Institution: University of Oxford
Unit of Assessment: 1 – Clinical Medicine

1 Unit context and structure, research and impact strategy

Our mission is **to apply an interdisciplinary scientific approach to medicine for global benefit**. We strive always to do this **in an inclusive, open and ethical way** that will sustain future research.

Our UOA is distinguished by its scientific **breadth, depth and scale**, providing the **critical mass** to deliver research that has global impact. Our research spans the full spectrum of biomedical science **from basic discovery to translation and implementation**. This REF period has seen **major expansion** of our research base, reflecting the energy and vitality of our UOA.

Key developments for this REF period

- Research income increased to £245M in 2019/20, averaging 3.6% annual growth.
- 547 independent researchers (500 FTE) for submission, compared with 251 researchers (238.5 FTE) submitted in REF 2014.
- Expansions of our overseas research centres, now with more than 2,500 affiliated staff supported by grant income exceeding £50M/yr.
- £185M capital expenditure including 4 new institutes in 33,300m^2 of new research space, and 1,900m^2 expanded or refurbished.
- Acquisition of an additional 10 acres of new land, strategically located on the hospital campus, to further extend our biomedical campus.

Highlighted achievements in this REF period

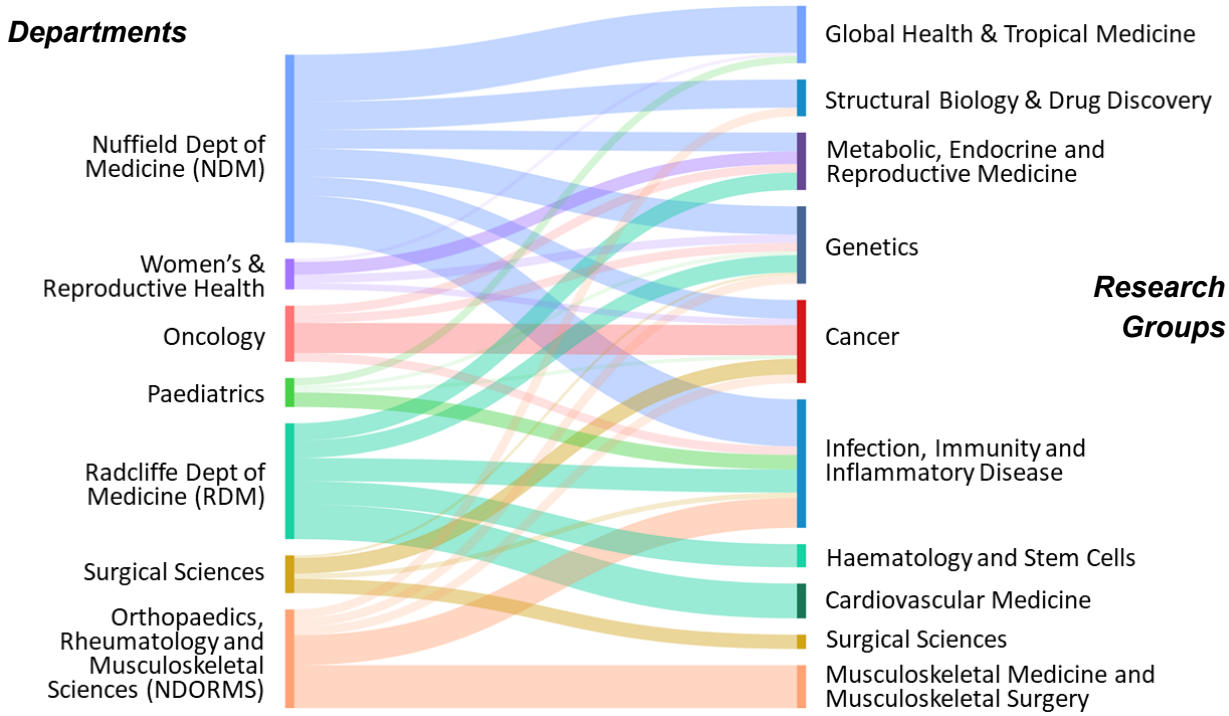
- Global leadership and contributions to the COVID-19 response including development of an effective COVID-19 vaccine; RECOVERY trial identifying effective therapy; testing and tracing programmes.
- Nobel Prize for Medicine (Ratcliffe, 2019) for his discovery of how cells sense and respond to oxygen availability.
- Advances by Africa and Asia Programmes in addressing major global healthcare challenges such as elimination of malaria in parts of SE Asia.
- NIHR BRC renewal (£114M, 2017), representing the largest funding uplift in the UK.
- Designation of Oxford's AHSC, Oxford Academic Health Partners (2020).
- Silver Athena SWAN Awards for all departments.
- Ten new Fellows of the Royal Society.
- Increased representation of women in senior leadership posts.
- 19 new spinout companies, 9 supported from a capital fund of >£600M managed by Oxford Sciences Innovation.

1.1 Unit structure

We have developed an organisational structure that provides critical mass across the breadth of clinical medicine, combined with the flexibility and finances to address needs and opportunities with force and velocity. Our **porous, interdisciplinary structure** makes us resilient and nimble, so that we can respond rapidly to new findings, new technologies and health challenges, and maximises our potential for delivering impact.

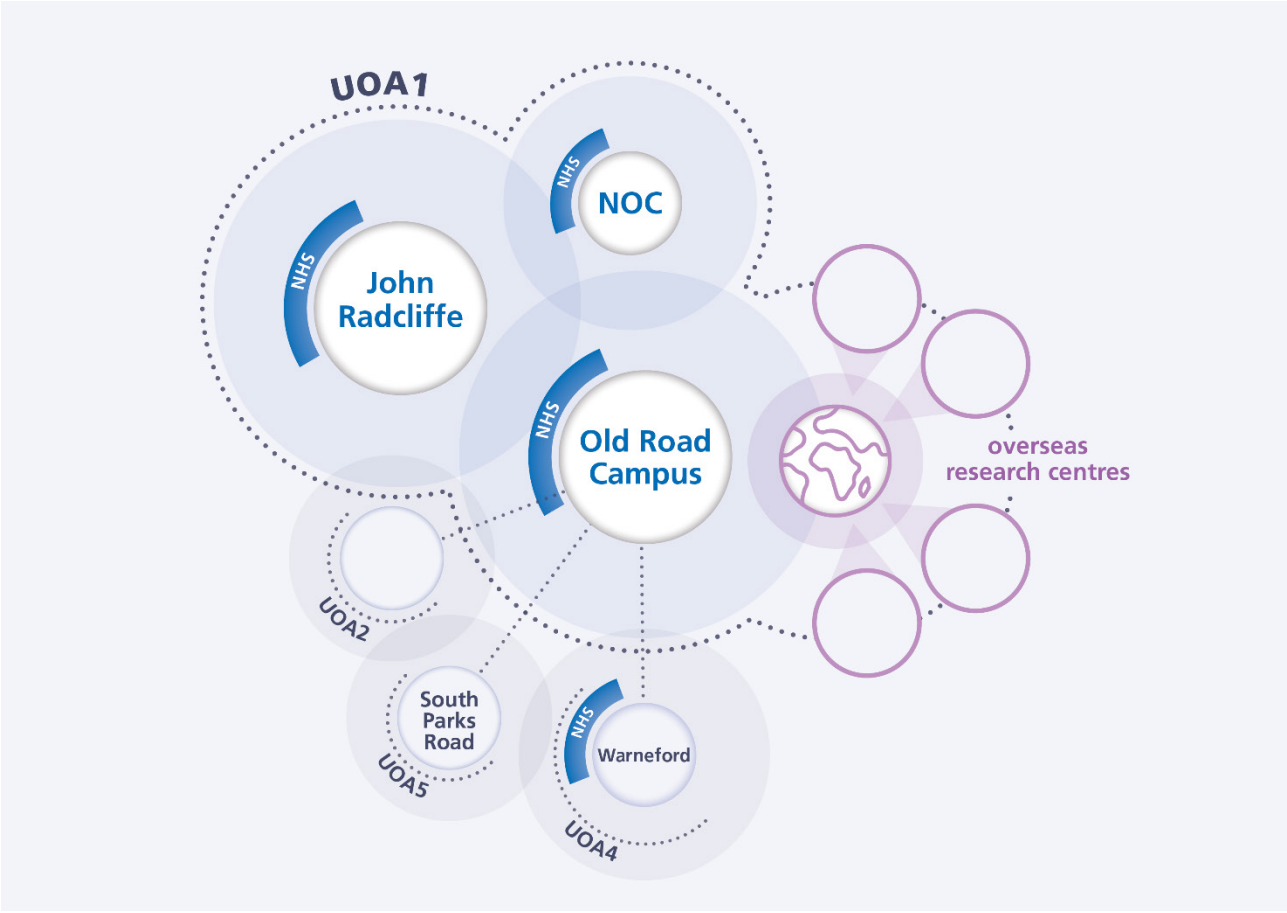
UOA1 researchers are primarily hosted within seven departments, to which the university **devolves financial and administrative management**. This allows us to deliver rapid and flexible support for individuals, research groups, strategic initiatives, innovation, collaboration and urgent societal healthcare need. Our departmental structure is porous by design: much of our research transcends departments so we encourage and support our researchers to share expertise and facilities. We create and support **interdisciplinary institutes,** building on the paradigm of the Weatherall Institute of Molecular Medicine (WIMM), which assembled a critical mass of clinical and non-clinical researchers on a hospital campus to work together using state-of-the-art approaches. This institute-based approach drives the evolution of biomedical science to bridge traditional specialty-specific structures. While individual institutes are embedded within departments, we populate them with researchers from multiple departments to create **extensive research networks** across research themes. **Research Groups** are configured around key areas of **clinically-driven research and cross-cutting technology**, which often span institutes and departments (Figure 1) and are described in more detail in Section 1.3.

Figure 1: Relationships between principal departments in UOA1 (left) and the ten Research Groups (right) whose requirements shape the implementation of our research strategy. The weight of each ribbon indicates the approximate split of FTE involved.



Accordingly, we have **developed our estate to be scientifically-themed**, rather than based on organ-specific or department-specific interests. This allows us to develop and focus critical mass and to bring people with different expertise and perspectives together outside conventional silos. In Oxford, UOA1 is physically clustered on three **closely-integrated, hospital-University campuses**, where co-location of facilities and expertise facilitates clinical translation and accelerates impact (Figure 2). By creating a shared integrated research organisation with our co-located hospital trust, this organisational structure supports our partnership with the NHS, exemplified by our shared NIHR BRC. Our overseas research centres are similarly integrated with local clinical and higher education institutes.

Figure 2: Relationships between UOA1 co-located University and NHS hospital campuses, other Main Panel A UOAs, and UOA1 overseas research centres.
NOC = Nuffield Orthopaedic Centre.



The majority of REF Panel A research is under the **leadership of a single Medical Sciences Division (MSD)**, which links the primarily pre-clinical (UOA5) and clinical (UOA1, 2 and 4) departments, and facilitates high-level strategic interactions across the University and beyond. This structure also supports **university-wide research themes**, which provide a wide interdisciplinary lens for major themes that span institutes, departments and divisions. The result is an organisational structure that is **energising to work in, dynamic and porous**. This allows us to **respond flexibly and rapidly to new challenges** and the benefit of this is richly evident in the scale, speed and quality of our unparalleled and impact-laden response to the COVID-19 pandemic (ICS-30RECOV-1, 31COVIDVAC, 32COVIDAPP, 33COVIDTEST). Together, these structures and themes provide enormous scientific **scale** from basic science discovery through to translational and clinical research, **scope** from individuals to populations, and global **reach**.

1.2 Research and Impact Strategy

Our research environment is underpinned by **seven Strategic Aims**, described in detail in Sections 1.2.1 – 1.2.7. These reflect the elements we identify as essential to deliver the most significant research outcomes and facilitate their greatest impact and have been refreshed since REF2014. Our Strategic Aims for research and impact are:

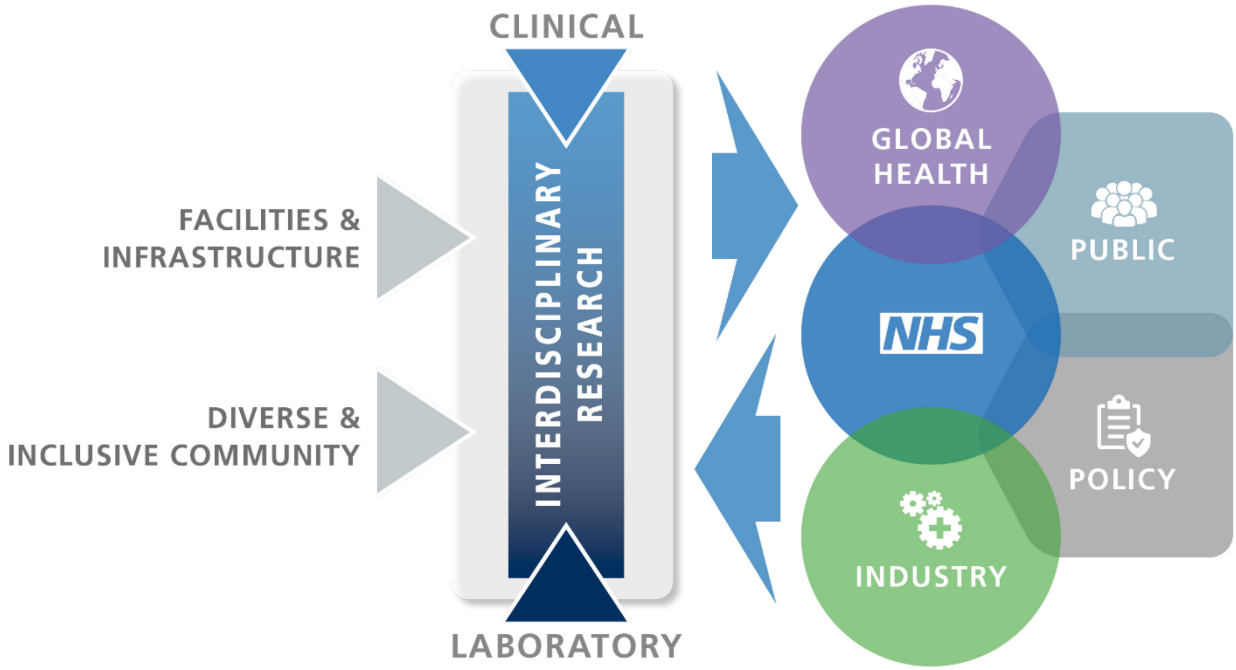
1. Invest in world-class **facilities and infrastructure**
2. Develop an **inclusive, equal and diverse** research community
3. Promote and strengthen **interdisciplinary research** across the breadth of medicine
4. Advance partnerships between the **University and NHS**

5. Partnership with **industry** for translation and impact
6. Respond to **new and global health challenges**
7. **Disseminate knowledge** widely and effectively, and maintain public confidence in research

Figure 3 summarises how the Strategic Aims contribute to achieving scale, scope and reach.

The detailed implementation of the Strategic Aims varies between the Research Groups, but the same principles apply to all. Achievements and plans in the context of these aims are set out for each Research Group in Section 1.3.

Figure 3: Relationships between the elements of research strategy to enable a spectrum of research and resulting areas of impact.



Our strategy is built on the foundation of the University's Strategic Plan, set out in the Institutional-Level Environment Statement (IES). Cross-references below to specific sections of the IES give wider context to local provision and practices.

1.2.1 Aim 1. Invest in world-class facilities and infrastructure

The University's Strategic Plan for 2018 - 2023 prioritises our commitment to *"invest substantially in the research environment, both human and physical"*. In this REF period, we have made major progress to remove the primary bottleneck on our clinical medicine endeavour - the availability of research space.

We **built major new interdisciplinary institutes** (Section 3.2), including the Li Ka Shing Centre for Health Information and Discovery containing the Big Data Institute (BDI) (£46M, 7,400m^2, 2015; a REF2014 aim), the Innovation Building (£60M, 18,000m^2, 2019) containing our BioEscalator (a REF2014 aim) start-up incubator, the Kennedy Institute extension (£3M, 750m^2, 2020), the Institute for Developmental and Regenerative Medicine (£31M, 5,900m^2, opening 2021), the Marcella Wing of the Botnar 3 (£10M, 2,000m^2, opening 2021). Not only do these buildings themselves represent high quality space for new research, but serve to decompress our existing space. They are **co-located with our existing institutes and hospitals** and promote interdisciplinary working. Outline planning permission is in place for further plots on our Old Road Campus, where we plan to build the Institute for Global Health (2024).

