Institution: The University of Manchester

1. Context and mission

The University of Manchester (UoM) ranks among leading research universities globally, with a history of world-changing achievements spanning almost 200 years. Our global collaborations include strategic partnerships with leading universities across the world.

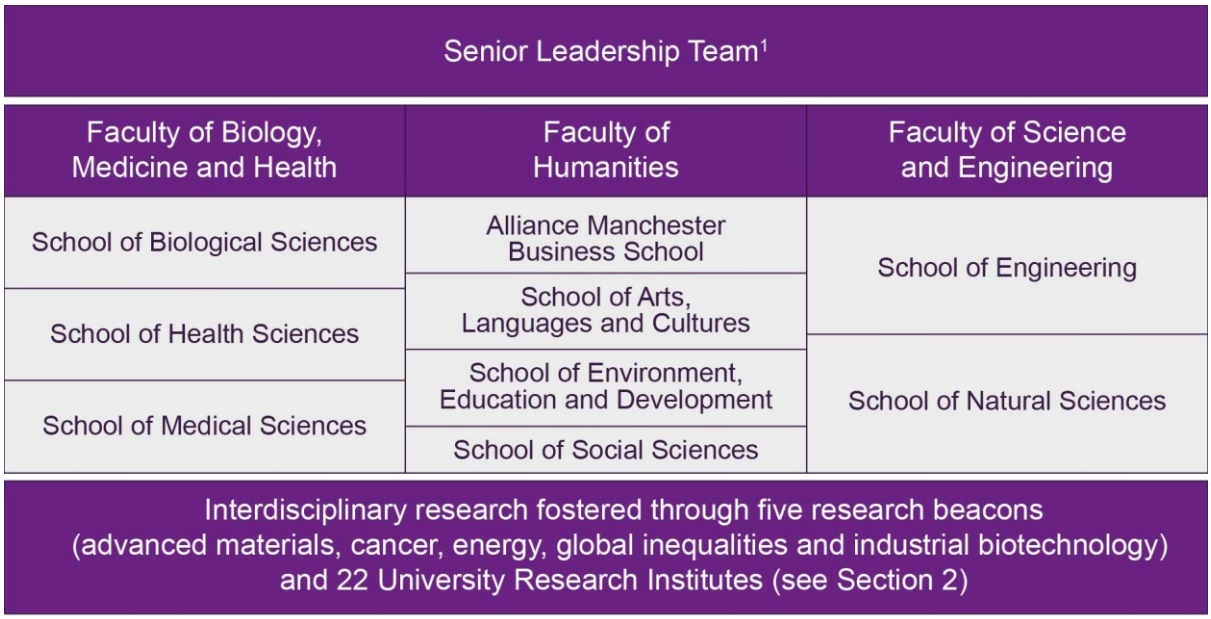
Our strategic goals are research and discovery, teaching and learning, and social responsibility. Running through our goals is an emphasis on innovation, civic engagement and global influence, all driven by our people and underpinned by our values (Figure 1). Our vision is "*to be recognised globally for the excellence of our people, research, learning and innovation, and for the benefits we bring to society and the environment*".

Figure 1 – Our Strategic Goals

The University employs >11,000 people, including >2,000 REF-eligible academics, nearly 2,000 research staff, and >1,000 technical and experimental officers. The majority of academics undertake research and teaching (~84% FTE). UoM has 40,250 students, including over 4,000 postgraduate researchers (PGRs). Placed 23rd in the 2020 THE global ranking of the most international universities: 36% of staff and 28% of students are from outside the UK. International research funding accounts for 15% of our research income including over 400 EU Horizon 2020 awards in the REF period. Our annual income exceeds £1bn with an average of 26% generated from research over the REF period.

Large multidisciplinary Schools and Faculties (Figure 2) and interdisciplinary University Research Institutes, which underpin our Research Beacons (Section 2), enable discipline-specific research excellence and interdisciplinary collaborations. Our REF 2021 submission includes 31 UoAs.

Figure 2 – University of Manchester Structure



[1]Membership: President and Vice-Chancellor (Chair); Deputy President and Deputy Vice-Chancellor; Policy Vice-President (Teaching, Learning and Students); Policy Vice-President (Research); Policy Vice-President (Social Responsibility); Vice-President and Dean (Biology, Medicine and Health); Vice-President and Dean (Humanities); Vice-President and Dean (Science and Engineering); Registrar, Secretary and Chief Operating Officer; Director of Finance; and Director of Human Resources.

