (2010) is based on carbon materials developed by Preece (**REF2021 Impact Case**) and wider impact is achieved through industry collaboration, e.g., 2018 RSC Industry-Academia Collaboration award for O'Reilly/BP for polymers for enhanced oil recovery.

2021-2026 Objectives: With solid-state materials reaching critical mass, we will focus on further developing the cleaner fuels and battery themes. With 4 new early-career researchers and purpose-built research space in the MSB, we are well-positioned to build upon this strong foundation in fundamental solid-state chemistry and become a leader within the Energy landscape. Our leadership and involvement in nationally leading UoB centres will facilitate the translation of fundamental science into applied technologies.

1.2.2. HEALTH: EARLIER DIAGNOSIS & BETTER TREATMENTS

A key strength in REF2014 was our EPSRC-DTC, Physical Sciences of Imaging for Biomedical Sciences (2008-2018), which established new cross-disciplinary networks across Medicine and the Life Sciences, with Chemistry at their cores. *Our objective was to capitalise on these networks to drive a challenge-led research agenda with specific focus on better treatments and earlier diagnoses.*

These objectives were addressed by a new EPSRC-CDT in Physical Sciences for Health (Sci-Phy-4-Health, 2014-2022), 4 strategic appointments in sensing: Barendt from Oxford, 2019; Pike from Bradford, 2020, UKRI-FLF; Neely from Leiden, 2014, EPSRC Healthcare Technology Fellow; Albrecht from Imperial, 2017, and 3 joint appointments with Institutes in the College of Medical and Dental Sciences that strengthen and expand expertise towards cellular-based treatments: Arno (from UoB, 2020; polymer-based therapies), Gupta (from Hull, 2017; EPSRC Healthcare Technology Fellow, point-of-care diagnostics) and Herten (from Heidelberg, 2019; fluorescence live-cell microscopy).

We have actively engaged in campus-wide drug-discovery projects to deliver a de-risked pipeline for external investment. Fossey developed a lead candidate, currently under development as a potential TB (GIBH, China) and multi-drug-resistant-TB (PHE) therapeutic. Cox's sustained collaboration with Biosciences delivered a new cancer immunotherapy, resulting in spin-out iOx Therapeutics. We have reported new drug-delivery vehicles for the eye (Peacock, US20160339079A1), multimodal nanocarriers for metallodrug delivery to cancer cells (Pikramenou/Hannon), and polymeric systems for siRNA delivery (Fernandez-Trillo).

UoA8's strengthened expertise in imaging and sensing has expanded, with particular focus on diagnostics. Tucker's fluorescent and electrochemical DNA sensors for point variant cancer biomarkers and Neely's new technology for sequence-specific functionalisation of DNA, which opened up a new approach for rapid screening of epigenetic biomarkers, have led to patented technologies (through BaseSense™) and UoB spin-out Tagomics, respectively.

Spin-outs evidence our successful impact strategy (**Section 1.3**). With outline studies benefiting from EPSRC-IAA support, subsequent translational activity led to NitroPep (2017, Peacock, **REF2021 Impact Case**) commercialising a novel antimicrobial surface-coating technology. 2020 saw Dove spin out 4D-Medicine to develop 3D-printable biomaterial scaffolds.

2021-2026 Objectives: We will strengthen our activities in developing therapeutic solutions, translate our work in sensing to develop point-of-care diagnostics and capitalise on recent strategic joint appointments and opportunities the new Molecular Sciences Building enables. We will embed emerging diagnostics technologies in the forthcoming **Birmingham Health Innovation Campus (Ref5a-4.2.2)** and establish the **Birmingham Interdisciplinary Centre for Nucleic Acids** to capitalise on growing strengths in these areas and nascent interactions and collaborations with strategic partners including the Rosalind Franklin Institute.

1.2.3. SUSTAINABILITY: REPLACE & RECYCLE

As part of growing research capacity, Sustainability was identified as a key priority after REF2014. *Our objectives were to lead research in replacing current technologies with sustainable alternatives and to design and implement superior recycling methods.*

Activities were re-focused to establish core strengths in battery recycling, plastics technologies and catalysis. We made strategic appointments and infrastructure/equipment investment to develop future technologies, provide replacement processes and materials, and develop recycling activities to improve process sustainability. New appointments in polymer recycling (Dove from Warwick, 2018), catalyst recycling (O'Reilly from Warwick, 2018), battery technologies (Allan) and photocatalysis (Jupp from Amsterdam, 2020, RS-URF) supplement existing strengths in the Sustainability Theme.

UoA8 hosts the flagship Faraday-funded Recycling Li-ion Batteries (ReLiB) project (PI Anderson, supporting 23 PDRAs, 20 PhDs). ReLiB is the UK's largest battery recycling project and when funded, was the biggest public investment in electric-vehicle LiB recycling research globally. The project champions new recycling and processing techniques to recover and re-use critical materials from end-of-life products (Anderson-GB20001183.9). ReLiB has facilitated key

collaborations (including National Renewable Energy Laboratory, BAM, CSIRO, Fraunhofer Institute). Leadership in the field was recognised by the invitation to write a seminal review of the area (Anderson, *Nature*, 2019).

Substantial investment in equipment (£2M) and personnel was made to rapidly grow polymer research, with focus on polymers/plastics recycling. This research complements investigations of Na-ion batteries as more sustainable alternatives to Li-ion batteries (Britton, Allan and Slater €8M EU-SIMBA project), of CO₂ as a sustainable feedstock in materials synthesis and electrochemical catalysis technologies (Rodriguez), and of polymers for sustainable plastics and biomedical applications (Dove).

Our impact strategy (**Section 1.3**) has facilitated our delivery of impacts in Production, Commerce and the Economy as well as developing policy in the sustainable use of plastics and driving the strategic elements and critical materials agenda (**Section 4.3.3**). A long-standing collaboration with P&G resulted in integration of a UoB-developed technology into several of P&G's major household product lines, pivoting to alternative, more sustainable materials (**REF2021 Impact Case**).

2021-2026 Objectives: Sustainability has become a thriving focus since REF2014, accounting for ~25% of our REF2021 outputs. We will capitalise on these achievements via further appointments, new collaborations (facilitated by the Birmingham Plastics Network) and through co-location with environmental scientists in the MSB. Key to translating the technologies developed is engagement with our industrial partners (e.g., Unilever, P&G), who are well placed to integrate solutions into their products. A key objective is further engagement with policymakers and researchers across human-, social- and life sciences to facilitate technology implementation.

1.3. Enabling and Facilitating Impact

We use enabling and supportive mechanisms to grow and sustain research programmes and generate impact. Researchers are supported throughout the translational pathway by the **Research Impact Committee**, the hub for UoA8's impact-generating activity, through:

- **Impact awareness raising**, coordinating activities/workshops to ensure researchers recognise potential impact in its many forms.
- **Supporting** researchers to develop **project-specific impact pathway plans** to maximise reach and significance.
- **Monitoring** our research pipeline to identify potential impacts. Our **Impact Lead** meets with researchers to facilitate impact delivery, e.g., UoB's technology transfer office, **UoB Enterprise (REF5a-4.1)**, supported patent filing to ensure NitroPep (**REF2021 Impact Case**) could commercialise its technology.
- **Harnessing appropriate expertise and timely stakeholder engagement**, working with College **Business Engagement** and **Strategic Research Development Teams (REF5a-4.1)** to identify market, policy and other impact opportunities, e.g., supporting the strategic partnership with P&G (**REF2021 Impact Case**).

Our **flexible workload allocation model** provisions for impact-generating activities. Since 2019, founders of three spin-outs (potential future Impact Cases) have benefited from **impact leave**, ensuring their agile response to emerging impact opportunities.

1.3.1. Delivering Impact in the Next Five Years

UoA8's REF2021 impacts focus primarily on **Commerce and the Economy**. We will develop our strong impact pipeline to **capitalise on significant nascent translational activity**, targeting our recent UoA8 spin-outs, by:

- increasing translational grant capture (e.g., InnovateUK, MRC Confidence-in-Concept) and working with UoB Enterprise to **showcase** translational activities to prospective investors and **exploit** our expanding IP portfolio (11 granted patents REF2021, cf. 3 in REF2014; 107 records-of-invention REF2021, cf. 26 in REF2014),

- our **Impact Lead** leading a **Chemistry Spin-Out Group** to expand commercialisation support,
- expanding our **Mentoring Scheme** to include **impact mentoring** from industry/third sector.

We will create new impact-generating activities that **diversify our impacts** and maximise their reach on:

- **Understanding, Learning and Participation** to disadvantaged and under-represented groups through **ChemBAM** (Section 4.3.2).
- **Influence and Policy**, capitalising on cross-sectoral programmes in Energy and Sustainability (Section 4.3.3).
- **Health**, promoting licensing of therapeutic agents.