In 2019, we **purchased 10 acres of land** from Oxford University Hospitals NHS Foundation Trust (OUH). This is adjacent to our existing Old Road Campus and will be transformative for long term expansion. Future plans for this land include BioEscalator II and new institutes. The University has raised £750M from issuing a bond [IES 2.1], which is enabling these major new land purchases and buildings.

We continue to invest in new **state-of-the-art facilities and equipment** (Section 3.3) including massive computational power, advanced long read sequencing technology, single cell technology, structural biology facilities including cryoelectron microscopy and high level containment facilities, biomanufacturing, MR imaging, advanced microscopy and facilities for microbiome studies including gnotobiotic housing.

1.2.2 Aim 2. Develop an inclusive, equal and diverse research community

The University's strategic aims 2018-2023 for research include to *"invest substantially in the research environment, both human and physical*." The success and sustainability of our research is underpinned by our commitment to inspire, recruit, train and mentor the very best staff and students who will undertake that research (Section 2). Intrinsic to this is the promotion of equality, diversity and inclusivity in everything we do, demonstrated by **Athena SWAN Silver Awards awarded to all our departments** during this REF period. We value and support our vibrant cohort of ECRs (22% of our submitted researchers for REF2021).

Appointment of women to leadership positions. This includes the Head of our NIHR BRC (McShane), Head of Department (NDWRH, Zondervan), Head of the Kennedy Institute of Rheumatology (Powrie), Head of the Diabetes Trial Unit (Adler), Head of Structural Biology and Deputy Head of Department (NDM, Y.Jones), and Deputy Head of Department (NDRWH, Granne). We now have approximately double the number of women in non-clinical senior posts (39% of senior research or professorial posts are women) compared to 2014.

Improved diversity in academic staff. During REF2021, 29 women in our UOA have received full professorial title in our Recognition of Distinction exercise and the success rate was 57% for both men and women.

Actions and initiatives to improve inclusivity, diversity and equality. With advice and input from the University and Division, our Departments and institutes have invested in and developed their own **focused programmes and initiatives** to fit with their contexts and needs. Actions during the REF period include developing personalised mentoring programmes and are described in more detail in section 2.2.

1.2.3 Aim 3. Disseminate knowledge widely and freely and maintain public confidence in research

Our University **Open Access** Publications Policy (2018) states that "*The value and utility of research outputs increases the more broadly they are available to be considered and used by others...A core component of this, as set out in the University Strategic Plan and the Digital Strategy is open access (OA) to research outputs*". All Oxford researchers are asked to deposit their journal articles and conference papers and other research outputs in the permanent open access Oxford University Research Archive (ORA) [IES 2.4]. In the REF period, UOA1 researchers have deposited over **16,000 outputs** in this repository, and the percentage of our outputs available with **open access rose from 60% in 2014 to 84% in 2019**.

We are committed to **open data** and our researchers deposit data in appropriate archives such as the protein data bank (PDB), US National Center for Biotechnology Information (NCBI) databases including the GenBank sequence database or ClinicalTrials.gov. Our commitment to this sharing approach is exemplified by our COVID-19 response – over only 3 weeks during the pandemic, a major effort completed an XChem crystallographic fragment screen on the SARS-Cov-2 main protease (von Delft, Walsh). To accelerate drug design the fragment hits were released to the public immediately before even a preprint.

We are committed to **ethical and responsible science** and have invested in professional support for extensive ethical review processes for research involving human participants or animals. The University's provision is described in the IES (section 2.7). We established a programme of research and training in **research integrity and conduct**, by the Centre for Statistics in Medicine (CSM) and the UK EQUATOR Network, (head office at the UK Centre with four others centres in France, Canada, Australia and China) a widely-cited and authoritative resource in journal and publisher instructions for authors. CSM and the EQUATOR Network play a central role in raising awareness and supporting adoption of good research reporting practices as well as conducting research into topics ranging from research conduct and transparency, peer review, and reporting guideline development. Our research students have access to approximately 350 courses, including **required courses** in research ethics, research integrity, avoiding plagiarism and other courses on good laboratory practice, statistics, presentation & communication skills to name a few.

These principles are particularly apparent through our commitment to **equitable global research** and principles of open access to tools and protocols and a robust ethical framework and expertise. Our research programmes in **Africa and Asia** have very long-standing collaborations with local physicians, scientists, and technicians at all levels of seniority. All of these teams are very deliberately **training the next generation of leaders in local biomedical research landscapes** to promote open, ethical and responsible research.

1.2.4 Aim 4. Promote and strengthen interdisciplinary research across the breadth of medicine

We recognise that within our University we have widespread excellence across many disciplines and this provides us with an especially rich environment for interdisciplinary research. Through our organisational structure we co-locate researchers with different expertise and promote networking. A distinguishing feature of our UOA is that we not only have a **critical mass in individual disciplines,** but **also in our interdisciplinary capacity**, rendering our research environment especially fertile. Our track record of novel discoveries and high-impact medical research demonstrates our ability to bring together interdisciplinary groups in our institutes and to cut across conventional scientific areas. Interdisciplinary research is fundamental to our strategy and approach and is evidenced in our organisational structure, our investments in buildings, facilities and people.

Using our flexible funding and organisational structure, we have **established three new university-wide interdisciplinary networks** in **Immunology** (2017)**, Metabolism** (2018)**,** and **Global Health** (2020), each supported by a research facilitator and pump-primed with funding from our internal John Fell Fund. We continued to support established themed networks of **Cancer** (including the CRUK Cancer Research Centre, renewed in 2017), and **Cardiovascular Science** (BHF Centre for Research Excellence, renewed in 2018). The **Oxford Martin School** [IES 2.6] supports interdisciplinary networks in infectious disease, pandemic genomics, antimicrobial resistance and electronic health records.

The **co-location of researchers with shared interests** is fundamental to our research and impact development strategy. The value of this is exemplified by our creation of the Big Data Institute, which brings together researchers from the departments of medicine, public health and statistics to address the study of human disease and healthcare at scales from molecules and genes to populations and

pandemics. The benefits of this were evident in our COVID-19 response and its impact through clinical trials, epidemiology and contact-tracing technology. We co-locate researchers using similar scientific approaches to develop scientific critical mass. The value of this is further exemplified by activity in the Wellcome Centre for Human Genetics, where we integrate genetics with a range of disciplines including diabetes, paediatrics, women's and reproductive health, metabolic and cardiovascular medicine. We actively boost interdisciplinary work with **interdisciplinary joint appointments,** including in the REF period with appointments between UOA1 and Engineering, and Statistics. **New fields of research** often emerge from interdisciplinary collaboration or crosscutting technologies and our research environment provides a strong platform to launch new ideas.

1.2.5 Aim 5. Advance partnerships between the University and NHS

Our research benefits greatly from a tightly woven and nurtured interaction between the University and the NHS including joint research administration, shared estate and clinical trial facilities on our shared hospital campuses and joint capital master planning (Section 4.1).

The Unit has **forged a close relationship with our NHS partner,** Oxford University Hospitals, NHS Foundation Trust (OUH) that greatly enhances translational research opportunities, accelerates clinical application (e.g. ICS-10TRANSFUSION, ICS-14ASTHMA, ICS-30RECOV-1) and fosters a rich collaborative environment between Unit researchers and NHS Clinicians. OUH is one of the UK's largest university teaching hospitals, with hospitals across several sites hosting some 2,000 active clinical studies and nationally-leading in patient recruitment to NIHR portfolio studies. Our co-location with the hospitals is key to fostering and influencing our relationship with the NHS and promotes cohesion and responsiveness at the interfaces between our mutual teaching, training, research and clinical activities (Sections 4.1 and 2.4.3).

Our relationship with the NHS is a critical factor in embedding the Unit's research on clinical campuses and developing joint activities, including through **Oxford's two NIHR Biomedical Research Centres**. The Unit is the major University partner in the OUH-hosted NIHR **Oxford Biomedical Research Centre** (NIHR BRC), a £23M per annum NIHR centre, renewed in 2017 with the award of the biggest uplift nationally in funding, to accelerate research translation into clinical practice (Director, McShane). In 2015, we agreed further integration with the award of NHS Foundation Trust status, a strong culture of collaboration and a **change of name for the Trust to Oxford University Hospitals NHS Foundation Trust**. Formal joint governance between the University and OUH includes a Strategic Partnership Board, linking OUH and the University to develop local healthcare. Our **researchers are integral to NHS management** including at Director and Trust Board level, as detailed in Section 4.1.

1.2.6 Aim 6. Partnership with industry for translation and impact

The University's strategic aims 2018 - 2023 for research include to *"engage with business, NGOs and others to grow the volume and value of non-public-sector-funded research on a sustainable basis"* and to *"continue to broaden and invest in our innovation activities and foster the entrepreneurial environment for staff and students."* This REF period has seen transformational change in our environment to support translation and commercial impact. We have made major investments, evolved our support and infrastructure, progressed how we reward and recognise researchers engaging in this activity, and driven new partnerships and models of partnership to maximise the impact of our research.

We **physically co-locate commercial and academic activity** through our BioEscalator, purpose-built to incubate early-stage start-up bioscience companies with high potential. Adjacent to our research institutes, the BioEscalator has already demonstrated significant effect in incubating companies to success and enriching the research environment through co-location (Section 3.4.2). The Novo Nordisk Oxford Research Centre is hosted in the same Innovation Building that houses the BioEscalator and is the largest on-campus co-located pharma facility in the UK.

We have driven a step change in **funding for translation and commercialisation** through a portfolio of internal University funds and Oxford-specific funds, Lab282 (for drug discovery) and Lab10X (for digital health). We have established **19 spin outs** with the focussed nurturing and support we provide through Oxford University Innovation.

We drive **ground-breaking innovative industrial partnerships,** for example the Structural Genomics Consortium, which has accelerated drug discovery through an open source model, sharing data, reagents, tools and expertise as widely and as early as possible. We **lead national-level industry collaborations,** exemplified by the National Consortium for Intelligent Medical Imaging (NCIMI), a partnership led by the University (Gleeson) with ten companies including GE Healthcare and Alliance Medical, which was supported by our UOA in a successful bid for £17.5m from the 'Data to Early Diagnosis and Precision Medicine challenge' from the Industrial Strategy Challenge Fund. NCIMI supports a network of academic researchers, NHS hospitals, clinical leaders, industry experts, charities and patients' groups to bring AI to clinical imaging analysis.

We **collaborate with industry for impact**. This can be to **support scale up**, for example for COVID-19 diagnostics (ThermoFisher) and vaccine development (AstraZeneca), which were established and executed rapidly to accelerate translation of expertise and academic research to address urgent societal need. Partnerships with industry and SMEs can be focused to **co-develop therapeutics,** throughout the drug discovery and development pipeline, or to **share knowledge and data** for example to tackle the major challenge of how to use the wealth of genetic, molecular and physiological data to understand both common and rare diseases, and how to accelerate the identification and development of drug targets.

1.2.7 Aim 7. Respond to new and global health challenges

The University of Oxford has the **largest concentration of global health research** in the UK and possibly the world, as well as the breadth and depth of knowledge to lead major initiatives (Box 1). Our global health research has its primary home in UOA1, but excellence spans beyond UOA1 and medicine into physical sciences, mathematics, statistics, social sciences and ethics. Our experience is that success lies in having **partnerships** and research already up and running, ready to pivot quickly to new challenges. Our achievements to date reflect the strength of our existing partnerships, our ability to pivot these partnerships to a new focus, and to use our global networks to establish new equitable partnerships at speed. We have deepened existing partnerships and established new ones to drive synergy with our research vision and translate and scale up. We lead **global networks** to strengthen global capabilities and co-operativity.

Our **overseas research centres** are a critical structure that enable our **global reach with an integrated pathway to impact** through staff in country, and have played vital roles in some of our impact case studies (e.g. ICS-03EBOLA, 12MALARIA). We host three of Wellcome's five Africa and Asia Programmes in Thailand, Vietnam and Kenya, with satellite units in Laos, Cambodia, Indonesia and Nepal. In the REF period, we established a new satellite unit in Myanmar (2014). Furthermore, our overseas research centres manage active trials in Papua, Afghanistan, the DRC, India, Mexico, Tanzania, Guinea, Gambia, Nigeria, Burkina Faso and Mozambique.

Our overseas research centres host more than 2,500 staff with a grant income exceeding £50M/yr. Since 2014, we have continued to **broaden the scope our global health programmes** to link medical, social and molecular sciences to address major challenges in healthcare in settings ranging from rural Africa to areas of rapid urbanisation in India and South-East Asia and middle income settings in Latin America (e.g. Brazil, COVID-19 work). 50 of our submitted staff for REF2021 are based in these units while remaining full members of the University of Oxford and integrated with their department.

Box 1: Strategy in action: highlights of Oxford's COVID-19 response

Our people, our interdisciplinary networks and teams, our global partnerships and our ability to provide rapid financial support allowed us to deliver scientific breakthroughs at a rapid pace and respond to the pandemic with a formidable array of impact-laden research. Our COVID-19 research response is illustrative not only of our impact (ICS-30RECOV-1, 31COVIDVAC, 32COVIDAPP, 33COVIDTEST) but also highlights how our Strategic Aims and our flexible organisational structures underpin the strengths of our research environment.

We did not begin at the starting line when COVID-19 emerged. We were building on 40 years of trusted global health partnerships (**Aim 6**) throughout South East Asia, Africa and Latin America and decades of work on high-threat infections such as SARS, highly pathogenic avian influenza, pandemic influenza, MERS, Zika virus, Ebola, Rift Valley fever, Lassa fever and plague.

We assembled an interdisciplinary (**Aim 4**) team to tackle COVID-19, including infectious disease, immunology, genetics, vaccinology, clinical trials, viral evolution and genetic diversity, computational biology, structural biology, medicinal chemistry, drug design, ethics and statistical epidemiology.

In January 2020, within days of the outbreak, vigorous activity was underway. A vaccine candidate had been designed (Gilbert, Lambe) and enabled by previous investment in infrastructure (**Aim 1**) such as our Clinical Biomanufacturing Facility, we were immediately able to prepare small batches for clinical trial. Meanwhile, through our global leadership (**Aim 7**) of ISARIC (Horby) we were characterising the nature of the disease emerging in Wuhan and establishing the first clinical trials.

The University's strategic priority 10 (2018-23) is to:

> *"increase the scale and scope of our central research fund to grow our capacity to pump-prime, and match-fund major research initiatives".*

We used £1M to underwrite vaccine manufacturing before external funding became available. Our use of this rapid funding ensured the project could progress and not miss the peak of local infectious, which proved critical to the accelerated vaccine development. The RECOVERY trial (Horby) went from protocol finalisation to first recruitment in only 9 days, enabled by established partnership with the NHS (**Aim 5**).

Impact:

By June 2020, phase III clinical trials of the vaccine (Pollard) were underway in the UK and globally at partner sites (**Aim 5**) and we had partnered with AstraZeneca (**Aim 6**). Our vaccine has proven effective, by end December 2020 was approved for use, and will be distributed at cost for the duration of the pandemic, and in perpetuity in developing countries (**Aim 7**) (ICS-31COVIDVAC). By November 2020, >17,000 patients had been recruited to the RECOVERY trial across 176 NHS hospitals (**Aims 4 and 5**) and outcomes about treatment had been found and were being adopted globally (ICS-30RECOV-1). Our immunology infrastructure and network (**Aims 1, 2 and 4**) accelerated antibody testing technology (ICS-33COVIDTEST), and we partnered with Thermofisher to scale up (**Aim 6)**. Epidemiology and ethics worked together (**Aim 4**) to drive forward mobile contact tracing (ICS-32COVIDAPP).