Since our 2004 foundation (merger of The Victoria University of Manchester and UMIST) we have worked closely with industry and other stakeholders to maximise the positive impact of our research in Greater Manchester (GM), nationally and globally. GM is one of the largest and most diverse city regions in the UK, with 2.8 million residents and another 7 million living within an hour's travel time. Through civic commitment, our research contributes to the delivery of GM's Local Industrial Strategy's priorities in health innovation, advanced materials, and building a creative and digital city region committed to clean and inclusive growth and carbon neutral living by 2038 (Section 2).

2. Strategy

Our strategy is to achieve research excellence and impact across diverse research activities, promoting cross disciplinary research, innovation and international recognition.

Unless otherwise stated, growth figures refer to the REF period.

Our strategic goals and achievements were:

- **To raise our research quality and global standing**. In 2020 we ranked 36th in the *Academic Ranking of World Universities (ARWU),* (38th in 2014), and 22% of our publications were in the top decile for citations in their field. We have two Nobel Laureates, two Regius Professors, 123 fellows of National Academies, 32 Fellows of Academia Europaea and 33 Clarivate Highly Cited Researchers. Two research teams were awarded Queen's Anniversary Prizes: Manchester Institute of Biotechnology (2019) and Imaging for Advanced Materials (2013).
- **To generate research impact and commercialisation**. We were first in the UK in the 2020 *THE* University Impact Rankings and 8th globally for social and environmental impact and contribution to the delivery of the United Nations Sustainable Development Goals (SDGs). Commercialisation progress was recognised by a rapid climb in Reuters' Europe's Most Innovative Universities ranking 8th in Europe and 4th in the UK in 2019.

In 2013, we set five priorities to achieve these goals:

i) People

We enhanced career development support and training for all researchers and set high recruitment standards. We invested >£10m in 136 early-career research (ECR) fellows, including flagship Presidential Fellows; another 121 were externally funded, including 14 UKRI Future Leaders. Research fellows increased from 332 to 456, including an expansion of externally funded fellowships to 355 in 2020. We awarded 6,642 research doctoral degrees.

ii) World-class research environment

We secured ~ £2bn research income, £389m external capital investment in research infrastructure and >£130m UKRI in-kind income. Our market share of the sector's research grants and contract income rose from 4% to 7%, placing us 5th in 2018/19 (latest HESA data); our share of UKRI research income rose from 5% to 7%.

iii) Interdisciplinary collaborative research founded on disciplinary pillars

We invested ~£147m in new interdisciplinary research to build teams and support success in external funding applications (ii above).

Our five **research beacons** highlight areas of interdisciplinary excellence and scale: **advanced materials, cancer, energy, global inequalities** and **industrial biotechnology**. Cross-cutting thematic priorities in **Digital**, **Creative** and **Environment** stimulated new collaborations with external stakeholders. **Policy@Manchester** draws our research discoveries into thought leadership and policy making forums (see iv).

Sixteen of our twenty-three interdisciplinary Research Institutes launched in the REF period, including our lead of the Henry Royce Institute (Royce) national facility (Figure 3). They encompass ~43% of our academic researchers. Twelve institutes combine STEM, social sciences and humanities. Each has a significant external funding portfolio and a large number of Principal Investigators: median 57; >100 in 10 institutes. Together they generated ~66% of our external research income and philanthropic donations.

Figure 3 – The University of Manchester Interdisciplinary Research Institutes

Cancer Research UK Manchester Institute*‡	Manchester Environmental Research Institute*†‡
Cathie Marsh Institute for Social Research*†	Manchester Institute of Biotechnology†‡
Christabel Pankhurst Institute for Health Technology Research and Innovation*†‡	Manchester Institute for Collaborative Research on Ageing†‡
Dalton Nuclear Institute‡	Manchester Institute of Innovation Research†
Global Development Institute*† ‡	Manchester Urban Institute*
Henry Royce Institute*†	National Graphene Institute and Graphene Engineering Innovation Centre – graphene innovation system*
Humanitarian and Conflict Response Institute†	
Institute for Data Science and Artificial Intelligence*†‡	Photon Science Institute†
Institute for Health Policy and Organisation*†‡	Productivity Institute*
John Rylands Research Institute* (special collections)	Sustainable Consumption Institute
Lydia Becker Institute of Immunology and Inflammation*‡	Thomas Ashton Institute for Risk and Regulatory Research*†
Manchester China Institute*	Work and Equalities Institute*

Key: * = launched in current REF period
† = research includes externally funded interdisciplinary collaboration between STEM, social sciences and arts
‡ = at least 100 PIs (Institute median is 52)

We host major national and international infrastructure (Section 4). Collaborations include the NHS, graphene innovation ecosystem and membership of national facilities including the Turing Institute for Data Science and Artificial Intelligence and the Rosalind Franklin Institute. Regional collaborations include the N8 Research Partnership, Northern Health Science Alliance and ERDF-funded AI and Cyber-security initiatives with Greater Manchester universities.