1.4. Supporting Interdisciplinary Research

Our vibrant and dynamic research environment is enabled by our tiered structure (Figure 1.3), which has supported interdisciplinary research through:

- **Strategic appointments**, proliferating interdisciplinary working through the **Birmingham Centre for Strategic Elements and Critical Materials** and **Birmingham Energy Institute**, which have been instrumental in attracting major Faraday Institution funding.
- **Cross-College joint appointments** and alignment of our Health Theme with institutional initiatives in Medicine in **Inflammation and Ageing** (Gupta), **Cancer Sciences** (Arno), and **Cardiovascular Sciences** and **COMPARE** (Herten) (REF5a-2.1.5).
- Our **Interdisciplinary Research Champion**, responsible for promoting and growing interdisciplinary research, and supporting the Director of Research in shaping cross-College activities.
- Establishment of **Interest Groups** and **challenge-led Research Themes**.
- **UoB structures** (REF5a-2.3), e.g., UoA8 is involved in three of the **Institute of Global Innovation's Emerging Focus Themes**: Confronting Antimicrobial Resistance (Fernandez-Trillo, Albrecht), Environmental Pollution Solutions (Dove) and Zero Carbon Fuels (Makepeace).
- Increased engagement in campus-wide and regional **interdisciplinary DTCs** (Section 3.1) and **continued leadership** in cross-campus CDTs (e.g., Sci-Phy-4-Health).

The number of publications co-authored by researchers from other disciplines/sectors (Section 4.1) and postgraduates with co-supervisors from other UoAs (Sections 2.6.1&3.1) evidences our **vibrant interdisciplinary research culture**. Furthermore:

- the new MSB will co-locate Environmental Sciences and Chemistry researchers to capitalise on the **Birmingham Plastics Network**, launched by both Schools in 2020. MSB is the first phase of a long-term development to co-locate health-based research at UoB, with Chemistry at its centre.
- strategic recruitment will unlock opportunities enabled by the new **Birmingham Health Innovation Campus** (£15M) and partner UKRI institutes, through secondments or relocation of spin-outs.

1.5. Open Research

We are committed to Open Research and FAIR data management. Researchers provide leadership in developing open-access journals (Section 4.4.5). UoA-level activities are guided by the University's Open Research Group (REF5a-2.2) to implement DORA and Plan-S to apply fair and responsible metrics in staff assessment (e.g., probation and promotion) and actively promote open publication.

Our **UoA8 Data Management Working Group**, chaired by our **Open Research Champion** (Tucker), ensures UoB's Open Research policies are embedded through training activities for all members.

Staff publish work as pre-prints (ChemRxiv/BioRxiv) and publicise outputs through social media, public engagement and conferences. Increasing numbers of accepted manuscripts are deposited in UoB's online repository, UBIRA (**Figure 1.4**).

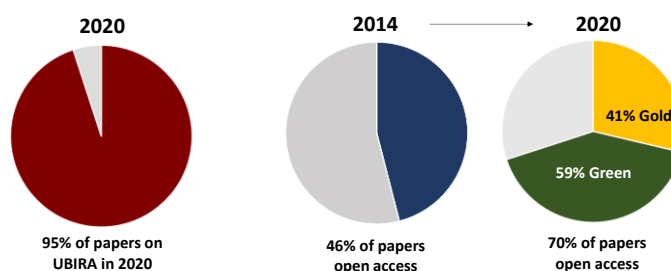


Figure 1.4-Open-access papers.

We support the Concordat on Open Research Data through our Research Data Management Policy, releasing open data through the University's e-repository, whilst protecting confidential data/IP.

1.6. Research Integrity

We are committed to the UK National Concordat to Support Research Integrity, as enshrined in UoB's Code of Ethics and Statement on Research Integrity (**REF5a-2.2**). All new staff undertake online research integrity, GDPR and ethical self-assessment training during induction (repeated biennially thereafter). Our **Plagiarism and Research Integrity Officer** (Chakrabarti) coordinates bespoke postgraduate training on ethics, responsible research methods, responsible innovation, ED&I and plagiarism.

2. People

2.1. Staff Development Strategy

We provide an inclusive, flexible training and development environment in which ED&I is embedded. This environment, shaped by the Researcher Development Concordat, enables individuals to realise their career ambitions and contribute collectively to UoA8's wider research and impact objectives.

2.1.1. Leadership Development

A specific staff-development objective was to **strengthen academic leadership** to help navigate a period of expansion and change. We have achieved this through:

- **training**: since 2014, 19 academics have completed **Leadership Programmes**, including bespoke programmes for female and BAME staff (**REF5a-3.4.4**),
- **encouragement and support** for staff to accept senior leadership roles, particularly female colleagues (Head of School, College Director of Global Engagement),
- **introducing deputy positions**, providing leadership development for early-/mid-career staff, improving resilience and aiding succession planning,
- **strategic recruitment** to expand senior leadership,
- **mentoring/coaching** to support staff in particular roles.

2.1.2. Training and Development

Performance and Development Review (PDR) is the primary tool for bespoke career development and support. Academics have three PDR meetings annually (**Figure 2.1**).

Mentoring is a major focus. New recruits and, increasingly, established staff, have mentors from HEI and/or industry. Senior leaders take advantage of **reverse mentoring**, and **PDRAs** pair-up with academics with experience relevant to their career goals. Staff are encouraged to undertake impact and grant-writing training and participate in pitch-to-peer events.

Coaching is offered to support development, provided by UoB's People & Organisation Development and supplemented by specialist external providers, e.g., since 2018, VOX-Coaching coached 5 staff (2F/3M, including 3 early-career) for major grant and fellowship panel interviews.

New staff undertake an institutional induction, including compulsory ED&I training (**REF5a-3.4.2&3.4.4**), supplemented by a bespoke School-level induction.

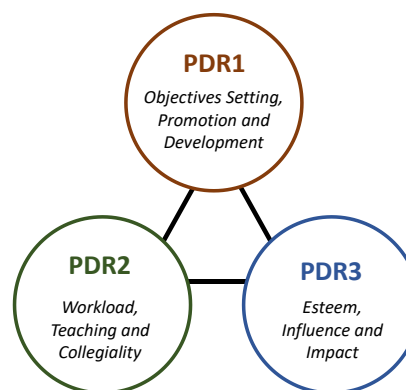


Figure 2.1-UoA8's PDR structure.

2.2. Staffing/Recruitment Policy

Our staffing and recruitment policy is driven by our desire to grow sustainably while maintaining a diverse, vibrant and collegiate environment. Beyond supporting the development of existing staff, we have ambitiously expanded (**Figure 1.1**) to achieve critical mass in key areas:

Four professors (1F/3M) (Albrecht, Herten, O'Reilly, Dove) have enhanced global visibility, brought international collaboration, industrial-stakeholder engagement experience, and expertise in leading large, multi-partner, interdisciplinary research programmes. Two of these senior appointments in polymers/soft materials have positioned UoA8 to respond to emerging global challenges (plastics recycling).

Two senior lecturers (2F) have strengthened links with the Quantum Technology Hub (Clark) (**REF5a-2.1.2**) and UKRI's Healthcare Technologies priority area (Gupta).

Eight lecturers/fellows (3F/5M) include one URF (Jupp), two FLFs (Makepeace, Pike), an EPSRC Healthcare Technology Fellow (Neely), two Birmingham Fellows (Arno, Allan) (**REF5a-3.4.1**) and two lecturers (Barendt, Yeung). These appointments have introduced new, complementary strands to our Research Themes (e.g., in clean energy, cell engineering and photocatalysis), improved connectivity with Life/Medical Sciences and created critical mass in solid-state materials, enabling major grant capture (**Section 3.1**). All Fellows hold proleptic positions; all other Category-A staff are on open contracts.

Diversity is a focus (**Figure 2.2**); we now have:

- a more balanced distribution of senior, mid- and early-career staff, facilitating succession planning,
- increased proportions of female staff,
- increased BAME staff [2/24 (8%), 2014; 4/32 (13%), 2020].