1.3 Research Group Impacts and Achievements

Our UOA derives its research strength and vitality from its highly collaborative and interlinked organisational structure, with departments and institutes supporting researchers in multiple Research Groups (Figure 1). Our response to COVID-19 highlights how our Strategic Aims enable our Research Groups to generate rapid impact (Box 1). We now provide selected highlights from across each of the Unit's 10 Research Groups to exemplify how the Strategic Aims described above (such as investing in staff and infrastructure) have guided their development during the current REF period, and will do so in the future.

1.3.1 Group 1: Infection, Immunity and Inflammatory Disease

Researchers across this group aim to develop mechanistic understanding of the immune system in health and disease, of pathogens and to develop new vaccines and therapies. To develop our environment for this work, we have recruited an extensive research community to create critical mass in these interlinked areas and we have devoted energy and resources to ensure that they are integrated and work together productively. Our success in achieving this was exemplified by the **depth, breadth, speed and impact of our COVID-19 response** (Box 1).

Progress during this REF period

- Relocation of the JDRF/ Wellcome Diabetes and Inflammation Lab (Todd, Wicker) to Oxford.
- Appointment of a new Kidani Chair in Immuno-oncology (Elliott, elected 2020).
- Renewal of the MRC Human Immunology Unit.
- Doubling in size of the Kennedy Institute of Rheumatology to 260 staff, with a current 750m^2 expansion (£3M) and £4M annually from the Kennedy Trust.
- Development and University-funding of the Oxford Immunology Network (Lead: Klenerman 2015) of 169 PIs and >380 staff from 14 department. This is a focus for strategic planning, hosts regular meetings, knowledge exchange and coordinates shared funding applications. This network developed the collaborative relationships that were pivotal to our COVID-19 response.
- Development through the Oxford Immunology Network of the Human Immune Discovery Initiative (HIDI, ~£1M grant from our NIHR BRC) including a research facilitator to support interdisciplinary collaboration and access to immunological expertise, the Human Cell Atlas (£7M Wellcome Strategic award). £340k of pump priming grants allocated over the last 2 years.
- Creation of the Oxford Centre for Microbiome Studies (OCMS, 2019, £3.8M, Powrie) for microbiome studies in health and disease (REF2014 aim). Facilities include anaerobic chambers, cytokine analysis, gnotobiotic and germ-free animal facilities, integrated with metagenomic, metatransciptomic and metabolomic analysis with bioinformatic support. This has leveraged national and international collaboration e.g. Versus Arthritis £2M award to the international Inflammatory Arthritis Microbiome Consortium (Powrie) and a £20M CRUK Grand Challenge award that includes OCMS expertise in germ-free and gnotobiotic models.
- Continued development of vaccine research facilities and capacity (REF2014 aim) through the Jenner Institute (Director, Hill) to assemble the largest not-for-profit vaccine grouping in Europe. Our global centre of excellence in vaccinology is based on vaccine-related experimental immunology, pathogen biology and genetics, vaccine design and production science and has delivered the largest output in vaccine research publications of any UK academic institution. Facilities include the purpose-built Centre for Clinical Vaccinology and Tropical Medicine, and researchers work in Oxford and internationally, especially in response to outbreaks.

Research and impact highlights

- The benefits of our vaccine infrastructure have been manifested in the development at pace of an approved **COVID-19 vaccine** (Gilbert) and clinical trials (Pollard) which have reached phase 3 in

the UK, Brazil, South Africa and USA with almost 20,000 volunteers enrolled (ICS-31COVIDVAC).
- The COVID-19 Multi-omic Blood Atlas (COMBAT) project team was rapidly assembled through the Oxford Immunology Network to study severe COVID-19 using deep immune phenotyping. This collaborative, interdisciplinary multi-omic project involves over 120 researchers including OUH clinicians, physicists and mathematicians.
- The first clinical trials of several Ebola vaccines (Pollard, Snape, Hill) began in Oxford and one of these was recently licensed by the European Medicines Agency and is currently being deployed in Africa in the DRC outbreak (ICS-03EBOLA).
- Research involving trials of 100,000 children supported typhoid vaccine development leading to WHO guidelines for use in high burden areas and $85M released by Gavi, the vaccine alliance, to support country introductions with 10 million doses used in a resistant typhoid outbreak in Pakistan (2019) (ICS-05TYPHOID).
- Pneumococcal vaccine research (Snape) led to changes in infant vaccine schedules in the UK in 2020 (ICS-21PNEUMO).
- Research on inflammatory biomarkers in asthma and COPD (Bafadhel, Pavord) leading to new guidelines for the use of steroids and biologics (ICS-21ASTHMA).
- Other new initiatives include two major Immunometabolism consortia funded by the Novo Nordisk Foundation (Monaco, Choudhury, total £14M); major programme on Dengue (Screaton).
- Leadership of the UK Clinical Research Consortium Modernising Medical Microbiology (Crook, Peto) applying whole-genome sequencing of pathogens (ICS-01WGS) and big data approaches to understand infections including noroviral, clostridial, staphylococcal, and, mycobacterial (ICS-01TB) infections. This work guides laboratory and clinical practice of microbiology across the UK and internationally.
- Spinouts including Mirobio (autoimmune therapeutics, Cornall, Davis), iOx Therapeutics (cancer immunity, Cerundolo), Orbit Discovery (peptide therapeutics, Ogg).

Strategic goals for next period
- Strong focus on COVID-19 and other potential emerging threats, building further infrastructure and tools to provide future health security, focused through the planned major new Institute for Global Health and Institute for Pandemic Preparedness (with a comprehensive research programme to include vaccinology, structural biology, drug discovery, high containment, diagnostics, surveillance and healthcare planning).
- Continue to invest in the development of vaccines against major human and animal pathogens (Hill, Pollard).
- Further expand the major programmes in pathogen and host genetics.
- Meet the evolving challenges of understanding and managing antimicrobial resistance, emerging infections, and differential host response.
- Develop antibody-based therapeutics from antibody sequencing to structural mapping of viral-epitopes and knowledge of the host response (Grimes, Screaton, Stuart).
- Exploit our capacity for high-throughput analyses to catalyse development of a new generation of synthetic vaccines in academic-industrial partnerships (Stuart), enabled by our expertise in genome sequencing/analysis, structural biology, drug screens, antibody isolation, and vaccine design.
- Continue to extend our leadership in the field of mucosal immunity and the role of the microbiome in human diseases (Powrie).
- Establishment of a Centre for Immuno-Oncology (Elliott) in NDM to develop research into cancer immunology and immunotherapy
- With the Institute of Developmental and Regenerative Medicine creation of a focus on developmental immunology.
- Roll out of a new £2.5M Kennedy Trust scheme to support intercalated Oxford DPhil studentships for medical students (4 each year for 5 years).
- New leadership of the MRC Human Immunology Unit (HIU) in the MRC WIMM (Simmons, starting 2021).

1.3.2 Group 2: Global Health and Tropical Medicine

This interdisciplinary group seeks to improve global health using a wide range of approaches including basic science, clinical trials, big data and social sciences. Our overseas research centres have a truly global reach and we integrate our Oxford and overseas researchers through our departments, seminars and networks to maximise productivity, collaboration, training and impact. Having researchers and units around the world is essential for us to maintain our understanding of global need and informs our research priorities. In global health, we believe that the best way to perform excellent research with an integrated pathway to impact is through staff in country. This provides populations with unmet need access to research and allows us to design and test interventions that can be adopted by local governments. We host three of Wellcome's five Asia and Africa Programmes (AAPs) which provides a key pathway to impact as detailed in our Impact Case Studies (ICS-03EBOLA, 05TYPHOID, 12MALARIA).

Progress during this REF period

- Our Africa and Asia Programmes in Thailand, Vietnam and Kenya now support satellite units elsewhere in Asia and Africa. Beyond this group, we work in many countries around the world including Mexico, the Democratic Republic of the Congo, India, Afghanistan, Tanzania, Guinea, Gambia, Nigeria, Burkina Faso, Mozambique, Brazil and South Africa.
- Our Thailand Unit (White, Day) based at *Mahidol Oxford Tropical Medicine Research Unit* (MORU) in Bangkok, opened a new satellite unit in Yangon, Myanmar (Smithuis) to add to units in Mae Sot on the border with Myanmar (Nosten), at Ubon Ratchathani and Chiang Rai in Northern Thailand, in Vientiane in the Lao PDR (Ashley) and in Siem Reap in Cambodia (Turner).
- In line with our REF2014 aims, MORU researchers are coordinating pharmacokinetic/ pharmacodynamic studies and multicentre clinical trials on the treatment of malaria, melioidosis, rickettsial infections, and critical illness management in resource-limited settings.
- Our Vietnam Unit, the Oxford University Clinical Research Unit (OUCRU) (Thwaites) is based in Ho Chi Minh City, and in Hanoi (van Doorn). It has established linked research units in Jakarta, Indonesia (Eijkman, Baird) and Kathamandu, Nepal (Basnyat).
- Our Kenya Unit (Bejon) is based in Kilifi, where it focuses on clinical and population-based research, and in Nairobi. The unit supports work in Bagamoyo (Tanzania) in vaccine research, Mbale (Uganda) in clinical trials and a network of studies in hospitals across Kenya. It is involved in our COVID-19 vaccine trials.
- A major programme (Pollard) on typhoid in Nepal, Bangladesh and Malawi; on pneumococcal vaccines and invasive bacterial disease surveillance (Nepal) and infant immunisation schedules (Uganda and Nepal).
- We host the Global Coordinating Centre for ISARIC (Horby), a federation of clinical research networks now in 132 countries and this has been crucial for our rapid and co-ordinated COVID-19 response.
- We coordinate the African Coalition for Epidemic Research, Response and Training (ALERRT, 2018) in nine African countries.
- We are a founding member of the European Clinical Research Alliance for Infectious Diseases (ECRAID, 2020).
- We are now establishing Oxford Global Health (2020) as a network to bring together medicine, physical, life and social sciences and humanities across the University to drive expansion of our already formidable interdisciplinary global health research activity. We invested internal John Fell Funding to support the initiative with a dedicated research facilitator (January 2020).

Research and impact highlights

- Established best-practice guidelines for the treatment of severe and uncomplicated malaria, malaria in pregnancy, scrub and murine typhus, melioidosis, leptospirosis, enteric fever, dengue fever, tetanus, bacterial and tuberculous meningitis, cryptococcal meningitis and viral encephalitis.
- Provided advice to the Kenyan Government on responses to COVID-19 including serological

surveillance, genomics and modelling outputs through the Governmental taskforce.
- Leadership of the multinational COPCOV study (White) of chloroquine/hydroxychloroquine as prophylaxis against COVID-19
- Co-ordination through MORU of the DeTACT (Developing Triple Artemisinin Combination Therapies) malaria treatment Programme which has clinical study sites in 13 countries across Asia and Africa (REF2014 aim).
- Leadership by our Kenya unit researchers of an international nutrition network (CHAIN) including Uganda, Burkina Faso, Pakistan and Bangladesh.
- Investigation by OUCRU researchers of the optimal diagnosis, treatment and prevention of life-threatening infectious diseases in South-East Asia, focused on tuberculosis, dengue, malaria, tetanus and enteric fever, with substantial work on drug-resistant and emerging viral infections, including COVID-19 (REF2014 aims).
- Completion of the largest ever randomised clinical trial in vivax malaria demonstrating cure with short course primaquine therapy (REF2014 aim).
- Characterisation of the genetic and clinical aspects of multi-drug falciparum malaria leading to treatment policy change (REF2014 aim).
- Demonstration of sustained elimination of multi-drug resistant falciparum malaria through targeted drug administration in villages with high prevalence in Myanmar (ICS-12MALARIA).
- Establishment of appropriate dosing of piperaquine leading to changes in the 3rd edition of the WHO Guidelines for the Treatment of Malaria (REF2014 aim).
- Establishment of the safety of artemisinin in the first trimester of pregnancy leading to changes in guidelines.
- Demonstration of clinical antimalarial activity of a novel antimalarial KAF156 in vivax and falciparum malaria.
- Demonstration that Orientia, Rickettsia and Leptospira pathogens are common and treatable causes of central nervous system infections in Laos, so doxycycline is required for empirical antimicrobial therapy (REF2014 aim).
- Estimation through the Global Burden of Disease - Antimicrobial Resistance Study (GRAM, Dolecek), of the scale and geospatial distribution of drug resistance from 1990 onwards to guide interventions to address this resistance (REF2014 aim).
- COVID-19 vaccine studies and subsequent vaccine use in South Africa, Brazil and Kenya.

Strategic goals for next period
- Development of the Institute for Global Health and Institute for Pandemic Preparedness.
- Building on the strength in UOA1, we continue to develop Oxford Global Health as a cross-university interdisciplinary research theme to foster critical mass across our four academic Divisions. Oxford Global Health will further bring our activity together with research beyond medicine (e.g. climate change, pollution, sanitation, prosthetics, policy, ethics, AI, non-communicable diseases, mental health) and recruit a Head of Global Health.
- Accurate epidemiological measures of disease burden for malaria, COVID-19 and pneumococcal pneumonia using practical, but state-of-the-art, diagnostic approaches.
- Mapping and understanding the molecular basis of antimicrobial drug resistance; and developing molecular/genomic epidemiological studies of major pathogens including malaria as an aid to public health policy and disease control.
- Understanding and reducing the rise of vaccine preventable diseases in LMICs.
- Understanding and addressing metabolic and cardiovascular disease in developing countries.
- New trials in treating *vivax* and *falciparum* malaria, leishmaniasis, neonatal sepsis, dengue, CNS infections, anaemia, respiratory diseases, severe malnutrition, HIV/AIDS, maternal and neonatal health, and enteric and zoonotic diseases caused by emerging pathogens.
- Optimising the use of new technology to improve the care of critically ill patients with infectious diseases in resource-limited settings

1.3.3 Group 3: Cancer

This group seeks to reduce cancer morbidity and mortality though integrated and interdisciplinary work ranging from basic science to clinical trials of new drugs and other therapeutic approaches. Cancer research in Oxford draws on the capabilities across multiple departments and institutes to leverage the benefits of interdisciplinary research groupings and we refresh these interactions through networking seminars, shared doctoral programmes and pump-priming funding. Much of our cancer research is co-located with the £126M purpose-built *Oxford Cancer and Haematology Centre* (OUH) at the Churchill Hospital, facilitating clinical research (Section 4).

Progress during this REF period

- Appointment of a new Kidani Chair in Immuno-oncology (Elliott, elected 2020).
- Appointment of Giaccia as Director of the Oxford Institute of Radiation Oncology (2019)
- Appointment of a statutory chair in Molecular and Population Genetics (Leedham, 2020)
- Appointment of two senior posts (Shi, 2020, ex- Harvard and Song, 2016) to develop work on epigenetics and bromodomains.
- Renewal of the *CRUK Oxford Cancer Research Centre (*Middleton/Lu, renewed 2017), to support and promote integrated cancer research across the University (over 300 members).
- Renewal of the Oxford branch of the *Ludwig Institute for Cancer Research* (Lu, uplift from £23M 2012-17 to £40M+ 2017-2022) to drive forward understanding of the molecular basis of cancer, the role of key transcription factors in cell growth, differentiation and death, angiogenesis, the cellular response to hypoxia and epigenetic gene regulation (REF2014 aim).
- Establishment of OxCODE (Oxford Centre for Early Cancer Detection, Lu, 2019) through investment from the CRUK Oxford Cancer Research Centre, NIHR Oxford Biomedical Research Centre, and University of Oxford John Fell Fund. The Centre integrates early cancer research across >20 departments and institutes, providing seed funding, and co-ordinating collaborations on projects including the SCAN, DART and DeLIVER programmes.
- Creation of a DPhil in Cancer Science programme (with a new MD-DPhil track) to provide research and translational training for clinical trainees, medical undergraduates and fundamental scientists from medical, mathematical and engineering sciences. A novel element of the scheme is our institutional investment (£3M) to provide post-graduation support packages to enable clinicians who have been through the scheme to retain research activity during their clinical training.
- Co-development with Biomedical Engineering of the interdisciplinary Oxford Centre for Drug Delivery Devices, initiated through an EPSRC programme grant (£9M) to developing new cancer therapies using drug and device combinations.