We established strategic international partnerships with the Universities of Melbourne, Toronto and the Chinese University of Hong Kong. Each has a pump-priming fund to initiate collaborations (£275,000 during the REF period). Dual PGR programmes with Melbourne and Toronto are supported by a further £160,000. Our global research collaborations are strengthened through partnerships with Copenhagen University, Peking University Health Sciences Centre, Tsinghua University, KTH/Stockholm University and the Indian Institute of Science. International partnerships in the Global South were supported through UKRI's Global Challenge Research Fund and the Newton Fund (£42m total).

iv) Impact: ensuring parity of support and esteem between research discovery, application and impact, including commercialisation where appropriate

Our mission is to deliver economic, social, cultural, health and wellbeing benefits for society and the environment. Our policies and infrastructure enable impact and engagement. Evidence includes our THE University Impact Ranking (see above), and the range and quality of our 160 impact case studies (ICS): over 30% report health impact, 23% economic and commercial, 24% policy, ~20% include public engagement or cultural impact, and 94% map to at least one SDG.

Impact is rewarded and celebrated. Impact is one of four criteria in academic probation and promotions (alongside research, teaching and academic service), and time is allocated to support impact alongside research activities. Events celebrating impact include our annual Distinguished Achievement Awards and Making a Difference Awards for social responsibility. Specialist professional teams support impact with target research users, including commercialisation (Figure 7), policy makers and influencers through Policy@Manchester, public engagement and the Masood Entrepreneurship Centre for PGR/ECR enterprise start-ups (Section 3).

Significant funding supports impact activity. An average £1.9m p.a. is invested through UKRI Impact Acceleration Accounts (IAA) from BBSRC, ESRC, EPSRC and STFC; MRC Proximity to Discovery and Confidence in Concept funds, and Wellcome Trust's Translational Partnership Award. These schemes lever additional direct and in-kind investment from industry and other partners; for example the EPSRC IAA (£6.4m) and ESRC IAA (£2.8m) over the REF period. Five UKRPIF awards, with significant industry co-investment, enhanced our impact infrastructure.

We shape and deliver **global, national and regional research priorities.**

Industry research collaborations generate significant **economic contribution.** HESA ranks us 4th in the UK for SME engagement and top two over the last two years for the value of industry collaborative research. We rank 5th in the UK for publications with industry, 24th out of 1,000 universities globally in the CWTS Leiden Ranking and 2nd for Innovate UK Knowledge Transfer Partnerships (KTPs) - 38 live. Our KTP portfolio increased by >50% (number and value) securing ~ £10.4m government funding and nearly £9m industry contribution (2013-2020). In 2018/19 two-thirds of the new KTPs were with SMEs and 40% were GM-based. Significant growth in our strategic industrial research partnerships include Unilever, Boots and four EPSRC Prosperity Partnership awards with AstraZeneca, BP and other global partners. Major industry partners in our doctoral training centres include the BBC, EDF, Rolls-Royce and GlaxoSmithKline. Over 1,500 GM-based SMEs access our advanced research facilities through ERDF and other programmes, attracting international inward investment from high-tech firms.

Research **commercialisation** generated £402m economic impact over five years to July 31st 2020. The 2020 relaunch of our IP commercialisation subsidiary has already doubled the number of annual spin-outs, reinforcing our presence in the top six for invention disclosures from 2014 to 2019 (>1000 in period 2015-20). The National Graphene Institute and Graphene Engineering and Innovation Centre are establishing Manchester as the major global hub for graphene and 2D materials research and commercialisation. We sit at the heart of Manchester's vibrant Oxford Road Innovation District and are developing the former UMIST campus into a city-centre world-class Innovation District (£1.5bn).

Our **health research** delivers benefits through our partnership with the NHS Trusts in Health Innovation Manchester and the Manchester Academic Health Science Centre within the context of a devolved health and social care budget (£6bn p.a.), including our Biomedical Research Centre (£28.5m) and NIHR Applied Research Collaboration (£8.5m). Our Wellcome Trust funded Translation Manchester (£3.6m) facilitates smooth translation pathways. The benefits of this infrastructure are detailed in our Panel A submissions. Our university-wide COVID-19 Rapid Research Response group coordinated a multidisciplinary contribution to address the crisis, including £4.2m UKRI research awards and over 8,000 patients recruited to 73 GM clinical studies.