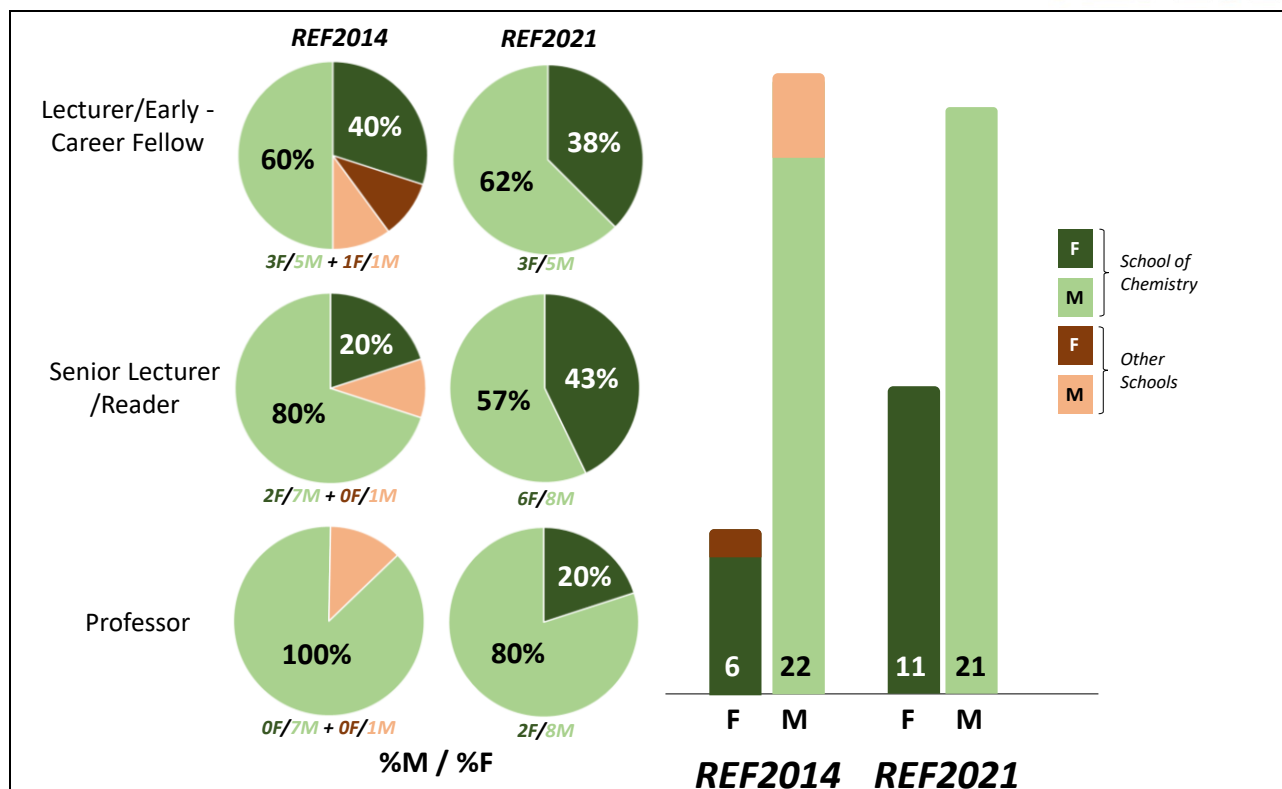


Figure 2.2-Gender data.

Our 2021-2026 objectives are to:

1. grow further to realise our REF2021 objectives (**Section 1.2**), through strategic joint appointments, which capitalise on institutional investment in Sustainability and Health and align to future development of the MSB,
2. support the development and promotion of existing female and BAME staff at all levels to meet, or exceed, institutional targets (**REF5a-3.4.5**) and sector averages [*Diversity Landscape of the Chemical Sciences* (2018, RSC)], and to deliver greater role-model diversity,
3. build on recent successes in supporting external candidates for prestigious fellowships and encourage/support existing staff to secure large grants, including fellowships.

We monitor diversity statistics throughout recruitment, taking positive action, if necessary, to mitigate unconscious bias. Guided by recommendations from Learned Societies [*Diversity Landscape of the Chemical Sciences* (2018, RSC), *Exploring the Workplace for LGBT+ Physical Scientists* (2019, RSC/IOP/RAS)], our ED&I Committee reviews our external profile and internal processes to ensure we recruit from a maximally diverse talent pool.

2.3. Supporting Early-Career Academics/PDRAs

Lecturers/Fellows receive a relocation package, support for visa applications, two PhD studentships and essential research equipment as part of their start-up packages (REF2021 investment ~£2.2M). They prepare a Probationary Personal Development Plan with their mentor, using the Vitae Researcher Development framework to target relevant training and development offerings from UoB's People Organisation & Development and the Research Development Team. Probationary targets, agreed with the Head of School in consultation with their mentor, focus on developing research activities. Teaching/administration responsibilities increase slowly, over three years for lecturers and more gradually for Fellows. Since 2014, all probationers passed probation and are now employed on open contracts.

PDRAs emphasise career ambitions and development. PDRAs have access to all-staff training opportunities, including UoB's **PERCAT** scheme (**REF5a-3.3**) and the Research Leaders programme. Mentors provide independent career advice. CV and interview training are provided

for those on fixed-term contracts, to support employment externally or redeployment. The Research Development Team encourages and supports fellowship applications (for internal and external PDRAs) with significant success: Marie Curie Fellows have increased from 3 (2014-2017, 0F/3M) to 12 (2017-2020, 3F/9M). PDRAs contribute to decision-making and help shape UoA8 policies, support and training provision through their membership of School, ED&I, Health and Safety, Research and Athena Swan committees.

2.4. Study/Impact Leave and Staff Exchange

Study Leave: Staff may apply for one term of Study Leave every three years. Since REF2014, one staff member has taken a one-year sabbatical; however, many staff, at all levels, have taken shorter periods of leave, focusing on major grant writing or visiting international laboratories for knowledge-exchange/training purposes (e.g., Chakrabarti, Harvard; Rodriguez, Stanford). Staff returning from, e.g., ill health, caring responsibilities, benefit from informal study leave and financial assistance (e.g., for travel/conference attendance, **Section 2.7.2**). We support fellowship holders (Royal Society, Faraday Institute) through recruiting Teaching Fellows (5 in REF2021) to cover teaching/administration duties.

Impact Leave: Preece's impact leave (0.4FTE for 2 years) to secure InnovateUK funding and engage industrial partners to grow ChromaTwist (Nature Research/Merck Spin-Off Prize 'One-to-Watch' 2020) evidences our flexible support for accelerating impact generation, which is integral to our impact strategy. With bespoke support from our **Impact Lead**, staff are encouraged to explore market and commercialisation opportunities. Since 2018, five ICURe awards have enabled an Entrepreneurial Lead (usually a PDRA/PhD) to take impact leave to validate the commercial potential of their innovation. These activities led to three spin-outs (Tagomics, 4D-Medicine and ChromaTwist).

Staff Exchange: The Research Impact Committee facilitates cross-sectoral exchanges, including supporting incoming industry researchers (e.g., a 2-year secondment of a Toray Industries researcher to work with Dove), through institutional exchange programmes (**REF5a-2.1.8**), and applications to internal and external funding schemes (e.g., RSC Mobility Awards, HPC Europa3). Honorary research positions stimulate staff exchange, particularly with strategic industry partners including BAE Systems, GSK, Sharp, Syngenta. For example, a 3-year Visiting Fellowship enabled a DSTL researcher to work (30%) with Pikramenou, using our facilities to develop ultrasensitive assays for strategically valuable molecules.

2.5. Recognition/Reward

We proactively support and encourage promotion applications and nominate staff for awards and prizes (Section 4.4.2).

All staff are considered annually for promotion by the Promotions Committee [membership 3F(1 part-time):3M]. Promotion criteria are discussed at PDRs; measures are put in place to address perceived weaknesses. The Senior Leadership Team provides guidance on applications, interview practice and support to unsuccessful applicants. Promotion applications and successes have increased in recent years (**Figure 2.3**).

Staff have received research training/supervision awards, including: UoB College Excellence in Doctoral Supervision Award (Slater, 2019); University Teaching Academy Award for Research-Informed Teaching to Sci-Phy-4-Health (Hannon/Neely, 2015), and Impact Awards for Preece's (ChromaTwist) and Dove's (4D-Medicine) spin-outs in RSC Emerging Technologies competitions.

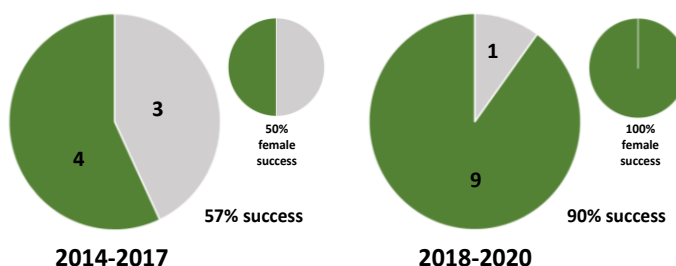


Figure 2.3-Promotion data.

2.6. Research Students

2.6.1. Recruitment Strategy

Our objective is to sustain a diverse postgraduate cohort that contributes significantly to delivering our research goals and sustaining a vibrant research environment.

We achieved our REF2014 objective to expand the Research School through funding diversification (**Figure 3.2**). A 72% increase in UoA8 postgraduate registrations in REF2021, with 39% co-supervised with other UoAs, stems from our strategy to move towards more challenged, interdisciplinary research, capitalising on EPSRC-CDTs: Topological Design, Sci-Phy-4-Health and Hydrogen Fuel Cells and Their Applications, and the regional BBSRC-funded MIBTP-DTP. Further support has come from STFC/EPSC DTPs, Faraday studentships, Diamond and UoB scholarships [e.g., 2020 intake (30): 15% DTP, 30% UoB], including from institutional initiatives, e.g., COMPARE (Nottingham), SUSTech (China) and BAM (Germany) (**REF5a-2.1.5**).

Our ED&I Committee monitors data, actively influences recruitment and works with our postgraduate-led Research School Liaison Committee to develop activities (e.g., IET *Look at Me Now* initiative, Gupta) to promote postgraduate study to under-represented groups and those with protected characteristics. Female applicants have increased in the last 3 years (now ~45%), with the 2019/20 female offer-to-acceptance rate at 92%.

Our **2021-2026 postgraduate recruitment objectives** are to increase diversity, maintaining numbers through targeting institutional strategic partnerships (**REF5a-2.1.5&2.1.8**) and increasing overseas recruitment. In the medium term, we will expand postgraduate numbers by capitalising on impact-generating activity and industrial co-funding.

2.6.2. Supporting Skills/Career Development

Our PhD students graduate with the research, transferable and organisational skills to realise their career ambitions, evidenced by high completion rates (since 2016 >92% within 4-year registration period) and those taking up academic positions (e.g., NIMS, Melbourne, SIOC, Cambridge) and entering industry (e.g., Sygnature, AWE, EDF, Syngenta).