Research and impact highlights

- Novel Cancer Therapies – demonstration of early signs of pre-clinical and clinical efficacy with associated experimental medicine programmes to confirm mechanism of action and provide the evidence to de-risk later stage registrational studies of novel agents including.
    - IMCgp100 bispecific molecule (Middleton with Immunocore, TCR-based melanoma immunotherapeutic, Tebentafusp, about to enter phase 3).
    - CD47 Antagonists (Magrolimab; Vyas in collaboration with Stanford and spinout).
    - Anti-Grem1 antibody for colorectal cancer Phase1 clinical trial (Leedham, with UCB)
    - Ultrasound Mediated Drug Delivery trial in pancreatic cancer using ultrasound induced hyperthermia to deliver non-invasive targeting of drug delivery (Middleton, Coussios).
- Development of MR Linac radiotherapy research (Maughan, with GenesisCare), providing patients with access to state-of-the-art treatment technology and researchers with the opportunity to develop new treatment protocols.
- National Consortium for Intelligent Medical Imaging (NCIMI, CMO Gleeson, UK Government Industrial Challenge Fund, £17M) to drive use of AI in clinical image analysis especially cancer, including the DART study (£11M from Innovate UK, Cancer Research UK and industry, to lead a new national programme of AI research to improve lung cancer screening (Gleeson,

consortium including Roche, GE, Optellum).
- DeLIVER, "The Early Detection of Hepatocellular Liver Cancer [DeLIVER]", (£2.5M, Barnes), including partners in primary care, chemistry, statistics, data science, clinical oncology, industry (Roche, Perspectum and others) and charity partners.
- CRUK Network Accelerator (£4.2M) with Southampton to study molecular determinants of response to cancer immunotherapy (Lu, Middleton, Elliott).
- The first tissue tomography results in colorectal cancer (Leedham).
- Development of epigenetic analysis platforms (TET-assisted pyridine borane sequencing - TAPS) for clinical implementation, now commercialized for impact through spin-out company Base Genomics (Song, 2019; company sold to Exact Sciences in a $410M deal, 2020).

Strategic goals for next period
- Over the next five years, further integration of cancer research across the University under 'Oxford Cancer' theme, under the leadership of Middleton and Elliott, building on areas of existing international excellence and developing unique interdisciplinary contributions.
- Realise the potential of Cancer Big Data to improve the early detection of cancer and to identify the potential for, and route to, cure at diagnosis.
- Invest in infrastructure, training and support that enable researchers studying a range of cancer stages, different cancer types, and cancer-related conditions to collaborate on, learn from, and contribute to, each other's research programmes.
- Recruitment and fund-raising to establish the Institute for Immuno-Oncology (Elliott) identifying determinants of clinical outcome with this new therapeutic class and nominating drug targets (linking to immunology groups and local industry).
- Build on several key enabling platforms and address core treatment modalities of surgery, radiation, antimetabolite drugs, hypoxic pathway targeting and immuno-oncology.
- Advances in molecular pathology (Verrill, Leedham)
- Strong focus on core discovery science, exemplified by work by Ratcliffe and the Ludwig Institute, including further development of potential therapeutic approaches around hypoxia pathways and cancer, and further development of epigenetics programme (Shi).
- Investment in Clinical Biomanufacturing Facility with links to early phase clinical trial units and advanced therapies.

1.3.4 Group 4: Haematology and Stem Cells

This group seeks to understand blood cell biology and disease and to develop new therapies for haematological disorders, including through the study of stem cells and their potential therapeutic applications. Research builds on the critical mass and infrastructure we have developed through the MRC Molecular Haematology Unit, the collaboration with the NHS and industry and cross-fertilisation with our interdisciplinary research environment.

Progress during this REF period
- Recruitment of new Director of the MRC Molecular Haematology Unit (2020, Patel) and a new Professor of Haematology (2020, Chakraverty).
- Renewal of the MRC Molecular Haematology Unit (£27M in 2017) to study the regulation of blood cell differentiation from the embryo through to adult life and how blood diseases arise as these processes go awry (REF2014 aim).
- Close integration with the Clinical Haematological Service in OUH, enabled by a £5.5M Haematology theme in the NIHR BRC (2017, Vyas).
- Formation of the Oxford Centre of Haematology (2018, Vyas), a virtual centre linking researchers and clinicians to integrate and accelerate research and promote the best available patient care.
- Co-development of a purpose-built Haem-Onc Early Phase Clinical Trials Unit that provides first-in-class and first-in-man capability, and a Haematology Phase II-III Trial Unit and NHSBT clinical trial unit, that have enabled practice-changing clinical studies (REF2014 aim) .

- Investment in state-of-the-art experimental platforms including single cell genomics, genome engineering and bioinformatics, to complement existing strengths in flow cytometry, mass cytometry and cellular imaging (REF2014 aim).

Research and impact highlights

- Discovery that blood stem cells are functionally heterogeneous (Jacobsen, Nerlov) and have the potential to produce all blood cells, but at a single cell level they produce only subsets of blood cells. This has important implications for blood stem cell therapies and haematological cancers.
- Discovery of key steps in differentiation of the earliest embryonic blood cells (Porcher, Nerlov, De Bruijn), which could help in *ex vivo* generation of cells and in understanding blood disorders originating early in development.
- Development of a molecular understanding of how prenatal stem and progenitor cells acquire specific mutations causing embryonic preleukaemia and childhood leukaemia in Down's syndrome (Roberts, Vyas).
- Multiple major contributions to single cell-level dissection of the hierarchy of blood progenitor cells that differentiate from blood stem cells (REF2014 aim).
- Discovery of how oncogenic mutations can perturb blood progenitor function, leading to blood cancer and use of single cell approaches to determine the clonal basis of response and resistance to targeted therapies (Vyas, Mead, Psaila).
- Definition of how epigenetic dysfunction leads to childhood leukaemia (Milne, Roy)
- Undertaken work that supported the FDA licensing of enasidenib, the first-in-class oral inhibitor of mutant Isocitrate Dehydrogenase 2 (Vyas).
- Work with Stanford to bring a new class of innate immune checkpoint, anti-CD47 therapy (Magrolimab), into clinical practice (Vyas).
- Leadership (Roberts) of the national clinical trial of convalescent plasma in COVID-19 as part of the RECOVERY platform trial.
- Leadership (Stanworth) of practice changing trials of platelets use to prevent bleeding in adults and in neonates.

Strategic goals for next period

- Development of new research directions:
  - understanding how DNA damage occurs, is sensed in blood stem cells and leads to blood disorders (Patel, Chapman)
  - understanding signals that regulate stem cell proliferation (Wilkinson)
  - understanding bone marrow dysfunction with aging and how somatic mutations lead to clonal haemopoiesis (Patel, Nerlov, Vyas)
  - New stem and immune cell therapies, collaborating with immunology (Chakraverty).
- Development of a new Centre for Advanced Cell and Gene Therapy with GMP cell manufacture and new clinical facilities to deliver new first-in-man T cell and gene edited stem cell therapies. The Centre will leverage local vector manufacture capability and will be a collaboration with Oxford BRC, OUH, Drue Heinz Foundation and others.
- Development of a new ISO-accredited GCLP 'Therapy Acceleration Laboratory' to perform specialist, high-value genetic and phenotypic analyses (including single cell analyses) of clinical trial samples, from first-in-human to registrational licencing trials.

1.3.5 Group 5: Genetics

This group uses functional genomics approaches to understand disease mechanisms and to identify genetically validated candidate therapeutic targets. Researchers with different disease interests are co-located in shared institutes, notably the Wellcome Centre for Human Genetics, and supported by computational and sequencing infrastructure. We have an outstanding track record in genomics and the supporting bioinformatic and statistical mathematical science, with a deep-rooted commitment to open-source method development, resource, and data sharing.

Progress during this REF period

- Appointment of new Director of Wellcome Centre for Human Genetics (Todd, 2019).
- Appointment of new Professor of Molecular and Population Genetics (Leedham, 2020).
- Relocation of the JDRF/Wellcome Diabetes and Inflammation Laboratory to Oxford (Todd, Wicker, 2019).
- Extension of funding to the Wellcome Centre for Human Genetics (£15M, 2020).
- Creation of the Oxford Harrington Center for Rare Diseases (Wood, Holländer)
- Investment in state-of-the-art sequencing technology including long read Nanopore, PacBio and MGI technology.
- Investment in huge scale computational infrastructure (~7,000 CPU cores, >80 GPU cards, >20PB fast access storage facilities and production on-premise cloud facilities).

Research and impact highlights

- Implementation of a genetic risk score to identify children at birth with a high risk of type 1 diabetes for randomisation into a primary prevention trial (Todd, Snape, Vatish).
- Identification of a novel non-hormonal target for endometriosis (Neuropeptide S receptor 1) based on genetics with inhibition in mouse models reducing inflammation and pain (Zondervan)
- Discovery of novel patient endotypes associated with outcome and response to therapy in sepsis using leukocyte transcriptomics (Knight, UK Genomic Advances in Sepsis Study).
- Development of the ToxNav test for variants in genes conferring risk of fluoropyrimidine toxicity, to be offered to all patients receiving 5-fluoruracil in OUH (Church, Taylor, Tomlinson; REF2014 aim) and commercialisation by spin-out (Oxford Cancer Biomarkers).
- Structure-guided design of TYK2 variants for genome editing and autologous haemopoietic stem cell transplantation as a potential therapeutic strategy for severe immune-mediated diseases (Siebold, Dendrou; REF2014 aim).
- Demonstration that copy number variation predicts colitis-associated colorectal cancer (Tomlinson, Leedham).
- Identification of pathogens associated with meningoencephalitis and sepsis using targeted metagenomic sequencing with a novel enrichment method (Bowden, Knight, Fraser).
- Development of novel, cost effective, high-throughput, virus-enriched sequencing method and computational pipeline for HIV (veSEQ-HIV; Fraser).
- T cell phenotyping at the single cell level with unprecedented precision, in human blood and small intestine using single cell RNA-seq and CITE-seq (Todd, Wicker).
- Development of innovative methods for B and T cell repertoire sequencing in leukaemias and immune diseases providing minimal disease monitoring and outcome prediction (Bashford-Rogers).
- Leadership in Genomics England Clinical Interpretation Partnerships (GeCIPs) (Taylor, Whiffin).

Strategic goals for next period

- Development of machine learning algorithms to interpret the clinical significance of variants identified by whole genome sequencing (with Genomics England).
- Further development of newborn genetic screening for rare mutations.
- Lead pathogen genomics and mathematical modelling to understand and respond to epidemics, including PANGEA-HIV to develop ultra-high-throughput HIV genomics and analytics in Africa (Fraser).
- Use transcriptomic biomarkers to identify sepsis patients with endotypes that are most likely to benefit from immune stimulation in a clinical trial of GM-CSF (Knight).
- Develop tool compounds for genetically-validated targets in our new Centre for Medicines Discovery
- Validate genetic insights in model organisms, induced pluripotent stem cells, tissue organoids, and patient-derived cellular assays.

- Advance genetically-identified candidate therapeutic targets: test TYK2 inhibitors and protective TYK2 variants (Siebold, Dendrou with Nimbus Therapeutics); Tau in diabetes and metabolic ageing (Todd); NPSR1 for endometriosis (Zondervan, with Evotec); explore IL-2 Treg therapy in Type 1 diabetes (Todd, Wicker, with Bristol Myers Squibb).
- Conduct clinical trials including: POLE and mismatch repair (Church, POLEM trial, Merck); IL-2 in children with type 1 diabetes to preserve insulin secretion (Todd, Wicker).
- Exploit structure-guided protein engineering to dissect the multiple functionalities of a protein *in cellulo* and *in vivo* e.g. Building on structure-function work (Tzima, Jones) with novel transgenic murine models (Davies) informed by human genetics data and patient samples (Watkins, Farrall).

1.3.6 Group 6: Cardiovascular Medicine

The group seeks to develop deep mechanistic understanding and new therapies for a broad spectrum of acute and chronic cardiovascular disease. Vitality has been enhanced by recruitment of a critical mass of researchers, investment in cutting-edge technology, a BHF DPhil programme and the BHF Centre of Research Excellence, which actively promotes interdisciplinary integration between researchers in multiple institutes with strengths ranging from genetics to imaging. This mix allows basic science findings to be translated into large clinical studies and impact.

Progress during this REF period

- Renewal of the BHF Centre of Research Excellence (2019, £6m), one of only two awarded at the full funding level, bringing together >70 PIs and integrating underpinning basic science through clinical cardiovascular research to population science and trials.
- Pivotal increases in clinical research capacity, through investment in the *Oxford Centre for Clinical Magnetic Resonance Research* (OCMR; Neubauer): e.g. new highest gradient strength 3T MRI to image cardiac fibre structure; *Cardiovascular Clinical Research Facility* (Leeson) with major developments in artificial intelligence applications to echocardiography; and *Acute Vascular Imaging Centre (AVIC*; Antoniades).
- Development of an integrated programme (Casadei) to reduce the health burden from atrial fibrillation through basic research, proof-of principle clinical studies, large-scale clinical trials and population science (with UK Biobank).
- Creation of the Institute of Developmental and Regenerative Medicine (IDRM, £31M; opening 2021) with a key focus on the molecular and cellular basis of cardiovascular health and disease.

Research and impact highlights

- The MR Imaging group (Neubauer, Tyler) has pioneered high field (7T) and hyperpolarised MRI programmes for cardiovascular clinical imaging in humans, which are unique in Europe. Results include demonstration of abnormal human cardiac metabolism; measurement of inorganic phosphate (and hence pH) in the human heart *in vivo* (Valcovic); combination with spectroscopy to understand cardiometabolic diseases (Jones).
- Discovery that coronary CT imaging can detect and quantify changes in peri-coronary fat tissue associated with coronary artery inflammation and provides a novel powerful predictor of cardiac death (Antoniades) with large scale clinical validation.
- Application of AI to echocardiography (Leeson) from proof of principle experimental work to some of the largest ever echocardiography studies; regulatory approval and NHS roll-out supported by the NHS Accelerated Access Collaborative.
- Discovery of novel disease mechanisms from genetic studies (Watkins, Farrall); providing insights into coronary disease, with a leading role in the CC4D consortium, through functional analyses (Channon, Douglas) and changing clinical practice (e.g. refining rare variant interpretation in cardiomyopathy) (REF2014 aim).
- Discovery of clinically-applicable biomarkers and targets (e.g. Neuropeptide Y) and imaging

insights into myocardial injury and recovery in acute MI (Channon, OXAMI study).
- Discovery of Plexin D1 as a mechanosensor for flow which regulates endothelial cell function (Tzima).
- Discovery of the role of calcitonin receptor signalling in the atrial remodelling underlying atrial fibrillation (Reilly).
- Contributions to understanding the cardiac impact of COVID-19: demonstrating how care of for acute coronary syndrome has suffered in the pandemic (Casadei); completion of first multi-organ imaging study in patients post COVID-19, and leading imaging in the national PHOSP-COVID follow-up study (Neubauer, Raman).
- Commercialisation for patient benefit, with spinouts including Caristo Diagnostics –vascular CT (Antoniades), Ultromics –cardiac ultrasound (Leeson), OxStem Cardio – regenerative medicine (Choudhury, Patient, with Riley [UOA5]).

Strategic goals for next period
- Re-development of AVIC into a new hybrid cardiac CT/cath lab facility (director: Antoniades) to translate AI-supported coronary CT imaging risk prediction and drive NHS implementation; define the best imaging strategy for patient stratification (Channon).
- Develop nucleic acid therapies for cardiomyopathy (Watkins).
- Develop clinical application of genetic risk scores in both rare and common disease.
- Undertake large scale phenotyping studies including UK Biobank ECG monitoring of 20,000 subjects to predict clinical consequences of silent atrial fibrillation (Casadei) and the largest combined imaging and genetics study in hypertrophic cardiomyopathy (Neubauer, Watkins).

1.3.7 Group 7: Metabolic, Endocrine and Reproductive Medicine

This group aims to develop mechanistic understanding of the underlying pathobiology to develop better therapies in metabolic, endocrine and reproductive healthcare. Researchers span multiple institutes and assemble expertise in molecular and cellular biology, electrophysiology, genetics, clinical medicine, epidemiology and drug trials.