Regionally, our research informs GM strategy and policy. Our President co-led the GM Local Industrial Strategy (LIS), informed by the GM and Cheshire East Science and Innovation Audit that we also co-led. Our GM Inclusive Growth Analysis Unit, co-funded with the Joseph Rowntree Foundation (£400k), developed evidence-based policies for economic growth and poverty

reduction. Manchester Institute for Collaborative Research on Ageing supported the design of GM's Ageing Strategy, enabling GM to become the UK's first city and region to achieve World Health Organization age-friendly status. We are core participants in GM's devolved health and social care partnership. Digital Futures researchers support GM's ambitions to be a top five European digital city region; including collaboration with GCHQ's new base in Manchester. Our climate and environment research informs GM's carbon-reduction strategy led by Tyndall Centre Manchester and Manchester Environmental Research Institute. Our contributions to GM's cultural sector and creative economy accelerated through the launch of Creative Manchester, supported by University endowment investment.

Our **public engagement** excellence is accredited with a National Co-ordinating Centre for Public Engagement Gold Engage Watermark. A public engagement academic lead and professional team coordinate activity, including through our public-facing Jodrell Bank Discovery Centre, John Rylands Library, Manchester Museum and Whitworth Art Gallery. Research-led public engagement is supported through training, mentoring and funding, and is recognised, rewarded and celebrated. We work with community partners through citizen science projects, patient and public involvement and engagement in health and medical research, and other forms of participatory research. Public events promoting understanding of research attracted >2m attendance (2014-19, HE-BCI).

v) Research integrity, including Open Research

We foster the highest standards of research integrity with senior leadership (Vice-President) oversight of research governance, ethics and integrity (RGEI), supported by an Academic Director, a University Research Ethics committee and a RGEI office. Our Code of Good Research Conduct includes a robust and independent process for investigating alleged misconduct and aligns with the *UUK Concordat to Support Research Integrity*. Regular research conduct, integrity, data protection and export compliance training is mandatory for all staff undertaking research. PGRs complete subject-specific training in research conduct and integrity, the same mandatory training as staff, and can access advanced research conduct training opportunities.

Our RGEI includes commitment to research reproducibility (Section 4) and creating an **Open Research environment.** We were an early signatory of DORA and endorse the Leiden Manifesto and responsible metrics principles through our Statement on Research Publication Metrics. Hence, we assess output quality through peer review, not journal metrics. Our Open Research Strategy is led by our National Research Library, working with a forum that mobilises our academic community.

ORCID registration is mandatory. The REF Open Access (OA) requirements are met by 97% of submitted and ~90% of in-scope outputs. OA is supported by our publications repository (PURE), data repository and a Library OA service, delivered by dedicated professional teams. Our institutional OA budget (£300,000 pa) supplements external funding for article processing charges (APC), OA monographs and ECR attendance at OpenCon. The Library and Manchester University Press are trialling OA innovations and preparing implementation of Plan S principles. This includes an OA journal that does not operate the APC model to help drive the development of the UK-SCL model policy; publisher negotiations for compliant transformative agreements, and additional support for OA monographs.

A refreshed 5-year strategy, launched in 2020, following University-wide consultation, focuses on:

i) research leadership, creativity and team collaboration at all career stages;
ii) interdisciplinary themes of digital, creative and environment;
iii) civic and international partnerships;
iv) producing benefits on a regional, national and global scale;
v) research-led innovation, enterprise and commercialisation;
vi) research culture and environment with exemplary research integrity, open research, and equality diversity and inclusion.

3. People

3.1 Staff strategy and support

People are at the centre of the University's strategic plan (Section 1). Our policies, infrastructure and transparent expectations help staff reach their potential and our collective ambitions. Our academic and research staff profile is diverse (42% women, 21% BAME, 3.8% declared disability, 7.8% LBGT) and 36% EU/overseas. In our latest Staff Survey (2019, 69% response rate) >80% of academics and research staff said the University is a good place to work.

The University's *Statement of Research Expectations* summarises academic expectations for producing outputs, funding and impact; professional conduct, including research integrity and collegial service; and our institutional responsibility to provide a vital, inclusive and well-resourced environment. The Statement informs recruitment, performance development reviews and progression decisions against transparent criteria in four domains: research, teaching, knowledge transfer and external engagement, and service to the University and the academic profession.

Employment policies exceed minimum statutory requirements for flexible, remote and part-time working arrangements, career breaks, family-related leave, and childcare support that includes two award-winning nurseries on campus. Comprehensive wellbeing services and activities for all staff and students are provided through an annual investment of >£250k in sports facilities, online mental health support and in-house counselling, occupational health and disability support services.

A similar proportion of research staff and REF eligible academics are employed part-time (13%). Most research staff (92%) and a minority of REF eligible academics (8%) have externally funded fixed-term contracts. Their career stability and progression is supported by transfer to open-ended contracts after four years continuous service and extensive development opportunities from the outset (Section 3.4).

3.2 Equality, diversity and inclusion

The University's EDI commitment and action plan progress is recognised through accreditations (Figure 4).