Courses and development opportunities are identified using an ongoing skills-gap analysis and annual Development Needs Analysis, informed by the Vitae Researcher Development Framework. Careers guidance is supported by UoA8's Careers Officer and UoB's Graduate School (**REF5a-3.2**). In addition:

- Project-specific research-skills training (e.g., UNIX training, PDF analysis) is overseen by supervisors and coordinated by Sections.
- UoA8 provides health and safety, ethics, research integrity, open research, ED&I and unconscious bias training.
- UoB's Graduate School and Library Services offer diverse training, ranging from project management/teamworking to entrepreneurship.
- Presentations at conferences, 'meet the speaker' events after seminars and our annual Postgraduate Symposium develop communication and networking skills. UoB's membership of Universitas21 and ERASMUS programmes enables research visits and international network development. Funds are prioritised for those needing additional support, for example, owing to disability or caring responsibilities.
- Our postgraduates are passionate about public engagement and develop their communication and engagement skills through diverse activities, many through ChemBAM (**Section 4.3.2**), e.g., a postgraduate won the 2020 Parkin Prize Lecture for her outreach work using Jenga to describe batteries. We train and mentor postgraduates wishing to apply for HEA fellowships (4 Fellow/Associate Fellow awards since 2018).

2.6.3. Monitoring/Support Mechanisms

A combination of group, supervisor, UoA8-level and institutional processes provides a comprehensive package of monitoring and support. Progress is monitored through monthly meetings with supervisors while half-yearly reviews allow for longer-term reflections on progress,

training, development and objectives setting. Annual reviews with a second academic align with key progression milestones. Monitoring is overseen by UoA8's **Graduate School Director** and managed through the central Graduate School. UoA8-level support goes beyond science; our **Postgraduate Welfare Tutor** provides pastoral advice and acts as mediator when required.

Our **Research School Liaison Committee** offers support and development activities for postgraduates, mentoring new starters and organising events to share science, develop careers, and support diversity. Members have representation at all decision-making School committees (School, Research, Education, ED&I, Health and Safety) and meet Senior Leadership biannually.

2.7. ED&I

Diversity in UoA8 is valued and supported through equitable action, inclusive policies and behaviour. ED&I pervades UoA8's strategy and is a standing item on all decision-making Committees.

2.7.1. Supporting Flexible and/or Remote Working

Flexible working opportunities support UoA8's diverse workforce. The Head of School reviews requests for part-time and/or flexible working in consultation with relevant stakeholders (e.g., Head of Education). Our collegiate culture ensures that short-notice requests for cover (e.g., bereavement) are readily accommodated. For longer-term changes (**Section 2.4**) contract-time reduction feeds into our staff-planning model, which is used to leverage funding for replacement staff.

Prior to 2020, 4 academics worked flexibly or part-time for health/caring reasons. To retain their active participation in School life, activities/meetings are scheduled, wherever possible, between 09.30-15.00.

Part-time staff have equivalent career pathways to full-time staff: outputs and promotion criteria are considered pro-rata to working hours. All part-time staff have been promoted since 2014.

2.7.2. Supporting Return from Periods of Leave/III-Health

Staff managing long-term illness and/or with caring responsibilities are offered additional support. Bespoke **return-to-work packages** extend beyond institutional policies (**REF5a-3.4.5**). These include:

- direct research support through a one-year **School-funded PDRA**, which can be used flexibly. Since REF2014, three academics used this support to maintain research momentum, one during maternity leave, the others upon returning to work,
- prioritised support from the institutionally administered **EPSRC Developing Leaders** programme,
- **zero teaching and administration** for returnees' first terms back and no new courses/administration roles for the remainder of that academic year,
- support applying for **institutional funds**, e.g., to finance collaborator visits to minimise returnees' travel or IT purchases to enable home-working,
- research-only **Keeping-in-Touch** days,
- **reasonable adjustments** to work schedules, objectives and workspaces.

UoA8 supports postgraduates to apply for **institutional funds** that provide up to 3 months paid sick leave and extended registration. Returnees meet the Graduate School Director and supervisor to ensure appropriate restructuring of schedules and research goals, if necessary.

2.7.3. Supporting Those with Protected Characteristics

We amend working patterns to ensure those with protected characteristics can work effectively, guided recently by the Equality and Human Rights Commission's guidance on COVID-19-related reasonable adjustments for employees.

UoB’s Disability Service helps managers/supervisors understand disabled employees’ needs, providing practical support and guidance, particularly with workplace adjustments and infrastructural changes (**Section 3.2.4**).

ED&I Committee supplements mandatory University-wide training (**REF5a-3.4.2**), with extensive education and awareness raising of innate and acquired prejudices, encouraging individuals to develop corrective behaviours to minimise unconscious bias and microaggressions.

UoA8 holds a Bronze Athena Swan award and will apply for Silver in 2022. We sponsored the 2020 LGBT+STEMinar Conference (at UoB) and ED&I Committee are currently reviewing UoA8’s operations against the Race Equality Charter’s five principles. In 2020, 500 people attended an online seminar series highlighting issues impacting minority groups in STEM. The programme was developed by a UoA8 postgraduate and supported by the RSC’s *Inclusion and Diversity Fund*.

2.7.4. Supporting Staff/Student Wellbeing

Staff can seek wellbeing guidance in various ways, from confidential discussions with their mentor/Head of School to using our confidential online suggestion box, or through UoB-wide support mechanisms (**REF5a-3.4.5**).

A well-developed support structure for postgraduates includes our **Wellbeing Officer**, the conduit to extensive institutional support, including Student Support and Counselling.

Our ED&I Committee uses an annual online survey and follow-up focus groups to assess wellbeing support, with the outputs informing future provision.

2.7.5. How ED&I Informed REF2021

UoA8’s REF Outputs Panel comprised four senior staff (1F/3M, two members of ED&I Committee). Members undertook compulsory ED&I training. The Panel regularly compared the overall pool of available outputs with those selected for submission **by gender, ethnicity, career stage, and PT/FT status** to check for evidence of bias. **Figure 2.4** evidences M/F and BAME staff’s proportionate contributions to our outputs (during REF2021, 4 staff undertook 7 periods of maternity leave totalling ~5 years).

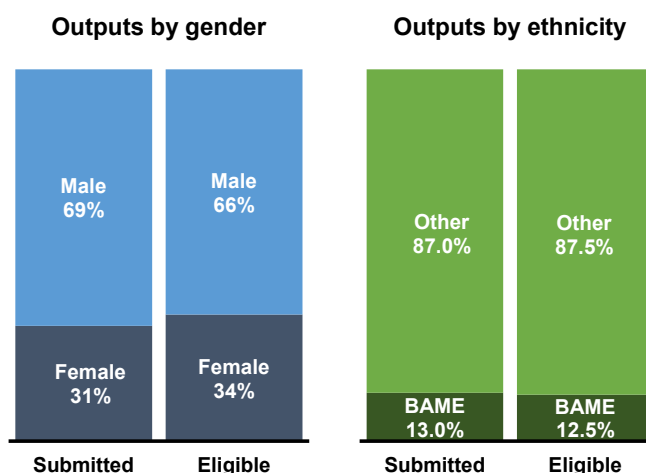


Figure 2.4-Submitted outputs compared to REF-eligible staff.

2.8. COVID-19 RESPONSE

Planned expansion has continued despite the pandemic. The need for home working highlighted the need to accommodate significantly increased flexible working. We have supported staff in developing skills in managing teams remotely, which will positively influence future flexible working.

Focusing on wellbeing support, we introduced ‘buddy systems’ and weekly meetings for all staff and postgraduates. Active staff engagement continued through fortnightly virtual coffee mornings and monthly School meetings. Our ED&I Committee hosted a programme of activities around mental health and wellbeing. A Return-to-Research group (representation from all Themes and career stages) developed buildings, laboratory, health and safety, and wellbeing programmes, which have supported the effective continuation of research during the pandemic.

3. Income, infrastructure and facilities

3.1. Research Funding and Income-Generating Strategies

Our income-generating strategy links directly with our research and staffing strategies. **Objectives**

for REF2021 were to:

1. **diversify income streams** to increase resilience, achieved by focusing more on challenged, multidisciplinary research alongside horizon scanning to capitalise on emerging funding priorities/opportunities (e.g., Faraday),
2. **make strategic appointments** to access new funding streams (polymers/plastics) and/or provide critical mass (solid-state materials) to enable major grant capture,
3. **reinforce our Research Grant Support Framework** to support staff in grant capture, from preparation to submission and post-award,
4. **provide staff with the time** to prepare competitive applications, using a supportive **PDR process** and an **effective workload model**.

3.1.2. Outcomes and Future Objectives

Figure 3.1 evidences the success of our income-generating strategy.