Progress during this REF period
- Ground-breaking work on oxygen sensing including the identification of further new oxygen sensing pathways and successful drug target identification, leading to the development of oral erythropoietin stimulating drugs to treat renal anaemia (Ratcliffe, Nobel Prize 2019, Lasker Prize 2016).
- Appointment of a Professor of Endocrinology (Ray) to drive understanding and application of circadian biology, and sleep in metabolic and inflammatory diseases.
- Appointment of a Professor of Diabetic Medicine and Health Policy (Adler), as Director of the Diabetes Trials Unit (DTU).
- Relocation of the JDRF/ Wellcome Diabetes and Inflammation Lab (Todd, Wicker) to Oxford to develop research into prevention and treatment of human type 1 diabetes, including identification of at risk newborns and testing preventative interventions (Todd and Snape).
- Opening of the Novo Nordisk Research Centre Oxford laboratories (NNRCO, £100M programme) to foster industry collaboration in metabolic health (REF2014 aim).
- Formation of Oxford Metabolic Health (2018), a wide-reaching bringing together researchers in the wider metabolism area. Pump-primed by our internal John Fell Fund and supported by NIHR Oxford BRC, supported by a research facilitator, it now includes around 60 research groups.
- Establishment of the Larsson-Rosenquist Foundation Oxford Centre for the Endocrinology of Human Lactation (LRF OCEHL, £2.9M).
- Creation of the Oxford-Bayer research alliance in gynaecological therapies (Becker, Granne, Lindgren, Zondervan, Oppermann, Kessler, £14M)

Research and impact highlights

- Validation of sFlt-1/PlGF ratio as a measure for predicting pre-eclampsia leading to a change in clinical practice and adoption into NICE guidelines (Vatish).
- Adoption of the Dawes Redman criteria for cardiotocography (CTG) in antenatal foetal monitoring and inclusion in NICE guidelines (Redman, Vatish).
- Development of new foetal growth standards based on a multi-centre study and their adoption by the World Health Organisation from the INTERGROWTH-21st study (ICS-20INTERGROWTH, £2.7M), co-ordinated through Oxford (REF2014 aim).
- Creation of the Novo Nordisk Foundation immunometabolism consortium (2015 and renewed 2020, Monaco, Choudhury, £14M) to study metabolic aspects of human disease with the Karolinska Institute and University of Copenhagen.
- EU-Innovative Medicine Initiative consortium (IMI-PainCare, £19M) to improve the care of patients suffering from acute and chronic pain involving 40 partners from 14 countries (REF2014 aim), with particular focus on Translation in Pelvic Pain (TRiPP) for endometriosis and bladder pain syndrome (£3.8M, Vincent).

Strategic goals for next period

- Further development of themes requiring interdisciplinary expertise including mental health with chronic pain and non-communicable diseases in women.
- Validation of therapeutic targets, along with novel methods of disease diagnosis and monitoring.
- Development of immune preventative and therapeutic approaches for type 1 diabetes.
- Recruitment to the Robert Turner Professorship of Diabetic Medicine

1.3.8 Group 8: Musculoskeletal Medicine and Musculoskeletal Surgery

This group seeks to understand and design better therapies for diseases affecting the musculoskeletal system. We have assembled the largest musculoskeletal research base in the UK and this is energised and routes to impact are facilitated by interdisciplinary working across multiple institutes and investment in advanced infrastructure.

Progress during this REF period

- Appointment to the Climax Chair of Clinical Therapeutics (Richards).
- Doubling in size of the Kennedy Institute to 260 staff, with a current 750m^2 expansion (£3M) underway, to accommodate additional researchers in computational biology, informatics and clinical trial management.
- Launch of the Kennedy Trust Arthritis Therapy Acceleration Programme (A-TAP, Buckley, 2018 £7M) in partnership with the University of Birmingham, benefitting 7 million people through a network of NHS trusts across the West Midlands and Oxfordshire.
- Linking inflammation research with trials expertise to develop academic-NHS-industry partnerships to enable early Go/No Go decisions in drug discovery.
- Development of the Centre for Statistics in Medicine (Richards) and the Surgery and Interventional Trial Unit (SITU, Beard) to explore novel surgical technologies, including the development and worldwide application of Patient Reported Outcome Measures.
- Establishment of the Centre for Myeloma Research integrating musculoskeletal science with haematology and oncology (Oppermann).
- Development of the Cellular Dynamics platform (Dustin) with advanced imaging facilities, image analysis and multi-omics data integration enabling multiscale analysis from single molecules to live cell imaging in tissue.
- Development of the UK's first extended total internal reflection fluorescence-structured illumination microscope

Research and impact highlights

- Demonstration in the CSAW trial (ICS-07SHOULDER), that a commonly performed shoulder operation is no more effective than placebo, resulting in changes to NHS England policy and NHS savings of over £100 million.
- Implementation of the BEST back pain management guidelines (Lamb) in over 165 Trusts in the UK, resulting in NHS savings of £1 billion per annum (RAND estimates).
- Leadership of major strategic programmes in discovery and translational research including the ARUK Centre for Osteo Arthritis Pathogenesis (Vincent, renewed 2017, £2M), the ARUK Inflammatory Microbiome Consortium (Powrie) and the MDUK Oxford Neuromuscular Centre (Talbott, Servais, Wood).
- Leading a large international consortium of 7 academic and 8 industry partners to define the molecular endotypes of osteoarthritis (STEpUP OA, £1.8M).

Strategic goals for next period

- Promote translational research and increase national and international clinical trials and medical statistics capabilities.
- Open Botnar phase 3 (Marcella Botnar Wing, 2021) to add 2,000m^2 of estate including a GMP clean facility for biomaterials and biomodulation including additive manufacturing technology.
- Development of the Climax Centre for Clinical Therapeutics.

1.3.9 Group 9: Structural Biology and Drug Discovery

Work here is focused on applying structural and biophysical approaches to understand disease mechanisms and discover new drugs. We have developed joint posts and work with the national Diamond Light Source synchrotron (Director of Life Sciences, Stuart, joint appointment) and Rosalind Franklin Institute to integrate advanced technology into the core of our research endeavours.

Progress during this REF period

- Secondment to Directorship of Rosalind Franklin Institute (Naismith, 2017 joint appointment) consolidating collaboration.
- Further development of on-site class 3 containment facilities for structural work on dangerous pathogens in the Oxford Particle Imaging Centre (OPIC), unique in Europe.
- Application of structural biology to medicine using approaches ranging from atomic level X-ray crystallography to the cellular level revealed by fluorescent light and X-ray microscopy.
- Structural Genomics Centre (SGC) established the first not-for-profit open science drug discovery company M4KPharma.com (Meds4Kids, 2017) to develop affordable brain penetrant ACVR1 inhibitors. M4K practises 100% open collaborative science and does not file patents, relying on protection via "prior art" disclosure and regulatory exclusivity. All data are openly available online.
- £7.8M funding to build a translational pipeline for SGC assets. Projects are disease agnostic and span a broad range of areas, including spondyloarthritis, chemotherapy-induced peripheral neuropathy and acute myeloid leukaemia.

Research and impact highlights

- A rapid crystallographic fragment screen on the SARS-Cov-2 main protease (von Delft, Walsh). To accelerate drug design, fragment hits were released to the public immediately.
- Production of COVID-19 spike protein (Burgess-Brown) for diagnostic test development and candidate therapeutic antibodies (Burgess-Brown, Cornall, Klenerman, Townsend, Lu)
- Identification of compounds, through *in silico* screening, for re-purposing to inhibit Ebola virus including a traditional Chinese medicine derivative with unprecedented potency (Stuart).
- The XChem platform (von Delft) to accelerate identification of low affinity binders for ‘undruggable’

proteins using high throughput crystallography with fragment libraries; and associated Fragalysis software to automate optimisation into more potent ligands have already attracted >80 academic and >20 industry users/screens.
- CryoEM structure of a mature flavivirus and the immature particle to unprecedented resolutions (Grimes, Screaton).
- Pre-competitive collaborations developed with major pharmaceutical companies (AbbVie, Bayer, Boehringer Ingelheim, Janssen, MSD, Pfizer, and Takeda) to make innovative high-quality probes available to the research community.
- Development of a Notum inhibitor targeting Wnt signalling for use in preclinical target validation in Alzheimer's Disease and cancer (Jones).
- Integration of structural biology with upstream genetics and downstream drug development, enabling e.g. ground-breaking progress in fibrodysplasia ossificans progressiva. Earlier work identified the causative gene ACVR1 (Wordsworth) and led to crystal structures, cellular assays and tool chemical inhibitors to understand the mutational activation of ACVR1 and therapeutic targeting strategy (Bullock) leading to identification of the investigational drug saracatinib as an ACVR1 inhibitor and now the Innovative Medicines Initiative (IMI)- supported phase 2 clinical trial STOPFOP (Bullock, 2020).

Strategic goals for next period
- Continue to develop the Centre for Medicines Discovery, building on the platform of the SGC, as a major initiative for academic and commercial partnership to help the community produce more accessible and affordable medicines.
- Develop protein-based immunogens capable of eliciting a protective immune response to virus infection, focusing on optimisation of recombinant viral glycoprotein immunogens (International Aids Vaccine Initiative).

1.3.10 Group 10: Surgical Sciences

Our surgical science researchers use state-of-the-art interdisciplinary approaches and advanced technology to develop the underpinning science and practice of clinical surgery. A Surgical Innovation and Evaluation theme is part of our NIHR BRC.

Progress during this REF period
- Expansion with 6 new senior posts: John Black Professorship in Prostate Cancer Research (Mills, 2015); Rosetrees / RCS Directorship and Professorship in Surgical Trials (Douek, 2018), two senior academics in transplant surgery (Knight, Hunter); Blackwell/Pharsalia and Lee-Placito endowed Professorship of Colorectal surgery (Buczacki, 2020); funding for Professorship of Surgical Sciences (2020).
- Interdisciplinary enrichment with 4 new academics in cellular pathology (Verrill, Colling), molecular biology (Mills) and bioinformatics (Woodcock).
- Three Clinician Scientist Awards (honorary consultants) from CRUK in surgical Oncology (Bryant, Lamb), and Wellcome Plastic Surgery (Issa).
- Establishment of RCS Surgical Intervention Trials Unit (SITU) with expansion of the surgical trial portfolio, and training of new investigators (now 8 active fully funded RCTs).
- Development of collaborations with engineering, industry and Big Data enterprises, including CRUK programme on molecular-targeted imaging (Hamdy, Vojnovic) in partnership with industry (ImaginAb)); support from NIHR and industry (Steba Biotech) to develop focal therapy in prostate cancer.
- Ongoing refurbishment of 1,100m^2 of dedicated surgical research laboratories and space on the John Radcliffe site.

Research and impact highlights

- NICE endorsement and large pan-European clinical trials for transplant organ preservation using normothermic perfusion (Friend), with spin-out OrganOx (ICS-19ORGANOX).
- Development of strong research base in prostate cancer management (Hamdy), leading the ProtecT trial with outcomes influencing NICE guidelines and global clinical practice (ICS-17PROSTATE).
- Development of a national prostate cancer research database 'one stop shop' for researchers to perform new analyses using distributed data and novel bioinformatic tools (Hamdy).
- Integration of digital pathology and AI with two Innovate UK grants (Verrill, Oxford PI: total £14.4m and £20m). PathLAKE grant supports R&D through a centralised 'datalake' of anonymised digital pathology images to facilitate application of AI and makes data accessible to academia, NHS and industry.

Strategic goals for next period

- Recruitment to the Professorship of Surgical Sciences
- Secure funding for a new 10,000m^2 facility, Oxford Centre for Innovation and Interventional Technologies (OCIT), embedded in the Churchill Hospital campus, with clinical and non-clinical research facilities as part of an interdisciplinary venture with Engineering (Coussios).
- Increased industry partnership to consolidate the prostate cancer biorepository for translational research.

2 People

2.1 Staffing strategy and staff development

We aim to recruit, retain and support our researchers to undertake impactful research of the highest quality (Strategic Aim 2). We invest in these people to develop an **inclusive, equal and diverse research community** to undertake excellent research and to develop its impact by supporting their interactions beyond academia. Our staffing strategy is designed to ensure **equality of access to research careers** and develop and support the careers of all our researchers. We believe that our staff deliver their best work when they are happy with their **work-life balance** and supported to undertake caring or through any difficulties they may encounter.

Research excellence is the overriding criterion for academic recruitment, and the University is committed to attracting, recruiting and retaining the very best academic staff. Personnel policies are executed by the devolved departments and reported centrally. Each department identifies priority areas for appointments in the University's annual strategic planning round, with emphasis placed on actively supporting new initiatives, building upon existing research strengths, opening new areas of interdisciplinary and collaborative research, or addressing core teaching needs. We are committed to providing all researchers with the intellectual and physical environment to advance their ideas, interests and careers. This capacity-building strategy engenders a **vibrant and diverse culture**, by complementing strong institutional support with academic autonomy and cross-disciplinary collaboration, building a launchpad for future successes, in Oxford or elsewhere.

Our strategy of **worldwide recruitment** has resulted in principal investigators, research staff and students from a wide range of countries, with **submitted research staff representing more than 45 different nationalities**. The University is committed to start construction of at least 1,000 new subsidised homes for staff [IES 1.0], recognising the increasing barrier of local housing costs.

Career Development: All departments hold regular **Personal Development Reviews (PDRs)** providing an opportunity for reflection and feedback. They are a forum to highlight and address obstacles to career progression, work/life balance and discuss opportunities for promotion, grant acquisition, co-supervision of graduate students, and broader service and leadership, within and beyond the University. Specific development needs can be mapped to internal or external training courses and any opportunities for additional responsibilities. Training is available for both reviewers and reviewees. Our departments draw on central University support structures to provide individual **career development programmes** [IES 3.1].

2.2 Inclusive and Flexible Environment

We are committed to supporting everyone in our UOA. There are regular staff surveys to gather information on staff experience and levels of satisfaction. In our most recent staff survey (2018), across all staff who responded in our UOA, **89% of women and 90% of men were satisfied with their job and 92% of women and 93% of men would recommend working at the University of Oxford to a friend**. Of our submitted researchers, 13.2% declare black or minority group ethnicity, 5.5% declare disability and 36.6% are female. Overall, **the proportion of all our researchers declaring black or minority group ethnicity has risen from 18.1% in 2013 to 23.7% in 2020**. These data help in the planning of further initiatives in our equality, diversity and inclusion work.

We do not tolerate bullying or harassment and promote a healthy, inclusive and supportive workplace through courses, workshops and other initiatives. We have a **network of advisors** trained to support staff who are experiencing bullying or harassment. **Implicit Bias** and **Responsible Bystander Training** run regularly and are mandatory in many settings.

All 7 departments and their constituent units have been awarded **Athena SWAN Silver awards** and had these renewed in the last round. Each department's Athena SWAN self-assessment team implements and monitors strategies to provide equal opportunity to all staff, with a particular focus on women's careers. We encourage those with caring responsibilities to apply for our posts by stating explicitly that where possible, part-time hours will be considered.

All chairs of recruitment panels are trained in equal opportunities and professional HR staff are involved in all appointment processes. **Implicit bias training is mandatory** for all staff involved in academic recruitment in the UOA. Interviews for **senior academic appointments cannot proceed without female candidates on the shortlist** unless there is explicit agreement from the Vice Chancellor. **Male and female researchers have similar success rates** when applying for the title of Professor or Associate Professor in our Recognition of Distinction exercise (Section 2.3.3).