Figure 4 – University of Manchester EDI accreditations

Our *Dignity at Work* policy for staff and students implements zero tolerance of discrimination, harassment or bullying, supported by our specialist team and reporting channels.

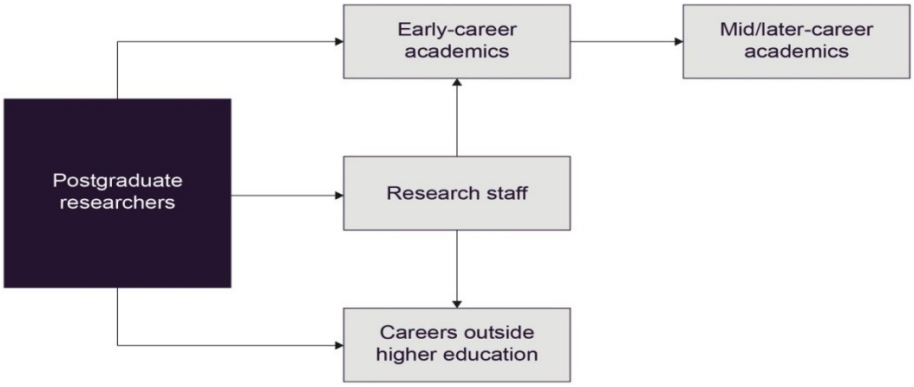
Equality targets are embedded alongside the other key performance indicators (KPIs) in UoM's strategic plan, mobilising improvements in the gender and BAME profile of our staff (Figure 5).

Figure 5 - University of Manchester's EDI KPIs and processes

3.3 Research career development

Extensive professional and career development opportunities are provided for all career stages and pathways (Figure 6).

Figure 6 – Career development pathways



3.3.1 Academic career development

Early Career Academics (ECAs) and research staff (ECRs) complete the New Academics and Researchers' Programme (AdvanceHE accredited) as part of their probation. A third of this training programme focuses on research, innovation and impact, and PGR supervision. A tailored programme for research fellows, with a focus on research leadership, developed and piloted with ~90 Presidential Fellows in 2018-20, is being rolled out to all research fellows.

ECAs are supported through probation (normally three years) with transparent expectations set at the outset (in line with the University's Statement of Research Expectations see 3.1), completion of the above training programme, resources available through their Research Development team and an academic mentor.

All academics and research staff are offered annual professional development reviews (PDR), >80% take-up each year. Career development is discussed as part of the PDR, including in-house training opportunities in research, innovation and leadership. Each year in total our academic and research staff complete >2,000 online courses and >1,000 places on workshops and leadership training programmes offered by our Staff Learning and Development Team and our Institute of Teaching and Learning.

Peer mentoring is embedded. Peer review is mandatory for most external research funding applications, with mock interviews for applicants called to interview. Faculties run regular grant-writing workshops and arrange peer-review feedback for outputs in preparation and once published (further detail is in the UoA environment statements).

All academics can apply for academic leave to initiate or complete an ambitious programme of research or impact activities (one semester/year after six semesters/years or pro rata part-time leave). The majority of proposals are approved (>75 %), reaching 90-100% in some UoAs.

3.3.2 Early Career Research Staff

We have held the EC HR Excellence in Research Award since 2011 recognising our full adoption of the principles of the *Concordat to Support the Career Development of Researchers*. Our Concordat action plans for biennial reviews have transformed the research environment for our circa 2,000 research staff. Achievements include improved engagement through research staff forums; creation of a specific promotions track for researchers and automatic transition on to an open-ended contract after four years' continuous service; visibility and recognition through a research excellence award scheme, an annual in-house conference; and research collaboration funding for research staff. Enhanced support for Principal Investigators in their role as line managers has been developed alongside innovative training programmes. Tailored support for research staff wellbeing has been implemented to supplement the University's wellbeing services, complementing ongoing Concordat-related initiatives.

The professional training and development programmes offered to PGRs and research staff map onto the VITAE Researcher Development Framework. These build upon our New Academics and Researchers Programme with additional courses supporting publishing, grant writing, knowledge transfer and impact (including pathways into industry, entrepreneurship and research commercialisation), and research leadership to forge independent careers. Training is complemented by mentoring and coaching programmes, and an organised peer support network.

The University *Statement of Expectations on the Career Development of Researchers* explains the responsibilities of the institution, the academic line-manager, and researchers themselves. It recommends ten days p.a. for professional development. Progress to embed this recommendation is being made: 60% of research staff undertake at least one formal development and training opportunity each year; one-third are mentored or coached; and one-third have at least seven days of professional development.