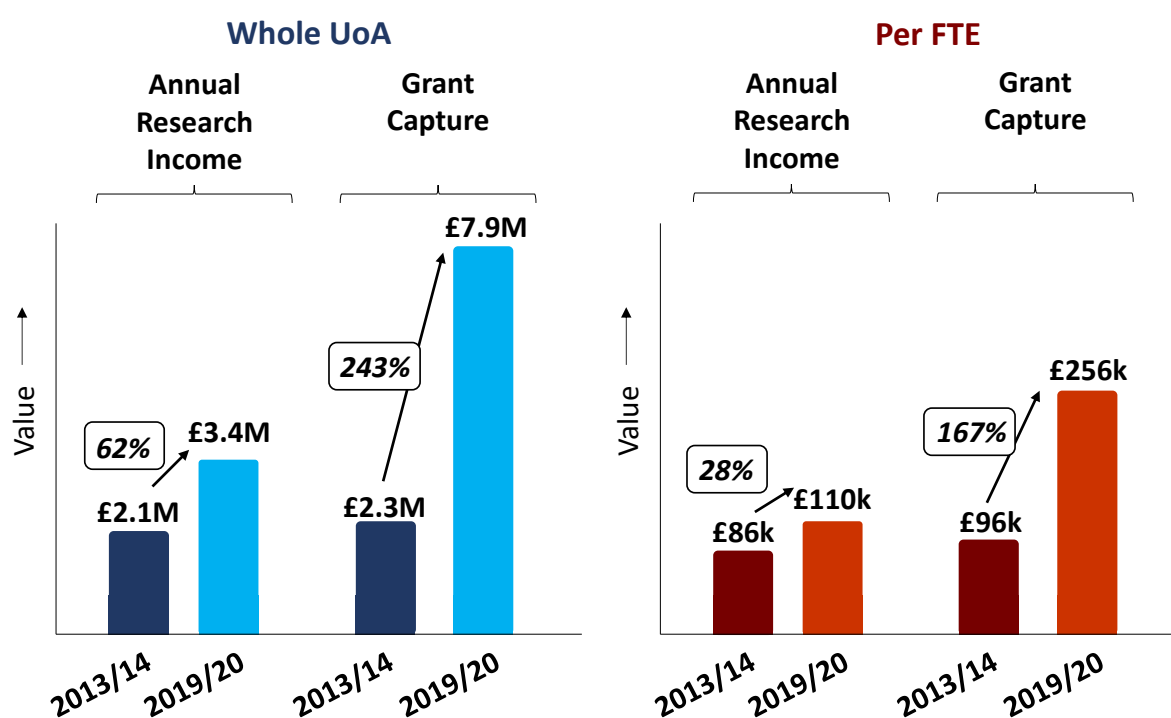


Figure 3.1-UoA8's annual research income and grant capture. Note: 2019/20 research income was lower than 2018/2019 (£4.2M, £167k per FTE, up 100% and 94%, respectively, from 2013/14) owing to reduced research activity during the pandemic.

We have diversified our income sources:

- Capitalising on new streams, notably the Faraday Institution, has enabled major cross-HEI/cross-sectoral research funding [ReLiB, Nextrode, CATMAT, Imaging Dynamic Electrochemical Interfaces].
- InnovateUK and industry funding (£22k in 2013/14; £574k in 2019/20) have increased impact-generating activity, supporting spin-outs Irresistible Materials (**REF2021-Impact Case**), Tagomics, 4D-Medicine and ChromaTwist.
- Strategic appointments in soft materials/polymers (O'Reilly, Dove, Arno) unlocked previously untapped priority funding areas. Significant grant capture in these areas, including 2 ERC Consolidator Awards (O'Reilly, Dove, ~£4M), has contributed 10 outputs to our REF2021 submission and nascent impact through spinning out 4D-Medicine.

We have supported early-career staff through grant-writing workshops, internal peer review and mentoring to win high-profile awards, including 1 URF (Jupp, £0.8M), 1 FLF (Makepeace, £1.2M), 2 EPSRC Healthcare Technology Challenge Awards (Neely, Gupta, £2.2M), 1 EPSRC strategic equipment award (Clark, £0.8M) and 5 Birmingham Fellowships.

Since 2016, a 180% increase in submitted grant applications by value, 52% increase in the average size of application and 25% increase in grant success rates by value evidences the success of our development and support mechanisms.

ED&I plays an important part in our income-generating strategy. UoA8 has undergone a change in research culture, supported by a dedicated change programme. In 2014, income from female staff was ~1% of the total annual income. By 2016, this had risen to 18% (just below the %female in UoA8, 22%) and by 2019, increased to 27%.

We have seen a 36% increase in the number of PhD awards (42% female, 27% BAME) in this REF period and 72% increase in postgraduate registrations, enabled through **increased emphasis on inter- and multidisciplinary research** providing new funding sources (**Figure 3.2.**):

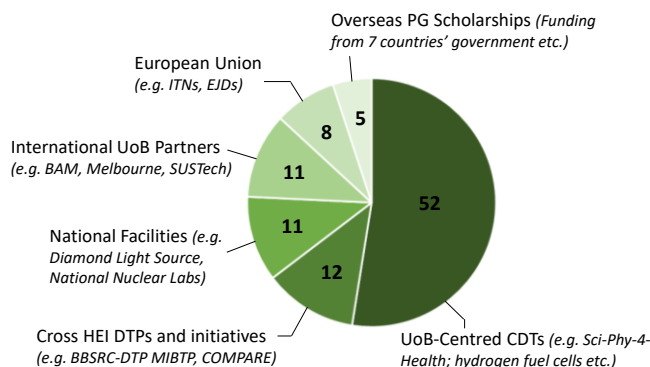


Figure 3.2-Number of inter- and multi-disciplinary PhD studentships.

Objectives for 2021-2026 are to:

1. **expand our Faraday-funding successes** to develop industry partnerships to translate our work in energy technologies and critical-materials recycling,
2. **build on our strength in sustainable plastics** and the new Birmingham Plastics Network to target cross-council, ISCF (Clean Growth Challenge Area) and industry funding opportunities,
3. **capitalise on UoB's partnerships with the Rosalind Franklin and Turing Institutes (REF5a-2.1.5) and knowledge-exchange investments**, particularly Tyseley Energy Park, Birmingham Health Innovation Campus (REF5a-4.2.2),
4. continue to **support all staff to improve grant capture and sustain success** in winning high-profile fellowships and grants,
5. **nurture and accelerate the careers of the next generation of researchers.**

3.2. Nature, Quality, Provision and Organisation of Specialist Research Infrastructure/Facilities

3.2.1. Infrastructure

Significant investment in infrastructure has created a vibrant environment, conducive to undertaking the highest-quality research.

- Costing £40M (further £2M for equipment), the Collaborative Teaching Laboratory (CTL) extended our research ecosystem to undergraduates, supporting research projects, dissemination and collaboration.
- £2.5M refurbished two floors of the Chemistry Building (laboratories, instrument rooms, offices) to accommodate ~50 researchers associated with new appointments.
- £0.5M created a teaching, technical and operations hub, repurposed under-utilised spaces into new instrument laboratories, refreshed breakout areas and provided new signage, showcasing key developments in UoA8's history, offering a more welcoming and inclusive environment.

The £80M Molecular Sciences Building, a new facility accommodating all Chemistry research (~6000 m²), reflects our ambition and will attract talent from the broadest pool. Opening in 2023 (one-year delay because of COVID-19), it will co-locate Chemistry with cross-campus STEMM activity, strengthen core capabilities and provide a platform for translating fundamental research into impact-generating activity, specifically in the targeted growth area of sustainability and the environment.

3.2.2. Facilities/Instrumentation

Sustained investment since 2014 has significantly expanded the range of techniques available to UoA8 researchers:

- A new state-of-the-art materials characterisation facility (£2M) underpins a **centre of excellence in soft matter/polymers/plastics recycling**. Its potential is demonstrated in a study illustrating how nanoparticle shape can enhance hydrogel adhesive and mechanical properties (Arno, *Nat. Commun.* 2020).
- Growing depth in electrochemistry, supported by investment (£0.5M) in **unique facilities for nanometre-resolution electrochemical surface characterisation**, produced the first report of constructive quantum interference-boosted thermoelectricity (Albrecht, *J. Am. Chem. Soc.* 2020).
- An upgrade (£0.3M) to Britton's MRI laboratory has enabled ***in operando* electrochemical MRI, shedding new insight into battery chemistry** (Britton, *Nat. Commun.* 2020) and attracting Faraday-funding.
- Our **Facility for Chemical and Materials Analysis** offers MS, elemental analysis, chromatography, ITC, fluorescence, UV-vis, (N)IR, Raman, NMR and XRF spectroscopy, and single crystal and powder diffraction. UoB investment (~£2M in NMR, MS) has maintained state-of-the-art provision, and long-term sustainability is ensured by Clark's £0.8M EPSRC award for a magnetometer.

Campus-wide specialist facilities/instrumentation are widely used:

- The Henry Wellcome **NMR** facility provides high-field instrumentation and expertise ([REF5a-4.4](#)).
- Access to the **e-Beam** facility (Physics) and **AFM** and **microencapsulation** facilities (Chemical Engineering) underpinned **two of our Impact Cases**.
- **COMPARE** ([REF5a-2.1.5](#)) was instrumental in recruiting Herten from Heidelberg. Many researchers use COMPARE's extensive microscopy and imaging facilities, including Neely, whose novel fluorescent probes for expansion microscopy (*ACS Nano* 2020) have been commercialised through Chrometra.
- Facilities (**FACS, sequencing, cell culture**) in the Medical School, accessed through UoB's Enabling Technologies Platforms ([REF5a-4.4](#)), underpin numerous collaborations ([Section 4.1](#)) and translational activity, including spin-out Tagomics.
- **High-throughput screening platforms** (Biosciences) were instrumental in instigating a TB drug-discovery programme (Fossey) and central to EU-EID-ITN, iDESIGN.
- **CaStLeS** (Compute and Storage for the Life Sciences) comprises a collection of computational and storage resources supporting UoA8's research (Hannon, *J. Am. Chem. Soc.* 2020) ([REF5a-4.5](#)).
- **Tyseley Energy Park** and equipment for the **Birmingham Centre for Energy Storage** (co-director Slater) are integral to Anderson's ReLiB programme.