We have made substantial progress in increasing the **representation of women in senior leadership positions**

- Deputy Head of Medical Sciences Division (Translation and Personnel) (McShane)
- Director, NIHR Oxford BRC (McShane)
- Head of Department (NDWRH, Zondervan)
- Deputy Head of Department (NDM, Jones)
- Deputy Head of Department (NDWRH, Granne)
- Head of Kennedy Institute (NDORMS, Powrie)
- Head of Division of Structural Biology (NDM, Jones)
- Head of Nuffield Division of Clinical Laboratory Science (NDM, Gill)
- Head of Diabetes Trial Unit (RDM, Adler)
- Head of the MRC Human Immunology Unit (RDM, Simmons, starting 2021)
- Head of the Big Data Institute (RDM, Lindgren, starting 2021)
- Head of Early Phase Clinical Trials (Oncology, Blagden)
- 50% of the faculty of 22 of the Kennedy Institute are female including 65% of the 11 tenured Professors

Heads of Department and other senior staff promote a **strong culture of flexible working**, including to provide a family-friendly environment where everyone feels able to take the time to care for children, partners, ageing relatives or other dependents. **All departmental meetings are scheduled within core hours** and the ability to arrange working hours (whether part- or full-time) around core departmental hours to suit family commitments is accepted practice. Annual PDRs provide an opportunity to discuss flexible working and other adjustments like part-time arrangements, compressed hours, job-sharing, staggered hours, term-time only working, and working from home. Flexible working is common: in our 2018 survey, across all staff in our UOA, 65% of women and 61% of men who responded reported having **flexible working arrangements**.

There are **generous terms for parental and adoption leave** and an extensive range of **University childcare services** available across our sites. Departments in this UOA have sponsored 25 additional priority nursery places for staff since 2017. Staff who have taken a break because of caring responsibilities can apply to the **Returning Carer's Fund** for grants (typically up to £5k) to support their return to research, e.g. retraining or conference attendance. Awards totalling £192k have been made to researchers in UOA1 since 2016. On returning from parental leave, researchers with significant teaching loads can request reductions so they can focus on research.

Five of our seven departments have a dedicated member of staff for Equality, Diversity and Inclusivity (EDI) training and culture, who drives support and activities in these domains. Our departments have introduced their own tailored measures to develop a positive, equal, inclusive culture, including a departmental Charter or Good Behaviour Framework for staff describing measures to support a positive collaborative culture; biweekly 'pulse' surveys and regular focus groups; mandatory anti-harassment and bullying courses; a wellbeing programme; and a portfolio of

podcasts and interviews with departmental role models to support career planning. The effectiveness of our support for our female researchers is evident in the **similar success rates for both female and male researchers for their submitted grant applications** since 2014.

In line with our institutional REF Code of Practice, **we have placed equality and diversity at the heart of our processes for developing this REF submission [IES 3.4]**. Considerations of eligibility, output selection and impact case study selection involved multiple people in fair, transparent, auditable processes that were sensitive to the different circumstances and characteristics of individual researchers. In addition to the University's Equality and Diversity and Unconscious Bias training, further **REF2021-specific Equality, Diversity and Inclusivity training was compulsory for individuals** involved in decision-making. **Equality Impact Assessments** have been undertaken and reflected on at key stages in the REF process.

2.3 Principal Investigators

Several features of our staffing policies and infrastructure support the recruitment, retention and development of staff in positions of research leadership, the research they undertake in our UOA and the delivery of its impact.

2.3.1 Flexible appointments encourage interdisciplinary working

We encourage staff to have affiliations with other institutions, which enrich our environment as well as facilitate their own research.

- **Interdepartmental appointments**: For example, Rittscher (NDM and Engineering); Myers (NDM and Statistics); Edwards (Surgery and NDORMS); Tyler (RDM and Physiology, Anatomy & Genetics); Dong (NDM and RDM).
- **Joint working with the NHS** (OUH and NIHR) (also Section 4.1): Our strong University-NHS links for enabling research career development and activity is underpinned by **mutual support for researchers between the University's departments and institutes, and OUH**. 960 consultants work in UOA1 clinical areas, of whom 220 (23%) are UOA1 researchers with Honorary Consultant contracts, most taking 'hands on' clinical roles in specialist clinical areas relevant to their research interests. Furthermore, >200 OUH NHS consultants are either specifically supported by the NIHR Oxford Biomedical Research Centre to undertake research, and/or have specified research sessions in their job plans. Senior NHS staff play a major role in UOA1, with exemplars including: Crook and Peto (diagnostic pathogen sequencing, ICS-01WGS); Travis (translational gastroenterology); Banning (interventional cardiology); Willett (trauma surgery and national acute service planning). **Our researchers are supported in their clinical activities through honorary NHS contracts, annual consultant appraisals, job-planning and revalidation**, underpinned by the multiple UOA1 staff who also hold senior leadership roles in the OUH, e.g. Board Non-Exec Directors (Bell, Screaton), Divisional Directors (Hamdy, Carr, Kennedy) Clinical Directors (Hassan, Granne), BRC Director (McShane) and Director of R&D/Associate Medical Director (Channon).
- **Inter-institutional Appointments** include joint appointments, notably with Diamond Light Source (Stuart), the Crick Institute (Ratcliffe), the Wellcome Sanger Institute (Kwiatkowski, Aanensen), Public Health England Porton Down (Carroll), the Rosalind-Franklin Institute (Naismith, Fritzsche); ETH Zurich (Holländer), NICE (Adler), University of Jena (Eggeling), Karolinska Institute (Jacobsen), Gothenburg (Rorsman). New forms of cross-university, cross-institute working have been pioneered by the Arthritis Therapy Acceleration Programme (Buckley joint appointment with University of Birmingham).
- **Interactions with Industry** (Section 4.2): we encourage staff to interact with industry to accelerate the translation of their research outcomes and to take up entrepreneurship training and mentoring provided by the University. Academic staff have substantial **freedom to**

undertake consultancy (up to 30 days per annum without any change of contract) and professionally supported opportunities to found **spinout companies** (19 in this REF period), with joint appointments where appropriate, e.g. Lunter with Genomics plc, Dorrell with Immunocore.

Within the University, **College appointments** bring senior staff together from across the University and contribute to cross-fertilisation of ideas and opportunities. Our overseas and global health programmes exemplify **sharing with other HEIs** by including investigators from a number of UK institutions.

2.3.2 Personal rewards and development opportunities

- **Titular distinction**: The University conducts an annual assessment process to reward academic distinction [IES 3.1]; 156 current UOA1 staff have been awarded the title of University Professor and 90 were awarded this title in the current REF period. 163 Associate Professor titles were also awarded this REF period. The success rate for applicants at **full Professor level was 57% for both women and men** and at **Associate Professor level 81% for women and 77% for men**.
- **Remuneration for merit** schemes support staff recruitment and retention [IES 3.1].
- The University's **Innovation Awards** scheme recognised UOA1 researchers in the Teamwork (Schuh) and Policy Engagement (Pollard) categories in 2020.
- The University's **Public Engagement Award** scheme has recognised six researchers and three groups from across UOA1 since 2016.
- **Internal pump-priming research funding** totalling £1.8M has been provided to UOA1 researchers and departments are empowered to budget for discretionary funds to meet especially time-critical needs.
- **Time for research**: All academic staff are entitled to one term's sabbatical for every six terms of service; academics who secure funding for substantial research programmes can have a reduction in teaching commitments for the duration of the research project.
- **Training and development:** Academic Leadership courses are run for Department and Unit Heads and others who wish to develop leadership skills [IES 3.1]. External coaching is available for senior staff at significant career development points.

The result of these initiatives has been the recruitment and retention of research leaders: We have over 20 FRS and over 50 FMedSci in our UOA. 40 Senior/Principal Fellowship or equivalent awards have been hosted during the REF period, and 21 staff are currently NIHR Senior Investigators. **Notable appointments among the 76 new senior staff** since REF2014 include: Adler (Cambridge), Chakraverty (Imperial College), Elliot (Southampton), Giaccia (Stanford), Patel (Cambridge), Ray (Imperial), Richards (GSK), Screaton (Imperial College), Servais (Liège), Shi (Harvard) and Todd (Cambridge).

2.4 Postdoctoral and Early Career Researchers

Over 119 ECR (HESA definition) are being submitted in this UOA, but our targeted support for early career development spans a wide range of posts. Our UOA has hosted over 48 Wellcome Career Development, Sir Henry Dale, or similar intermediate Fellowships during the REF period, and over 70 transitional fellowships such as Sir Henry Wellcome, NIHR Postdoctoral or EC Marie Curie awards. ECRs in their first faculty position are supported as above. MSD offers rich career development opportunities for **postdoctoral researchers** (outlined below), and many of our current leaders have benefited from this training on their way to running their own programmes.

Many early career researchers secure their own Independent Research Fellowship, with funding from within the University or further afield. These fellows have the same status as tenure-track academic staff with regard to space allocation, access to facilities and input to policies. Post-doctoral

Box 2. ECR development: Professor Leanne Hodson

Mentored as a postdoctoral fellow in OCDEM, Leanne was awarded a BHF Intermediate Basic Science Research Fellowship in 2011. She was encouraged to take on leadership roles in RDM and chaired the RDM Career Development Committee and sat on the OCDEM Management Board, was Academic lead for Athena SWAN in OCDEM and now sits on the RDM Athena SWAN self-assessment team (SAT). Her department supported her to take the Academic Leadership Course and paid for her to undertake the Women Transforming Leadership Programme (Said Business School) in 2015.

She was awarded the title of Associate Professor in 2014 and awarded a BHF Senior Fellowship in 2016, followed by a titular professorship in 2018. She was appointed as Senior Research Fellow, Green Templeton College in 2018 and awarded the Starling Medal, Society of Endocrinology, UK in 2018.

She helped develop and now chairs the Basic Science panel for the Society of Endocrinology (BES) Leadership and Development awards. She has been the MSD representative on the Research Staff Working Group. To pass on her experience, she was awarded internal funding to run a workshop 'Playing with Presence: Confident Personal Impact Training' for 7 female DPhil students in 2018.

research assistants (PDRAs) are typically recruited on externally funded projects led by academic staff. Some PDRAs start developing independent responsibilities for specific parts of those projects, while others take their first independent steps on a transitional postdoctoral fellowship in their own name, while benefitting from close mentoring and infrastructure of an existing research group. Junior Research Fellowships (JRFs) from colleges offer further such opportunities (IES 3.2) and our submitted staff include 3 current appointees. All are supported to identify and work towards next steps in their career. Our declared ECRs include all of these types of independent researchers and also individuals in the early stages of their first academic post.

The University has established a new **University Advocate for Research Staff** as a single point of liaison with University management. The University's work to support career development in accordance with the **Concordat to support the Career Development of Researchers** has been acknowledged by the **European Commission's HR Excellence in Research Award** which the University has held since 2012 and renewed in 2020. A Divisional Lead (Frater) has responsibility for supporting the **research culture and career development of researchers**, especially early in their careers.

2.4.1 Support during early career development

Support specifically oriented to researchers early in their careers, both before and after first gaining independence, includes:

- **Personal Development Reviews**. These provide an opportunity for reflection and support in career development (Section 2.1). Supervisors have particular responsibility for ensuring they are undertaken fully for early career researchers and action points followed up.
- **Formal mentorship scheme** run by senior staff under the University's Code of Practice for the Employment and Career Development of Research Staff, and annual appraisal. We also support 144 UOA1 researchers (of whom 107 are women) through MSD's Peer Mentoring Circles.
- **Opportunities for teaching and training**. The University and MSD Skills Training programmes provide a wide range of relevant courses including how to apply for a first grant, being a principal investigator, time organisation, and building and managing teams.
- **Specific development schemes** to support postdoctoral scientists include the NDM Leadership Scheme, the Women's Transforming Leadership Course (Said Business School, with departmental sponsorship) and Leadership and Management Skills training.
- **Research facilitators** who support fellowship applications and career development.
- Competitive **fellowship schemes**, some with formalised career development programmes,

including the BHF Centre of Excellence transition fellowships and the Kennedy Career Development Programme (Box 3).

- **Opportunities** to gain experience on departmental leadership groups and committees on same terms as academic colleagues (e.g. Box 2).
- **Internal Research Funding** specifically for early career researchers, including through our John Fell Fund (£878k for UOA1 early career researchers in this REF period) and internal allocation of our Wellcome Trust ISSF (£282k to ECRs). Our Human Immune Discovery Initiative (HIDI) has provided pump-priming support to 30 ECRs, postdocs and research students in UOA1 (total £338k) enabling follow-on awards including a Versus Arthritis Fellowship .
- **Introduction to research in industry:** We have developed a programme of postdoctoral fellowships jointly funded with industrial partners, including Novo Nordisk (20 recruited) and BMS (22 recruited; Box 7). Fellows have both industrial and academic supervisors and work on carefully chosen projects with potential for industrial impact.
- **Membership of our Themed Research Networks** (Section 1.2.4: Immunology, Metabolism, Cancer, Global Health) to develop collaborations, discuss ideas and develop research proposals, present and critique data. For example, the OxImmuno Literature Initiative involved 29 postdocs and 58 students in what became an internationally-significant resource, enabled by support from the network's research facilitator. With over 300 reviews published, this initiative now has wider reach with BioRXiv and MedRXiv linking directly to our review website.

Box 3: Kennedy Career Development Programme

The Career Development Programme at the Kennedy Institute (KIR) guides the development of early career researchers ('fellows') to launch their own independent laboratories. It provides mentorship, a clear set of expectations, and a transparent decision-making process to support fellows as they work to secure tenure at the KIR or seek comparable positions elsewhere.

Fellows are recruited competitively. They undergo annual PDRs with the KIR Career Development Advisor and/or Director of Research and are strongly encouraged to select an additional mentor from the KIR Faculty. They are also encouraged to complete the EMBO Training and Leadership Course. A committee of two Oxford professors outside the KIR and an equivalent from outside Oxford formally evaluate the fellow's progress at years 2 and 4, based on potential to secure an external senior fellowship or build a grant portfolio, and provide detailed feedback. With a successful year 4 review, the initial five-year package is supplemented to seven years. By the end of year 6, a decision is taken on whether the fellow has established a largely self-sustaining research programme. If not successful at years 4 or 6, the fellow is given a further year of support as they pursue opportunities outside the KIR.

11 fellows have joined the programme since 2013, four with external fellowships from the outset and the other seven gaining external career development fellowships, investigator awards and research grants. Most are still within their 7-year programme. This support totalled £3.7M.

2.4.2 Support for Early Career Clinical Researchers

The Oxford University Clinical Academic Graduate School (OUCAGS, Pugh) supports the careers of **clinical academics in training posts** across MSD, including seminars, an accredited programme of research training, overseas placements, and funding opportunities.

Notable achievements include:

- Expansion to **74 Academic Clinical Fellowships (ACFs) and 61 Clinical Lectureships (CLs)** in post in 2019 (44% female), the majority in UOA1.
- **92% rated their academic experience as excellent or good** in 2019
- 54 of 80 Clinical Lecturer leavers over the last decade have gone on to academic posts or fellowships, and likewise 100 of 164 ACF leavers.

- Clinical doctoral training fellowships (Section 2.5).
- Support for at-risk specialties including 10 clinical lecturer posts in surgery over the last 5 years.
- With OUCAGS the Oxford Cancer Centre has developed a doctoral training programme in Cancer Science (Middleton, 19 per year) which **provides ongoing post-doctoral support** to retain successful researchers in academia as they continue their careers.

Working with our partners OUH and Oxford Brooks University, through the Oxford Academic Health Partners (Section 4.1), **we support academic trainees in nursing, midwifery and other allied health professions relevant to the Unit's research**, such as physiotherapy, supported by the NIHR Oxford BRC.

2.5 Research Students

The training mission of our UOA is integral to its research. We are explicitly committed through the University's Strategic Plan to ensure that we **recruit students of outstanding potential** whatever their background; foster a **supportive research culture** and provide **excellence in supervision, training, and resources**; support student well-being effectively; and increase the funding available to support research students.

The University aims to increase postgraduate research student intake by up to 400 per year and towards this end has recently founded a new graduate college [IES 3.3]. We also aim to significantly expand our graduate funding by creating an additional ~75 scholarships across MSD by 2023 (as part of a University-wide priority in the Strategic Plan), in part by establishing a Graduate Endowment Matched Scholarships scheme worth £10M, matching funding by donors.