ECRs are exposed to a range of career options and networks. Over the REF period >150 PDRAs had placements or secondments through our KTPs, IAAs and related schemes. Outgoing fellowships and industrial placements are funded by the BBSRC Flexible Talent Mobility Accounts and other schemes. Over half of our research staff engaged with non-academic partners as part

of their research and impact activities. We collaborate in the Prosper initiative to enhance postdoctoral career success in industry (£4.4m, Research England Development Fund).

This comprehensive infrastructure has enhanced researcher' calibre and career progression; including a 10% increase in promotion rates for research staff, reaching an average 147 promotions p.a., and a rapid increase in the numbers completing the AdvanceHE-accredited Leadership in Education Awards Programme (LEAP) for teaching excellence and internal leadership programmes (~350 research staff since 2018). Investment for research staff fellowship applications, including institutional match funding, expanded the number of our externally funded research fellows across the REF period to 355 employed in 2020. Increased investment in internally funded fellows nearly doubled with the Presidential Fellows recruitment of future leaders (£5.1m of total £10.4m), which increased the international profile of our fellows through appointments made from 24 countries.

3.3.3 Postgraduate research students

UoM Doctoral College delivers a training and funding environment that prepares ~4,000 PGRs to further their careers. Substantial competitive funding (>£116m) from UKRI and major charities (Wellcome Trust, BHF) support Centres for Doctoral Training (CDT or DTC) and Doctoral Training Partnerships (DTPs). We currently lead 12 CDT/DTPs and partner in 11 others; 20% of our PGRs are registered with a CDT/DTP programme. We invest in UoM studentships (approximately £6.7m p.a.). Our President's Doctoral Scholar Awards enhance support for the most outstanding PGRs with >100 studentships each year (£2.5m over four years) and a bespoke training programme focusing on research leadership and impact.

Academic supervision is supported through a PGR supervisor toolkit, new supervisor training and an online system (eProg) that monitors progression against milestones, including year-end reviews. We support supervisors' applications for UKCGE-accreditation and 7% of UKCGE-accredited supervisors are from UoM. In the PGR Experience Survey 92% of our PGRs report that their supervisor has the skills and subject knowledge to support their research.

PGRs complete an annual skills and development needs audit in discussion with their supervisory team, from which a tailored training programme is devised. The extensive training menu is designed by the Doctoral College and maps onto the VITAE Research Development Framework, as for research staff (3.3.2 above).

We prepare PGRs for a range of careers. PGRs are offered placements and internships in industrial, government, clinical and cultural organisations. They explore career plans and options at the annual Pathways event, hosted by the Careers Service. Our Masood Enterprise Centre (MEC) trains PGRs in commercialisation and entrepreneurship; over 750 PGRs took this training or participated in entrepreneurial competitions such as Venture Further over the REF period. MEC partners with UCL to evidence how knowledge exchange activities can benefit PGR career development. Over 300 gained LEAP programme accreditation for teaching excellence (3.3.2 above).

The publications record of our PGRs illustrates their excellence: 22% of our REF-submitted articles include a PGR author and 48% published during the REF period, including a rapid increase in the thesis by publication format to 32% of all doctorates awarded in 2020. PGRs achievements are celebrated through the PGR Excellence Awards. Nearly half progress into university employment (~35%) or research positions in other sectors (~13%).

3.4 EDI in our REF Submission Institutional Code of Practice

EDI principles were applied throughout the preparation of our REF submission, including EDI and unconscious bias training for all staff involved in decision-making. Equality impact assessments (EIA) embedded EDI principles to inform and improve decision-making. The EIA results show no major discrepancies and EDI progress since REF2014, although some gender and ethnicity differences remain. Women accounted for one-third of our REF output and ICS authors, but a slightly lower average number of outputs (2 vs 2.3 for men). BAME staff submitted a similar average number of outputs to White staff, but were under-represented among ICS authors (BAME staff comprised 15% of our REF submission and 7% of our ICS authors).

4. Income, infrastructure and facilities

4.1 Support for acquiring research funding

Our University *Statement of Research Expectations* commits to providing services and infrastructure to enable researchers to secure external research funding. This commitment has helped deliver growth in our research income and market share over the REF period, accompanied by significant UKRI income in-kind; with our interdisciplinary research institutes and other collaborative vehicles driving much of this success (Section 2.ii-iii).

Figure 7 - Research and Business Engagement Services

Comprehensive Research and Business Engagement professional services work with researchers from project inception to completion, with specialist teams to support grant writing and project management for major collaborative bids, impact-generating activities, development and management of industry collaboration and strategic partnerships, and commercialisation (Figure 7). Faculty arranged peer review of applications (Section 3.3.1) are supplemented for large strategic calls with a University-wide peer-review process under senior oversight (Vice-President Research), to ensure quality and priorities are met. This support through professional service and academic peer review has produced above sector average success rates; for example our UKRI success rate was 38% by volume and 35% by revenue compared to the sector average 28% and 27% (2015-2020).