3.2.3. Operational and Scholarly Infrastructure

Fourteen technical and professional services staff, including 6 new posts since 2014 (2 experimental officers, 2 research technicians and 2 pre- and post-grant award support roles), provide dedicated support for our expanding research activity. This internal Research and Impact Framework connects UoA8 to campus-wide teams supporting research and impact-generating

activity, and interfaces with campus-wide scholarly infrastructure, e.g., the Institute of Advanced Studies (**Section 4.2**).

The **Research Support Office** assists with all aspects of grant preparation, including proactively identifying research opportunities. Bespoke assistance is given for complex projects and bids to corporate business, including costings, ethics, integrity and governance. Diverse (gender/seniority) internal selection panels provide support for all. Bespoke assistance is provided for applicants whose first language is not English. The grant set-up team facilitates timely project starts and a Research Support Administrator provides post-award support. We draw on the expertise of **UoB Enterprise (REF5a-4.1)** to develop spin-outs, 4 of which were formed in REF2021.

Our technical officers run services, train users and undertake method development. They are actively involved in, and contribute, through networking, training and sharing of good practice, to the £3M Research England TALENT-project. Access to UoA8's facilities is free at the point-of-access for UoA8 researchers although significant cost recovery is obtained through grant capture and external user charges.

Campus-wide facilities operate under a culture of reciprocal support. For example, UoA8's Mass Spectrometry suite (12 instruments) is one of five nodes comprising UoB's Mass Spectrometry Enabling Technology Platform (**REF5a-4.4**). Each node serves a particular community, but the Platform offers wider technical expertise and instrumentation for UoA8 researchers. Researchers also use UoB's mechanical/electrical workshops and the **BEAR computing infrastructure** (£4M Tier-2 ESPRC investment) for data sharing, data archiving and high-performance computing (**REF5a-4.5**).

3.2.4. ED&I Considerations

Since 2014, we have improved accessibility and inclusion.

- The Chemistry building is now fully wheelchair accessible and offers gender-neutral toilet facilities and designated breastfeeding, baby-changing and private prayer space.
- Our ED&I Committee informed the design of the CTL, which is fully accessible and fitted with height-adjustable benching and fume cupboards, and the MSB, to maximise accessibility and inclusion.

3.3. Using Infrastructure, Facilities and Expertise for Impact

An increase in challenge-led research and translational activity has seen our infrastructure, facilities and expertise increasingly used for impact generation.

- The 4 spin-outs launched by Chemistry staff used our laboratories and analytical facilities for pre-launch development.
- Faraday funding has established a unique, state-of-the-art capability for battery research. Users can access a 202-channel battery-test facility, scale-up capability, battery manufacturing facility and EUCAR7-rated battery testing and safety chamber.
- Anderson's ReLiB project is capitalising on expertise in robotic segregation, and physical and chemical separation of metals, to develop economically feasible solutions to recycling and/or re-using automotive batteries. Drawing on campus expertise in economics and law, ReLiB is maximising impact through shaping policy (**Section 4.3.3**) and enhancing links in the value chain.
- Exploiting a unique partnership between UoB's Birmingham Energy Institute and Tyseley Energy Park (**REF5a-2.1.7**), ReLiB is developing a demonstration facility for high-tech battery-recycling technologies at Tyseley.
- UoA8 researchers' expertise is regularly requested for public engagement in science (**Section 4.3.1**) and consultancy work: between 2014-2020, 7 staff undertook consultancy work, e.g., Norwegian company Glucoset exploited Fossey's expertise in saccharide sensing, and ThermoFisher, Albrecht's background in nanoscale electrochemistry for optimised gene synthesis.

3.4. External Infrastructure/Facilities

Central Facilities: UoA8 researchers make extensive use of national and international research facilities; total in-kind income in the reporting period for UK facilities' use is £5.1M from 290 days of experimental time (**Figure 3.3**). Notably, the Harwell Campus has seen researchers taking advantage of dedicated beamtime available through the Diamond-UoB collaboration (**REF5a-4.4**). Hriljac's position at Diamond has generated further linkages.

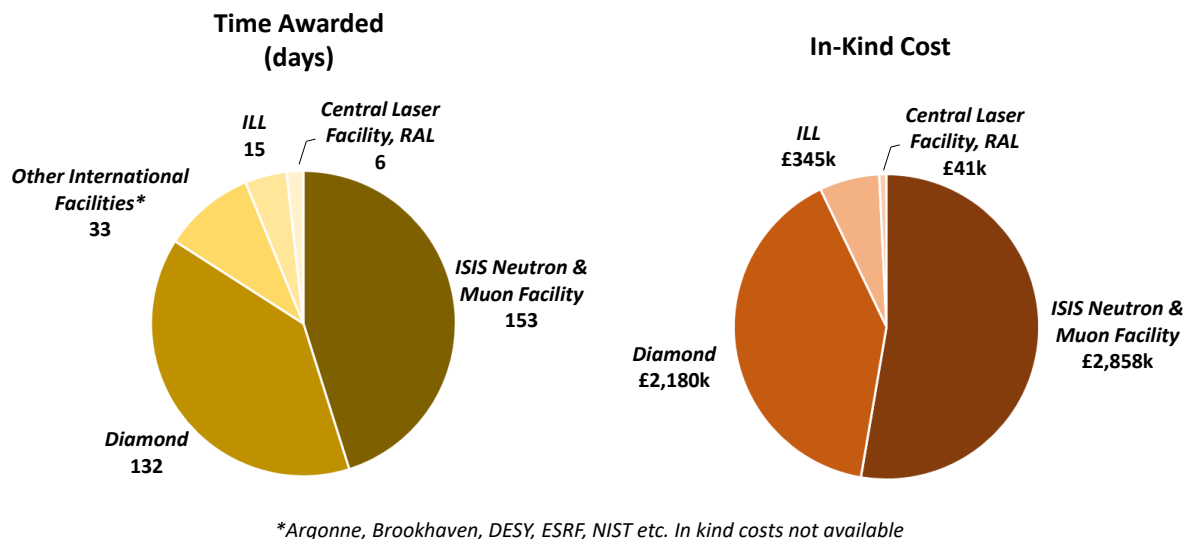


Figure 3.3-Central facilities' use.

Launched in 2019 (Lead: Albrecht), the **UoB-BAM Virtual Centre for Collaboration in Materials Science and Chemistry** provides access to BAM's expertise and unique facilities, including transmission Scanning Electron Microscopy, nanometre-resolution Auger spectroscopy/imaging, and state-of-the-art scattering facilities for soft materials characterisation. In 2020, we welcomed our first cohort of 3 jointly supervised postgraduates.

4. Collaboration and contribution to the research base, economy and society

4.1. Collaborations

UoA8 researchers collaborate widely, evidenced by the co-authorship in our REF outputs submission (**Figure 4.1**):

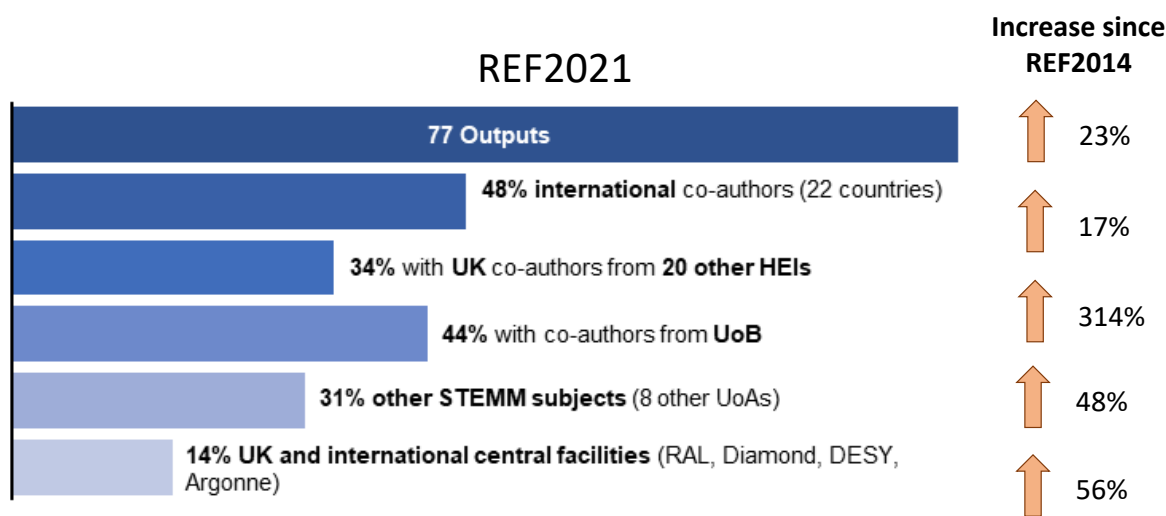


Figure 4.1-Outputs' co-authorship.