2.5.1 Doctoral programmes

We offer 12 conventional 'direct entry' programmes, in which the research project starts in the first term, most usually aligned with individual departments. We have a number of structured research degrees under the umbrella of the Medical Sciences Doctoral Training Centre (MSDTC). The first year involves rotation between laboratories and coursework before a final choice of project. MSDTC programmes and their funders are currently:

- **Cardiovascular Science** (British Heart Foundation)
- **Cellular Structural Biology**, a collaborative programme with Diamond Light Source and the Rosalind Franklin Institute (Wellcome Trust)
- **Chemistry in Cells** (Wellcome Trust and industrial sponsors), in collaboration with Chemistry (UOA8)
- **Genomic Medicine and Statistics** (Wellcome Trust)
- **Doctoral Training Fellowship Scheme for Clinicians**, the DPhil in Biomedical and Clinical Sciences (Wellcome Trust and NIHR)

Broader options for graduate study include programmes in collaboration with other institutions, both within the UK and internationally:

- **Health Data Science**, in partnership with Health Data Research UK and the Turing Institute, with six other UK universities (Wellcome Trust).
- Participation through the Kennedy Institute in the **Rheumatoid Arthritis Centre of Excellence** (Versus Arthritis), with the Universities of Glasgow, Newcastle and Birmingham, partnered with the Kennedy Trust Prize Studentships to recruit 8 students per year who bridge the partner Universities.
- **National Institutes of Health** Oxford-Cambridge Scholars Programme (NIH), for collaborative projects with Bethesda, Maryland.
- **DPhil-MD programme** with Peking Union Medical College (Chinese Scholarship Council -

Chinese Academy of Medical Sciences).
- To maximise opportunities in our overseas research centres, we are establishing a specialist track within the DPhil in Clinical Medicine, in **Tropical Medicine and Global Health,** with around 12 scholarships per year for students based in our overseas centres in Africa and Asia.

Three new programmes have been designed during the REF period, with first cohorts due to start in 2020 or 2021:
- **Cancer Science** (Cancer Research UK) with additional funding realising 19 places, including 4 clinical training fellowships with bundled postdoctoral support.
- **Computational Discovery** at the interface between life and physical sciences (EPSRC), in partnership with IBM Research
- **Inflammatory and Musculoskeletal Disease** (Kennedy Trust for Rheumatology)

2.5.2 Student Funding, Recruitment and Diversity

We have focused on improving access to our graduate programmes as part of our drive to increase the number and quality of our research students. This has been underpinned by strong collaboration through a unified **Medical Sciences Graduate School** (Director: Gilbert), which has created a single point of entry for graduate applications and administration. The Graduate School's strategy has three main elements: improving the recruitment process; providing students with a first class training experience; and fully funding our research students. The number of DPhil graduates in UOA1 has increased by 31% between 2013/14 and 2019/20, while the number of applicants has increased by 55% (direct to departments, UOA1) and 23% (MSDTC, UOAs 1-5).

We have improved the funding we can offer to research students. We now have **more competitive stipends (>£18,000 per annum) and four-year studentships as standard** (except for 3-year clinical trainees). We have strengthened processes to allocate unrestricted University and available UKRI **studentships on the basis of academic merit** to students worldwide, via establishment of a Division-wide funding model, incorporated new internal funds. The Division holds an **MRC Doctoral Training Partnership** that supports approximately 25 students (UOAs 1-5) on any programme in the MRC's remit, while the MSDTC programmes offer fully-funded studentships including a generous allowance for research expenses. We offer a wide range of **clinical training fellowships,** including 5 Wellcome-funded clinical DPhil awards annually, 1-2 from MRC, and locally-administered schemes funded by BHF, CRUK, the Kennedy Trust and Novo Nordisk.

To encourage applications, the Graduate School website provides clear and comprehensive information on the application process, and funding and research opportunities organised by research theme, with direct links to potential supervisors. During the REF period we have taken steps to **increase diversity of our graduate student intake**, including:
- **Contextual data at application**: applications are now evaluated on the basis of factors including POLAR demographic status, provision of free school meals, and postcode, with ranking enhancement for disadvantaged students.
- **The UNIQ+ graduate access programme** [IES 3.3] gives an introduction to doctoral study to candidates who might not otherwise consider a research degree. In its first year (2019), 9 students undertook a paid internship in a UOA1 laboratory and received mentoring and guidance on applying for graduate study.
- Established **summer internship programmes** to encourage overseas students from China, Japan, Brazil, Mexico and Africa to pursue research at the University of Oxford.
- **Improved monitoring** of each Doctoral Training Centre programme, including admissions data by gender and origin (fee status).

Across MSD (broadly UOAs 1-5), the proportion of the PGR intake that declare ethnicity as BAME increased from 29% in 2013 to 34% in 2019. We will also embrace new University initiatives during the next REF period, such as the Academic Futures programme [IES 3.3] for under-represented

students, which will start with a focus on Black and Mixed Black British students. Through listening to and reflecting on evolving experiences, we seek to learn how we might better encourage the widest range of students to study with us.

2.5.3 Student Support

Students are **members of colleges** that provide a range of study and social facilities, support and often accommodation [IES 3.3]. Each student is allocated a college adviser who is not their supervisor and who provides **independent pastoral support** and can act as a student advocate. Our researchers contribute to this college support through their college affiliations and through college leadership roles (including Pollard, Vice Master St Cross; O'Callaghan, Dean, Queen's; Wordsworth, Dean, Green-Templeton; Coles, Cellular Lead, Reuben).

We offer a variety of routes to support students' **wellbeing and mental health** [IES 3.3]. The University has a **large professional Counselling Service** available to graduate students. A graduate student **peer-support network** also supports student well-being and mental health and since 2018 we have funded a programme training for these student volunteers. Colleges provide **college nurses** for simple medical advice and support. Information is provided via the Graduate School, at departmental and programme inductions, and via the University's Student Welfare and Support services. The **Link Counsellor Scheme** gives tailored advice to colleges and departments on supporting individual students, and the **Disability Advisory Service** assists both students and their host departments and laboratories.

Quarterly online progress reporting provides a **mechanism for early identification of issues** and appropriate interventions, whether personal or project-related, and members of the Graduate School Executive regularly advise departments and doctoral training centre programmes on individual student cases. Within MSD, the recently established Equality, Diversity and Inclusion Steering Group includes representatives of the Graduate School and the graduate student community, and will pursue an **inclusive culture that promotes equality and values diversity**.

OUCAGS gives support to **clinical trainees** through and beyond their doctoral studies, to help integrate research and clinical training and navigate through the associated logistic challenges.

2.5.4 Student Supervision

All research students have two or more supervisors who are responsible for their scientific training; they **assess training needs**, and identify appropriate courses that students should attend. All supervisors are **required to complete an online training course** before they supervise a research student; retraining is compulsory every 3 years. The University's **Code of Practice for Supervision of Research** sets out how supervisors should advise, guide and support research students in all aspects of their research project, including with regular meetings; and encourage them to participate in the wider University community.

Supervisors and students write **quarterly reports,** which are reviewed by the Director of Graduate Studies and the College Adviser. A centralised electronic system for reporting allows efficient communication between all parties and rapid dissemination of information. **Excellence in Supervision awards** have recently been introduced to promote and share good practice.

Progress is evaluated by independent assessors through **academic milestones** of Transfer of Status and Confirmation of Status. After 1 year the student must pass a Transfer to DPhil status assessment, involving a report and interview. At 3 years the student must confirm this status, with a report, presentation and plan for completion within 4 years. These provide valuable opportunities for all parties to reflect on progress and training, supervisory or other needs. Of students starting since 2013, over 86% of those completing did so within 4 years.

2.5.5 Student Training

The Medical Sciences Graduate School provides thematic training and support for all students within UOA1. Whether entering directly into a department or into the Doctoral Training Centre, all students are trained in an **environment in which there is a strong critical mass of experts and resources**.

- **Induction programmes** help integrate students as rapidly as possible and introduce the opportunities available.
- To foster a sense of belonging, a number of **community-wide events are organised**, including a highly successful annual symposium, featuring talks from current students and alumni working in a variety of fields and showcasing a variety of relevant topics. The annual **Divisional DPhil Day** provides a showcase of graduate student activity.
- Students have access to over 350 courses, including required courses in ethics, plagiarism and good laboratory practice, and all **undergraduate lectures** in MSD.
- A wide-ranging programme of **training in transferable, research and specialist scientific skills** is open to doctoral students, led by a Director of Skills Training and Researcher Development (Sabokbar). Over 90 courses and events are offered each year. Recent developments include courses in research integrity and reproducibility in research.
- The skills programme incorporates specialist **technical courses** available through the Doctoral Training Centres, such as electron microscopy, x-ray crystallography, MATLAB programming and computational biochemistry. Partnership with Diamond Light Source has enabled provision of training direct from Diamond staff.
- Opportunities for **interdisciplinary training and exchange** are fostered. Reciprocal arrangements are in place that provide all students access to courses offered to externally-funded DPhil programmes, such as those supported by Wellcome and the BHF.

We have developed our training in translational research and entrepreneurship:

- We work with the University Careers Service to provide **micro-internships** of 2-5 days each giving placements in the private and public sector; interactive workshops developing **commercial awareness**; and the opportunity for 1-to-1 careers consultations and to work with Careers Outreach Fellows (recent DPhil graduates who can help signpost potential career options).
- Many of our full-funded studentships, e.g. from Wellcome Trust, include a **transitional fund** that can be used to support internships and other activities for career development towards the end of the course.
- Opportunities to **work closely with an industrial partner** are provided by five MRC Industrial Collaborative Awards Studentships (iCASE) per year. Close links with pharmaceutical companies provide additional benefits to students through funding support and industry expertise.

We are developing a **course in Innovation Strategy for DPhil Students** with a project team including DPhil student, post-doc, academic, and entrepreneur representation to deliver 50 hours of teaching over an academic year in 2-3 day modules. This builds on recently developed introductory courses in innovation and entrepreneurship.

2.5.6 Exemplars

The excellence of the clinical school and graduate programmes has enabled students to make major contributions across the spectrum of clinical medicine. Our success in training and developing our students' potential is evidenced by the many national and international awards they have won, with examples listed in Section 4.11.3.4.

3 Income, infrastructure and facilities

3.1 Income

Our strategy is to grow a diverse and sustainable portfolio of research funding. Research income in UOA1 grew by 33% from 2013/14 to 2019/20 [REF4b and Figure 4]. More than 50% (by value) of the funded research projects starting during the period were for 4 years or longer.

Research income reported for 2015/16 in REF4b includes £80.6M capital income that was incurred in other years but, due to a change in HESA reporting conventions, could not be aligned with the expenditure date. This is excluded from income described below and average growth above.

Key funders: In the REF period, the Wellcome Trust (total income £360M), Medical Research Council (MRC, £232M), Cancer Research UK (£109M) and NIHR (£124M) remained major funders. The NIHR Oxford BRC (renewed 2017, total award £114M) received the largest uplift in funding of any BRC in the UK. All NIHR income is reported under Health Research. The NIHR BRC also accounted for £149M of our income-in-kind [REF4c].

Other notable **charitable income** includes the British Heart Foundation (£40.9M), the Kennedy Trust for Rheumatology Research (£27.2M), Versus Arthritis (£15.8M) and the Structural Genomics Consortium (£13.7M).

UK Public Sector income has grown considerably over the period and includes income from the Departments of Health and Social Care (£43.2M); International Development (£12M); and Business, Energy and Industrial Strategy (£7.5M). Commercialisation of our work has been advanced by £12.8M from Innovate UK over 31 projects. £9.3M research income came from OUH, NHS Blood & Transplant and other NHS units, reflecting our close links with both local and national NHS providers.

EU Government funding is predominantly from the European Commission (£87M). Major awards included the ULTRA-DD FP7 consortium for drug discovery (total €50M with £7.4M income to Oxford during the REF period, *Bountra*); the consortia MultiMalVax then OptiMalVax for a high efficacy malaria vaccine (together £7.0M), and IMPROVE for vectored vaccines for prostate cancer (£3.0M), both coordinated by Oxford (*Hill*). Seven ERC grants were awarded to our researchers.

Over the REF period, our **industry** research funding has grown in support of strategic partnerships, including with AstraZeneca, Novo Nordisk and BMS. Over £17.8M of non-EU industrial funding was associated with clinical trials, and £11.7M from UK charities, out of £89M research income for trials from 2013/14 to 2018/19.

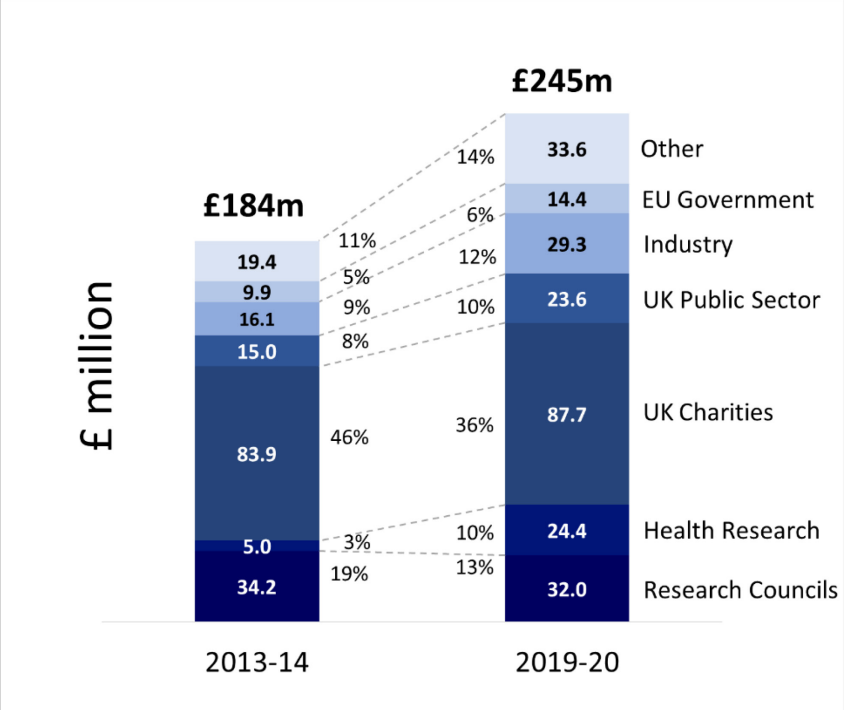


Figure 4: Growth and diversification of research income from 2013/14 to 2019/20.

Support for securing funding includes 5 research facilitators, and other professional support roles, who assist researchers in identifying appropriate sources, preparing accurate budgets and assembling high-quality applications. The MSD team and the central Research Services team supplement this with support for the largest applications and the most high-volume schemes. Support for legal and contractual aspects is described in Section 3.4.

Our research income is supplemented by **philanthropic donations** that enable research, including new endowed Chairs, new buildings, fellowships and studentships, equipment, and public engagement projects. In 2020, this route enabled us to rapidly support projects to address the COVID-19 pandemic (Box 1). We used unrestricted philanthropic donations received for COVID-19 research to establish the **COVID-19 Research Response Fund (CRRF)** for high quality, high impact projects. 256 applications were received and reviewed between April and June 2020. 91 awards were made to projects totaling £8.2m, of which 46 awards totaling £5.5M were led by UOA1 researchers. Some of this funding underpinned the vaccine trial (Box 4).

Early stage translation is **pump-primed through internally-managed funds** designed to develop the potential in our UOA's research. The Medical and Life Sciences Translational Fund (comprising MRC Confidence in Concept, BBSRC IAA and a portion of Wellcome ISSF) has distributed over £6.8M funding (income) to projects in UOA1 during the REF period. Further support was given to 18 projects through the University Challenge Seed Fund (£1.5M). Lab282 (2016), a joint initiative

Box 4: Accelerating the COVID-19 vaccine trial

£600k of the CRRF was allocated to pay for the temporary buildings that were used to vaccinate volunteers in the Oxford-AstraZeneca vaccine clinical trial. From the call deadline on 9 April 2020, they were notified that the funding was awarded on 15 April and the budget was made available for spending from 24 April 2020. The extremely rapid review and awarding process for the CRRF allowed the buildings to be ordered and delivered to the Old Road Campus and for the clinical trial to begin vaccinating volunteers while the University awaited receipt of the trial's major external funding. This action was critical to allow the trial to start in time to vaccinate volunteers during the first wave.