Through EDI monitoring we identify where specific groups (ECRs, women, BAME staff or staff with disabilities) are under-represented in applications and awards. These data inform workshops to support applications, our internal peer review arrangements and feedback, and decisions when assembling large research teams for major funding calls. Our EDI commitment is threaded through post-award support, including access to OA and impact resources (Section 2 iv-v) and research facilities (Section 4.2 below).

4.2 Research infrastructure and facilities

Our investment in research infrastructure and facilities (~£584m) is part of one of the biggest investments in facilities undertaken in any UK university. Investment decisions are driven by the University's strategic plan and shaped by national and regional priorities and opportunities for collaboration (Section 2 iv). Over the REF period £389m was secured from external sources for capital investment, including £28m ERDF funding and £80m in five UKRPIF awards.

Our strategy delivers state-of-the-art, fit-for-purpose equipment underpinned with well-qualified, well-resourced technical support. Many parts of this infrastructure are used by academics and industry partners from across the world.

The University of Manchester Library is the only National Research Library in the north of England. With >10m items, it is the largest non-legal deposit library in the UK, holding the most extensive digital collections of any UK academic library. Ranked second in the UK and globally within the top five for its university special collections; in a number of fields it is world leading. The collections are accessible with curation-enhanced digital imaging facilities.

Our **research IT infrastructure** includes:

- **High Performance and High Throughput Computing (HPC/HTC)** including 'free-at-point-of-use' access for smaller-scale users. Over £6m was invested in these platforms over the REF period. Collaboration in the N8 Centre of Excellence in Computationally Intensive Research (CIR) provides an EPSRC Tier-2 Graphics Processing Unit-based HPC platform.
- **Research Software Engineer** team (25 FTE) provide a fully cost-recovered service, ensuring service continuity and institutional memory between projects.
- **Research applications support and training** covers programming, software engineering and research IT facilities.
- **Research data storage** (8TB) per researcher, with higher requirements costed into grants.
- **Digital innovation** though significant IT investment (£5m in REF period; £15m total) to extend the digitisation, curation and access to the University's cultural assets and to support Open Research.

Our Faculty of Science and Engineering (FSE, Panel B) has a substantial portfolio of large equipment infrastructure, the majority of which is shared internally by research groups and externally with other academic and industry partners. UoM's **Jodrell Bank Observatory (JBO)** operates the UK's **e-MERLIN** telescope array, involved in global observation networks, funded by the STFC and EC. **JBO** hosts the international **Square Kilometre Array (SKA) headquarters** (since 2017), one of three global SKA sites and governed by an intergovernmental treaty. SKA HQ was financed by UK public monies (£10.8m) and UoM investment (£5.7m), with our astronomers leading technical development projects.

UoM hosts the **Henry Royce Institute**, the UK's national facility for advanced materials; accessible to external HEIs and industry. EPSRC invested £150m in capital build and cutting-edge equipment between 2015 and 2020. The 2D materials core theme of the Royce is underpinned by equipment offered through the University's **National Graphene Institute** and the **Graphene Engineering Innovation Centre**. Other examples are the world-leading £11m **Henry Moseley X-ray Imaging Facility** and the **National Grid Power Systems Research Centre** (largest UK university high-voltage laboratory).

We operate a number of **EPSRC National Research Facilities (NRFs)**, including in electron paramagnetic resonance. Our ~£5m suite of facilities for X-ray photoelectron spectroscopy (XPS) provides a spoke of the EPSRC NRF and took delivery of a 'world first' spectrometer for hard XPS in 2018. In 2020, we were chosen to host the hub of the new £10m NRF for laboratory X-ray computed tomography. Our **Michael Barber Centre for Collaborative Mass Spectrometry** supports >30 University and 18 external research groups and companies. UoM is a founding, Tier-1, academic partner of EPSRC-supported **UK Community for Analytical Measurement**. The **Dalton Nuclear Institute's Cumbrian Facility**, part of the National Nuclear User Facility, provides the most advanced nuclear research capability in the UK for academic and industry collaboration.

It includes the Industrial Strategy Challenge funded **RAIN (Robotics in AI and Nuclear)** specialist facilities supporting collaboration with Sellafield Nuclear Site. UoM is the hub for the **International Centre for Advanced Materials (**£732m BP, £6.6m UoM), providing BP with access to extensive research infrastructure and University expertise. UoM hosted the **EPSRC Supergen Bioenergy Hub** and hosts and co-directs three of the **EPSRC Supergen Hubs** (2018–22: Bioenergy, Energy Systems, Offshore Renewable Energy). **Tyndall Manchester** is one of four core partners in the UK Tyndall Centre for Climate Change. FSE researchers play major roles in developing and using the **ATLAS detector at CERN**, lead the UK catalysis hub at the EPSRC-funded **National Laboratories at Harwell Science and Innovation Campus**, and are major users of other Harwell facilities, in particular Diamond Light Source.