3 Faraday-funded projects focusing on **Energy** (Oxford-led Nextrode, Bath-led CATMAT, and Liverpool-led Imaging Dynamic Electrochemical Interfaces), involve extensive collaboration with multiple institutions (10 UK HEIs) and organisations (including UK Battery Industrialisation Centre, Royce Institute, 20 companies).

Within **Health**, 16 academics collaborate with colleagues from Medicine and Life Sciences, other institutions and industry. Many collaborations stem from UoB's **Drug Discovery Club**, which facilitates the assembly of multidisciplinary teams to advance drug-discovery projects. Significant translational activity and impact generation evidences the success of these collaborations, e.g., a commercialised **antimicrobial surface-coating technology** (REF2021 Impact Case).

Within **Sustainability**, Faraday-funded **ReLiB** unites 10 groups from 5 Schools (including Law and Economics) at UoB, 11 groups from 6 other UK HEIs, Diamond, 3 international academic and 13 industrial collaborators. Major EU networks include **NATURE** (EID-ITN), in which 2 universities and 1 European industrial partner are developing biodegradable substitutes for commodity plastics.

Collaborations involving non-academic stakeholders continue long-established relationships, e.g., with **P&G** in **personal care products** (REF2021 Impact Case), and **DSTL** exploiting UoB's strength in **sensing**. Other collaborations have arisen from new appointments, e.g., Dove's work in sustainable plastics (**Unilever, Infineum, Polymateria**).

4.2. Enabling and Supporting Collaboration

UoB encourages and enables collaboration via focused support, facilitation, judicious use of its estate, and active engagement with central institutes (Ref5a-2.3).

Collaboration opportunities are encouraged through:

- A School **travel/subsistence fund** for researchers (early-career prioritised) to establish new collaborations, supplementing College/University schemes.
- **Matched funding** for collaborative PhD projects with industry (Infineum, Unilever, DSTL), CSC and other overseas HEIs [BAM (Germany), SUSTech (China)].
- **Encouraging researchers to take leadership/coordinator roles on major collaborative projects** through a flexible workload-allocation model (balanced by deployment of teaching-focused staff whose number increased from 6 to 8 since 2014).
- **Promoting and publicising collaborative exchange programmes.** We have welcomed international researchers through Royal Society Exchange and Newton Mobility grants from 6 countries, leading to numerous joint papers and a high-profile Advanced Newton Grant award to a female Professor from Fudan University.
- Using our **Sci-Phy-4-Health CDT** as a driver for interdisciplinary interactions.
- Purposely **co-locating research groups** (shared laboratories/offices) from disparate fields.

Our **Interdisciplinary Research Champion** stimulates collaboration through hosting '**pitch-to-peer**' sessions, seminars from new appointees, and **away days** involving other UoAs to encourage active engagement in cross-campus (REF5a-4.2.2&4.2.3) and cross-HEI initiatives (COMPARE, BAM, Diamond-UoB). Colleagues are further supported in their applications for internal grants to fund:

- **pump-priming projects**, e.g., the Wellcome Trust ISSF-funded **Enabling Chemistry Scheme** for Medicine-related projects has led to an MRC-funded collaboration between Cox, Bottegoni (Pharmacy) and McCabe (Medicine) developing **new drugs for thyroid cancer**,
- **workshops** to explore potential collaborations, e.g., through UoB's Institute of Advanced Studies. A recent example led to the **Birmingham Plastics Network**.

Our **Impact Lead** connects researchers with external stakeholders to facilitate impact-generation and translational activities.

Hannon's directorship of UoB's **Institute of Advanced Studies** (IAS, 2015-2019) promoted UoA8 engagement in interdisciplinary activities and contributed to the UK/global research base.

- **IAS-funded symposium**, '*New Frontiers in Colloid Science*' (2017), stimulated collaborations between Chakrabarti and Manoharan (IAS Distinguished Visiting Fellow, Harvard), a joint studentship (IAS Research Investment Scheme), and an Implementation Grant with Chen (Illinois at Urbana, Champaign), supported by the BRIDGE Programme (REF5a-2.1.8).
- **IAS-funded exchange visit** established a collaboration between Klumperman (Stellenbosch) and Dove/O'Reilly.
- **The IAS Intercontinental Academia** brought Nobel Laureates Lehn and Yonath to UoB (2019).
- **IAS-funded academia-industry workshop**, '*Technology Touching Life*' (2016), led to a multi-postdoc EPSRC grant with Dentistry and 5 collaborative publications.

4.3. Wider Contributions

4.3.1. Impacts on Understanding, Learning and Participation

We have a strong ethos of public engagement, offering activities on campus, e.g., **Lapworth Lates**, at Birmingham's Science Museum: ThinkTank (**Meet the Expert, I'm a scientist get me out of here**), in partnership with **Pint of Science. Chemistry@Work** events at the Black Country Living Museum, RAF Cosford, and the National Space Centre (400 attendees per event) showcased our research in Sustainability and Energy, including nuclear waste disposal (Hriljac), clean fuels (Anderson) and next-generation batteries (Slater).

COVID-19 highlighted the importance of online platforms for public engagement. We produced videos for UoB's social media channels in which academics and early-career researchers discussed their research and its impact on society. Judicious selection of presenters (gender/BAME) provided diverse role models to engage under-represented groups.

Staff regularly contribute to **The Birmingham Brief** (e.g., "The Fate and Sustainable Future of Plastic", Dove, 2020) and **The Conversation** (e.g., "Nerve Agents: what are they and how do they work?" Cotton, 2018). With ~5.3M reads, Cotton is the most-read UoB author (next highest: 1.3M reads).

4.3.2. Engaging Schools and Schoolchildren

Schnepp launched the award-winning **ChemBAM** in 2017 in response to the RSC report *Public Attitudes to Chemistry*. **ChemBAM showcases 'real-world' chemistry, aligned with UoA8's research, through activities directly linked to the national curriculum**. A Creative Commons licence ensures teachers and pupils can freely access the resources. ChemBAM has secured ~£60k (RSC, industry, alumni) to support its activities, **Figure 4.2**:

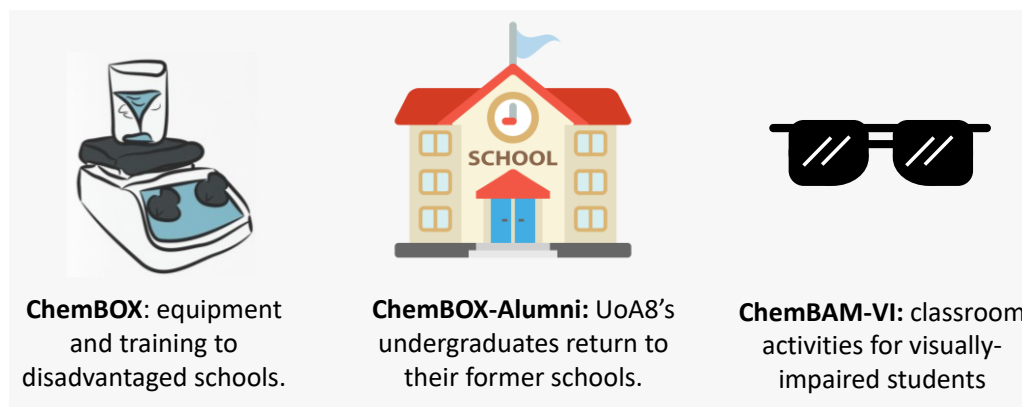


Figure 4.2-Three ChemBAM initiatives.

ChemBAM's website has attracted >100,000 hits since launching (~50% non-UK). The team has directly trained 227 teachers and 26 technicians and reached 3,100 pupils, with many more impacted indirectly via shared resources. In 2020, ChemBAM launched a home-learning resource to support pupils during lockdown (32,000 hits, Dec 2020).

We host **West Midlands Chemistry Teachers Centre**: monthly lectures (many given by UoA8 staff), attended by 300+ students from the West Midlands, moved online in 2020 and reached an international audience. 2,500 Sixth-form students (102 schools) have participated in **Spectroscopy in a Suitcase workshops** since 2016.

4.3.3. Impacts on Policy and the Environment

Examples include:

- **Energy**: Makepeace co-authored *Ammonia: zero-carbon fertiliser, fuel and energy store*, Royal Society (2020), which has been used to brief government (DfT, BEIS, DEFRA) and members of the International Energy Agency Hydrogen Technology Collaboration Programme Tasks 32 and 40 focusing on hydrogen storage.
- **Health**: Albrecht and Neely contributed to a response to a Parliamentary Enquiry into the Government's Strategy on Antimicrobial Resistance, submitted through the Institute of Global Innovation (2019).
- **Sustainability**: Anderson and Walton (Metallurgy & Materials) authored *Securing Strategic Elements & Critical Materials for the United Kingdom*, Birmingham Policy Commission (2020). Dove co-authored *SYNERGY: A Circular Economy for Polymers in Liquid Formulations*, RSC (2019) and the White Paper, *Science to Enable Sustainable Plastics*, Chemical Sciences and Societies Summit (2020).