Our Faculty of Biology, Medicine and Health (BMH, Panel A) offers extensive platform technologies, most operated with, or available to, NHS and academic partners, including **Core Laboratory Facilities** (**Bioimaging** including super resolution microscopes; **Biological Mass Spectrometry**; **Biomolecular analysis**; **Electron Microscopy**; **Flow Cytometry** including single cell systems; **Genomic Technologies** with integrated bioinformatics support; **Histology**; **Proteomics**). Over £28m has been invested in the equipment base (plus >£14m from UoM), staffing has increased from 33 staff in 2014 to 49 in 2020, and turnover has increased from <£2m in 2014 to ~£3.5m in 2020. An extensive **Biological Services Facility** provides a wide range of model organisms and with strategic investment from Wellcome now incorporates **Genome Editing.** The Facility is one of the largest in Europe, with 9000sqm of usable space, turnover of £2.5m, 42 FTE staff (38 in 2014), £1.4m investment since 2014, including the construction of a germ-free facility. **Core Imaging Facilities** (preclinical and clinical PET, MR and PET-MR imaging), **Manchester Clinical Research Facility, NIHR Biomedical Research Centre** (£28.5m, the largest outside the southeast of England) and **Manchester Clinical Trials Unit** are run jointly with our partner NHS trusts. The Faculty hosts the **Wellcome Centre for Cell-Matrix Research** (£6.6m) and the **Stoller Biomarker Discovery Centre** (MRC and philanthropy £13m)**,** the largest single-site discovery proteomics centre in Europe. The **Proton Beam Therapy and Research Centre** (£6m) is jointly run with The Christie hospital, and the University houses the **CRUK Major Cancer Centre** (£35m) and **CRUK Radiotherapy Centre of Excellence** (£16.5m). The **Oglesby Cancer Research Building** houses 150 Manchester Cancer Research Centre scientists and 100 support staff in state-of-the-art laboratories (£38m from CRUK and UoM). UoM co-owns the Manchester Science Partnerships which houses >150 research-based businesses and fosters collaborations between SMEs and larger companies, and our co-investment in **Citylabs 1.0** (£25m) brings together and accelerates collaboration between UoM researchers, NHS and industry.

Our Faculty of Humanities (Panels C, D) researchers benefit from a distinctive infrastructure. In addition to discipline-focused and dedicated research laboratories, workshops, and performance spaces, the research environment includes an ESRC-funded secure data access facility (safepod), the collections of **John Rylands Library**, **Whitworth Art Gallery (WAG)** and **Manchester Museum (MM),** and the new **data visualisation and behavioural science/economics laboratories** housed in the Alliance Manchester Business School which were part-funded with RPIF investment (£9.7m). The **WAG** and **MM** are major assets for our interdisciplinary **Creative Manchester** initiative as sites of research collaboration and public engagement. The **WAG** collections of over 60,000 artworks are in a building transformed by an award-winning £15m investment in 2015 which included improved research and engagement facilities and new exhibition spaces. The **MM** collections span more than million objects, from Darwin to Turing, with research collaborations and public engagement further enabled by the £13m investment (2019–22) to create expanded exhibition space and new South Asia and Chinese Culture galleries.

Our TRAC demonstrates £239m research equipment spend from 2013 to 2020. Faculty leadership teams identify and enable the most effective and efficient ways of delivering a sustainable world class equipment and computing infrastructure with University-level oversight and coordination. The substantial STEM infrastructure and procurement is managed by dedicated Faculty-level facilities groups in BMH and FSE to ensure sustainable operation, collaborative and shared use,

competitive access to support the highest-quality science, and significant external use by HEIs and industry alike, contributing to delivering impact through partnerships.

Measures exist to ensure that the equipment can be accessed by all. For example, Schools support ECR access (including PGRs) while they establish a grant portfolio to fund access charges. This approach also incentivises the ECR cohort to develop collaborations with established researchers.

4.3 Supporting the reproducibility of research

UoM is a member of the UK Reproducibility Network (UKRN). Our UKRN academic lead and Open Research forum catalyse development of open research practices across the University. Awareness and capability is built through events, training, mutual learning through innovation exemplars, and advice through the Library-run online forum. Our research IT strategy includes investment in a work programme to engage researchers in trialling and recommending tools to support open research practices, including data management (Section 4.2 above).