4.4 Indicators of Wider Influence

4.4.1. Conferences/Research Events

Since 2014, staff have given >300 invited talks at conferences, workshops and meetings. **Highlights** include **plenaries** at the Bunsen Society for Physical Chemistry (Herten, 2015), 13th European Conference on Bioinorganic Chemistry, (Hannon, 2016), TheoBio17 (Peacock, 2017), 4th German SupraChem Conference (Hannon, 2017), Mediterranean Conference on Materials and Renewable Energies (Allan, 2018), International Symposium on the Photophysics and Photochemistry of Coordination Compounds (Pikramenou, 2018), Pacific Polymer Conference (O'Reilly, 2019), High Polymers Research Group (Dove, 2019), European Symposium on Fluorine Chemistry (Slater, 2019), Australian/New Zealand Magnetic Resonance Conference-25 (Britton, 2019) and invited lectures at the Gordon Research Conference in Polymers (Dove, 2017), Molecular Motors and Switches (O'Reilly, 2019).

O'Reilly delivered the Dow (University of Victoria, 2020), DSM (ACS, 2020), Aldrich (Columbia University, 2019), CBE (Cornell University, 2019) and Covestro (Texas A&M, 2018) **Distinguished Lectures**.

4.4.2. Prizes/Awards

Since 2014, 11 members of UoA8 (**5F/6M, 1 BAME**), spanning senior, mid-career and early-career staff, have received 26 national/international prizes and awards:

- **Allan**: Bryan Kelly Award, British Carbon Group (2019).
- **Clark**: Lonsdale Lecture Prize (2020), Physical Crystallography Prize (2020); Alan Beeston Early-Career Researcher of the Year (2019), RSC/IOP BTM Willis Prize (2019).
- **Cotton**: British Empire Medal for services to Chemistry and Education (2014).
- **Dove**: MacroGroup UK Award (2020), RSC Emerging Technologies Award (2018), RSC Norman Heatley Award (2018), Macromolecules/Biomacromolecules Young Investigator Award (2016), RSC Gibson-Fawcett Award (2014).
- **Fossey**: Czarnik Emerging Investigator Award (2016).

- **Hriljac:** DISTINCTIVE Consortium, 2020 RSC Industry-Academia Collaboration Award.
- **O'Reilly:** RSC Corday-Morgan Prize (2020), Polymer Chemistry Lectureship (2020), RSC Industry-Academia Collaboration Award (with BP) (2018), Journal of Polymer Science Innovation Award (2018), Macromolecules/Biomacromolecules Young Investigator Award (2017), RSC Gibson-Fawcett Award (2016), SCI/RSC McBain Medal (2014), 2019 Finalist, UK Blavatnik Awards in Chemistry.
- **Peacock:** RSC Inorganic Biochemistry Discussion Group, Young Investigator Award (2016).
- **Preece:** RSC Emerging Technologies Finalist (2019), Nature Research/Merck Spin-Off Prize 'One-to-Watch' (2020).
- **Schnepp:** (with Patchett/Rogers): RSC Inspiration and Industry Award (2020) for inspiring the next generation of chemists.
- **Yeung:** British Crystallographic Association Parkin Prize Lecture (2019).

4.4.3. Prestigious Fellowships

Dove and O'Reilly hold ERC Consolidator Grants, Davies and Pikramenou were Royal Society/Leverhulme Trust Senior Research Fellows and Fossey and Simpkins, Industry Fellows. New appointees, Pike and Makepeace, are FLFs; Jupp is a URF and a VENI Fellow. Herten was awarded an Academy of Medical Sciences Professorship. O'Reilly is a Fellow of the European Academy of Sciences.

4.4.4. Service on Panels/Committees

UoA8 researchers at all career stages exert influence and shape the development of the field through leadership as chairs and members of committees, panels and bodies spanning the discipline.

Contributing to UKRI Strategy: Hannon was a member of the EPSRC Strategic Advisory Team in Physical Sciences (2014-2017), Johnston, the EPSRC e-infrastructure Strategic Advisory Team (2014-2017) and O'Reilly, the EPSRC Strategic Advisory Network (2012-2017) and ED&I Committee (2013-2014).

Service on panels: including STFC and UKRI-EPSRC Schemes/Fellowships, ICSF, ERC grants, EU schemes, ACS-PRF, NWO, SNSF, ANR, Novodisk, FWO, The Royal Commission for the Exhibition of 1851, Royal Society Newton International Fellowships. 11 staff are EPSRC College Members and 4 Associate Members.

Supporting Central Facilities: Slater is a member of the STFC-ISIS crystallography user group and Diamond Light Source diffraction panel. Early-career staff provide service through Allan's and Clark's membership of the Diamond peer-review panel, and Clark's membership of the ISIS Facilities Access Panel (RAL), the Science Review Committees for the NIST Center for Neutron Research and ORNL Neutron Scattering Sciences Division (US).

International Universities: *Promotions and appointment panels:* SUSTech, KTH Sweden, Universities of Hong Kong, Athens; *Visiting Professorships:* Fudan and Tongji Universities, University of Mons; *Advisory boards:* TU Munich, University of Konstanz, KAUST, Vietnamese Academy of Science and Technology.

4.4.5. Journal Editorship/Contributions

Since 2014, 22 staff have held associate editorships or been members of editorial advisory boards across 34 peer-reviewed journals. Of note:

- O'Reilly is a Reviewing Editor for *Science*, on the Editorial Advisory Board for the *Journal of the American Chemical Society* (appointed Associate Editor in 2021) and the first UK Associate Editor for *Macromolecules*.

- 8 staff have provided leadership in developing open-access journals, including Tucker and Fossey as Associate Editors, and Pikramenou, Chief Editor of *Frontiers in Chemistry (Supramolecular Science and Nanoscience)*, Slater, Associate Editor of *Applied Science*, Albrecht and Britton, Editorial Board members of *Scientific Reports*, Gupta, Associate Editor of *RSC Advances*, and Fossey and Rodriguez, Editorial Board members of *Molecules*.
- Hannon led the international search committee for the new Editor-in-Chief of the *Journal of Biological Inorganic Chemistry* and O'Reilly was part of the international search committee for the current Editor-in-Chief of *Macromolecules*.
- Early-career researchers, Pike, Barendt and Makepeace, are Review Editors, and Arno and Yeung, Editorial Board members for *Frontiers in Science, Chemistry*.
- Arno and Yeung are Community Board members for *Materials Horizons*.

4.5. Supporting Chemistry

Collegiality within UoA8 is reflected by strong citizenship across the discipline. All staff contribute to maintaining the highest standards of scientific rigour through reviewing manuscripts and grant applications for national and international funding agencies.

Many staff play leading roles in Learned Societies, sustaining the vibrancy of the discipline, influencing future directions, advancing training and development, and advising on policy.

Within the **RSC**, we have/had representatives on:

- **Organic** (Davies), **Faraday** (Horswell), **Analytical** (Gupta), **Materials** (Preece, -2015) and **Dalton** and **Chemistry Interface** (Peacock) Division Councils and Division **Review Advisory Group** (Peacock).
- **7 Interest Group Committees** including Officer roles: Theoretical Chemistry [Johnston, Chair (2016-2018)], Electrochemistry [Horswell, Secretary (2020-2022), Albrecht, Chair (2014-2017)].
- **Awards Committees:** Travel and Scientific Meeting Grants [Davies (2018-2020)], Research Fund Working Group [Peacock (2017-2020)] and Organic Awards Committee [O'Reilly (2014-2016)], Materials Awards Committee [O'Reilly (2017-2019)].
- **Early-career researchers** are committee members of the British Crystallographic Association Chemical Crystallography Group (Yeung), and Macrocyclic and Supramolecular Chemistry Group (Barendt).

Beyond the RSC:

- **Society of Chemical Industry:** Cox, Fine Chemicals Group, Chair (2017-2019); Davies, Young Chemists' Panel, Chair (2014-2016).
- **British Liquid Crystal Society:** Chakrabarti (Steering Committee).
- **High Polymer Research Group:** O'Reilly (Council).

International Learned Societies:

- **American Chemical Society:** Dove, O'Reilly, POLY Awards Committee.
- **China Scholarship Scheme:** Fossey, International Academic Advisor.
- **European Ampere Society:** Britton, first female Chair (2017-2021) International Division of Spatially Resolved Magnetic Resonance.
- **International Society for Electrochemistry:** Albrecht, Secretary (2018-2020).
- **Society for Biohydrogels:** Dove, founding committee member (2016).
- **Society of Biological Inorganic Chemistry:** Hannon, President (2016-2018).

The activities delivered through these diverse roles provide opportunities to advance UoA8's commitment to ED&I. For example, at the **14th European Conference on Biological Inorganic Chemistry** (2018, Birmingham, 400 participants), organised by Hannon/Pikramenou, plenary lectures were 50% female and Keynotes/Session lectures similarly diverse (both 41% F). O'Reilly co-chaired the **RSC 14th International Conference on Materials Chemistry** in Birmingham (2019, 600 participants) with 50% female invited speakers (across plenary/keynote/award). Chakrabarti/Preece won an EPSRC grant (2019) to organise a series of **British Liquid Crystal Society Annual Training Workshops** at UoB. These workshops provide education/training for early-career researchers in the highly interdisciplinary field of liquid-crystal research. The first two workshops attracted over 100 attendees with contributions from 12 experts (4F, 3 BAME).

Concluding Remarks

Our vibrant research environment promotes collegiality and equality to support and develop world-class researchers to lead and influence the discipline. The School of Chemistry at UoB has grown in size, ambition and success during REF2021 and is well placed to achieve the economic and societal impacts needed to address the challenges of the 21st century.