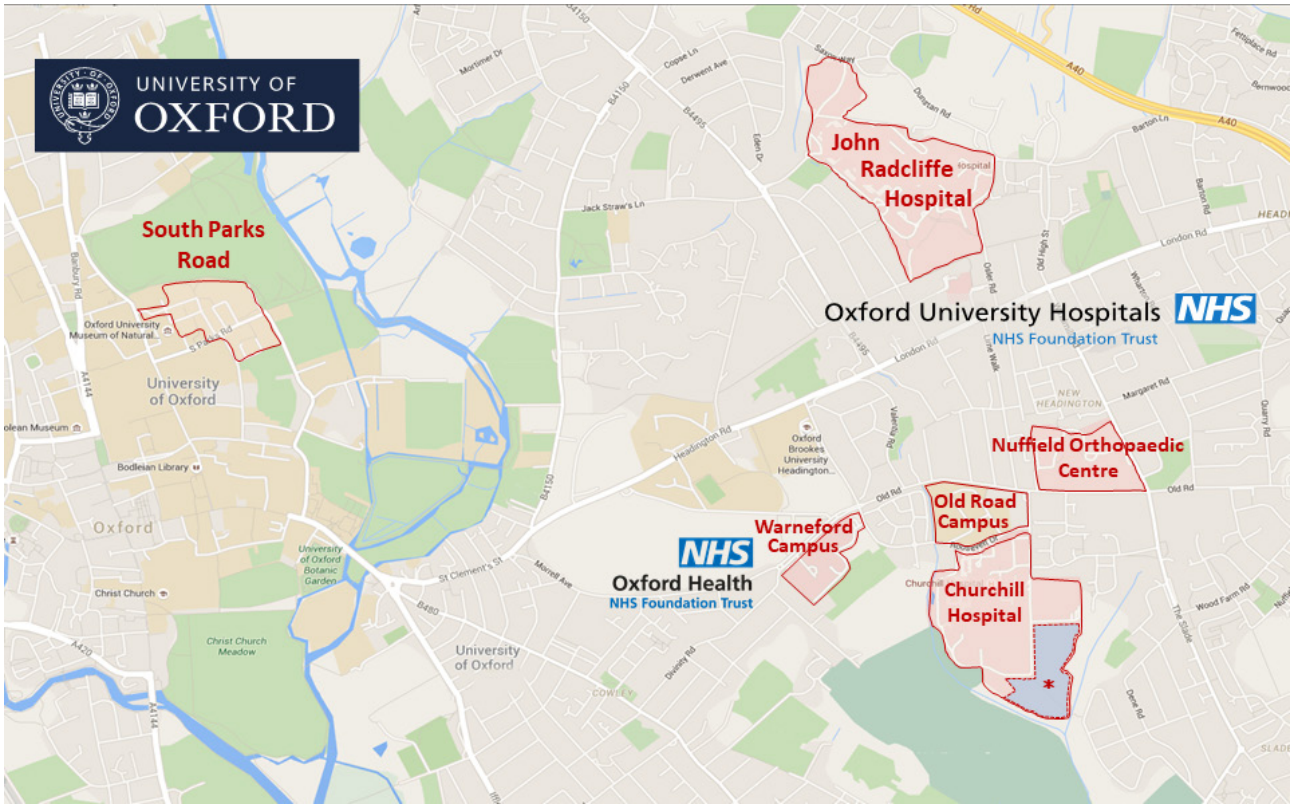
between the University, Evotec and OSI to translate disease-related biological pathways into focused drug discovery programmes has awarded £7.9M for 25 research projects in UOA1. Lab10X, a joint initiative between the University, Sensyne Health, Evotec and OSI, was created in 2019 to translate AI and digital health solutions for data-driven drug discovery and development.

3.2 Buildings

Our UOA's buildings in Oxford are immediately adjacent to, or physically embedded within, our partner NHS hospital sites, a strategy that has taken advantage of available space to pursue parallel expansions across all four hospital sites that lie within a one mile radius in Headington, Oxford (Figure 5). These sites also host our Departments in UOA2 and UOA4, and are only 2 miles from our biological (UOA5) and physical sciences departments in the Science Area in central Oxford. Together, our buildings and sites constitute a vibrant, integrated and multi-disciplinary health sciences campus that underpins the scale and scope of our research.

The continued development of our Unit's buildings during this REF period, and the co-location with other UOAs and NHS partners, is illustrated by the growth of the University's Old Road Campus (Box 5). The majority of our research institutes are situated on university-owned land on the Old Road Campus adjacent to the Churchill with the Weatherall Institute of Molecular Medicine on the John Radcliffe hospital site.

Figure 5: **Map of principal locations of UOA1 research and NHS sites. The land recently acquired by the University on the Churchill Hospital site is shown in blue.**

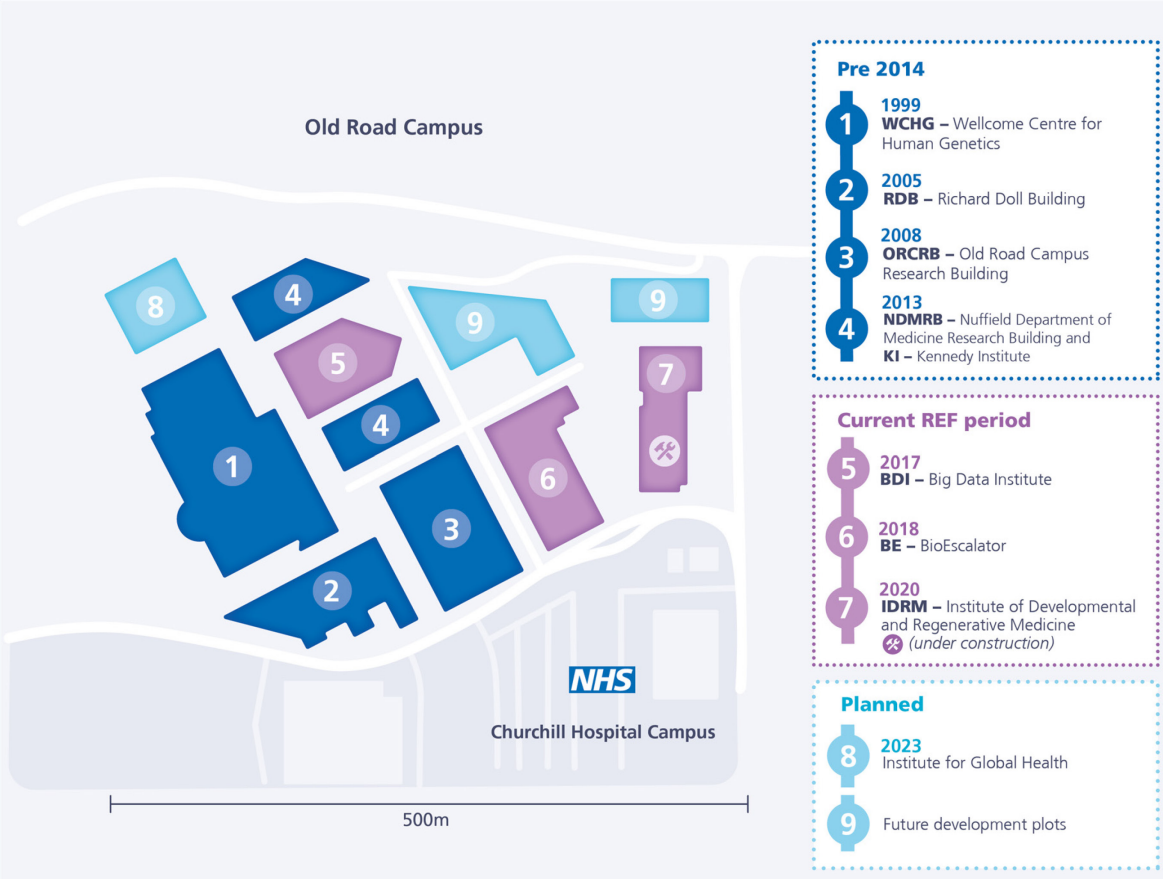


Box 5: Old Road Campus

Our strategy to create a fertile interdisciplinary environment is exemplified by our structured and accelerating development of the Old Road Campus on university-owned land adjacent to the Churchill Hospital during this REF period. The catalytic value of our approach was evident from the success of the Wellcome Trust Centre for Human Genetics (1999), the first institute on the campus, which brought together an essential critical mass in genetics and structural biology to accelerate research across a wide range of diseases. Further major institutes followed including the Old Road Campus Research Building (2008), the Target Discovery Institute (2013) and the Kennedy Institute (2013).

In this REF period, we have added the **Big Data Institute** (£46M, 7,400m^2, 2015; a REF2014 aim) to study healthcare at scales from molecular to population, the **Innovation Building** (£60M, 18,000m^2, 2019) containing our **BioEscalator** (2019, a REF2014 aim) start-up incubator and the **Novo Nordisk Oxford Research Centre** (NNORC, £100M, 2019) bringing industry onto our campus; the **Kennedy Institute extension** (£3M, 750m^2, 2020) and gnotobiotic/microbiome facility and the **Institute for Developmental and Regenerative Medicine** (£31M, 5,900m^2, opening 2021).

In 2019, we **purchased 10 acres of land** from Oxford University Hospitals NHS Foundation Trust (OUH). This land is adjacent to our existing Old Road Campus and will be transformative for long term expansion. Future plans for this land include BioEscalator II, new research institutes and housing major commercial partners. The University has raised £750M from issuing a bond, which is enabling these major new land purchases and buildings.



Our departments all have major component units incorporated into the hospital sites. There are units of all our departments at the OUH's John Radcliffe Hospital; Oncology, NDSS, RDM and NDM at the OUH's Churchill Hospital and NDORMS at the OUH's Nuffield Orthopaedic Centre. This places researchers in the appropriate context, with clinical care for cancer, haematology, dermatology, transplantation and elective surgery at the Churchill Hospital, musculoskeletal medicine at Nuffield Orthopaedic Centre and most other specialties and acute care at the John Radcliffe Hospital, ensuring our researchers are in touch with contemporary clinical medicine and are, literally, well-placed to develop the impact of their research through clinical translation. Co-location in the hospitals facilitates patient participation in clinical research studies. In turn, many UOA1 staff provide state-of-the art clinical services to NHS patients, which attracts specialist referrals for research studies and develops innovations for the NHS which drive adoption and impact. Exemplars include inherited cardiomyopathies (*Watkins*), genetic craniofacial disorders (*Wilkie*), ankylosing spondylitis (*Bowness*) and multiple endocrine neoplasia (*Thakker*)

Regionally in Oxfordshire our researchers work closely with the nearby Diamond Light Source synchrotron facility [UKRI income-in-kind, REF4c] and Rosalind Franklin Institute with whom we share staff (notably *Stuart* and *Naismith* respectively, Section 2.3.1) and produce shared research outputs. Beyond the UK, our researchers work on location in our Africa and Asian Programmes co-located with Thailand's Mahidol University, the Ho Chi Minh City Hospital for Tropical Diseases and the Kenya Medical Research Institute.

3.2.1 New buildings and space

Our sustained investment in new buildings means that our researchers work in high quality, purpose-designed laboratories. During the REF2021 period our capital investment in physical construction was £185M, including:

- Innovation Building (£60M, 18,000m^2, 2019), a new building to house the University's BioEscalator (business incubator), the on-campus Novo Nordisk Research Centre Oxford (a £100M investment in Oxford) and centralised operational facilities for the Old Road Campus.
- The Big Data Institute (£46M, 7,400m^2, 2015) within the Li Ka Shing Centre for Health Information and Discovery, a new building to focus expertise and develop further critical mass in the acquisition, handling and analysis of large, complex, heterogeneous datasets to drive forward disease understanding and therapeutic development.
- The IMS-Tetsuya Nakamura Building, home to the Institute for Developmental and Regenerative Medicine (£31M, 5,900m^2, opening 2021), will bring together developmental biology relevant to medicine with research on tissue regeneration to develop innovative therapeutic approaches.
- Marcella Wing of Botnar 3 (£10M, 2,000m^2, opening 2021), to house a GMP Clinical Biomanufacturing Facility for implantable medical devices.
- Oxford Centre for Clinical Magnetic Resonance Research expansion and infrastructure enhancements (£5.5M, 679m^2, 2017-2019) to accommodate a further 3T magnet and enable hyperpolarised MR clinical research to study organ metabolism, especially cardiac metabolism in human disease.
- Kennedy Institute expansion (£3M, 283m^2, 2020) to accommodate researchers in computational biology, informatics and clinical trial management.
- COVID-19 vaccine trial buildings (£1m, 2020)
- Led the creation of the NIHR National Biosample Centre in Milton Keynes (£25M, 2014) to provide robust archival storage of clinical samples for users across the United Kingdom.

3.2.2 Investment in existing buildings

As well as investing in new space we are have invested in existing buildings in order to optimise their use in support of our academic endeavour. Significant projects that have added to our research capabilities include:

- PET Radiopharmacy Facility (£5.8M, 2017, 419m^2) to provide GMP-grade PET radiopharmaceuticals and radiotracers for clinical trials and preclinical research.
- MRC WIMM Centre for Computational Biology, (£2.4M, 2016, 783m^2) refurbished to accommodate 60 computational biologists
- Kennedy Gnotobiotics Facility (Matilda II) (£3.2M, 2016, 349m^2) to study animals that are germ-free or have precisely defined microbiomes.

In 2019, we **purchased 10 acres of land** from Oxford University Hospitals NHS Foundation Trust (OUH). This land is in close proximity to our existing Old Road Campus (Figure 5) and will be transformative for long term expansion of our biomedical science research capacity. The University has raised £750M from issuing a bond [IES 2.1], which is enabling these major new land purchases and buildings. Further plans for investment in the coming REF period include:

- Institute for Global Health
- Institute for Pandemic Preparedness
- BioEscalator II
- Expanding the Clinical Biomanufacturing Facility
- Expanding early phase trials facilities

3.3 Facilities and Resources

The resources and facilities available to researchers in the Unit are rich and varied. Over the REF period we have developed and maintained research infrastructure to accelerate translation, notably in single cell analysis, drug and target discovery, imaging, manufacturing capacity, clinical trials, clinical facilities and data analysis.

We have invested in technology for the analysis of single cells through the creation of the Oxford Single Cell Biology consortium (£3m+), where we have transformed our capabilities in single cell sequencing, CytoF technology and single cell and molecular imaging.

Drug and target discovery: Drug discovery infrastructure is well developed in our Target Discovery Institute and in the Structural Genomics Consortium and includes high throughput liquid handling and robotic cell screening, curated compound libraries and tool compounds, protein production facilities, advanced analytical technology, mass spectrometers, NMR and medicinal chemistry facilities with state-of-the-art chemical synthesis laboratories.

Imaging: We have developed a number of advanced imaging facilities for clinical and basic research. Highlights include MR imaging and spectroscopy including clinical high field imaging with advanced hyperpolarised clinical MR facilities in cardiac (^{13}C) and respiratory (Xe); new Cryo-Electron microscopy facilities (£3.6m); and one of the country's first MR-Linac clinical research facilities (£3m) in partnership with GenesisCare. State-of-the-art CT facilities are intrinsic to our Acute Vascular Imaging Centre (AVIC) which has led to high profile work on cardiac CT (Antoniades) which will be further developed over the next six months.

Manufacturing capability: Our Clinical Biomanufacturing Facility is embedded within the Jenner Institute and can produce biological Investigational Medicinal Products (IMPs) according to Good Manufacturing Practice, which has been exceptionally important in enabling new vaccine trials. It has been pivotal in the development of our ChAdOx-SARS-Cov-2 vaccine and an extension is planned. A new manufacturing facility for implantable medical devices will open in June 2021 as part of the development of the Botnar Research Centre and will be the only such facility run by an HEI in the UK.

Clinical Trials Centres: we have invested in these in Oxford and in each of our main overseas units. In Oxford, trials units include the Diabetes Trial Unit (Adler, formerly Holman), Respiratory Trials Unit (Rahman), the Oncology Clinical Trials Office (Maughan, Blagden from 2021), and the Surgical Intervention Trials Unit (Douek, Beard), all embedded in the Oxford Clinical Trials Research Unit (OCTRU, Richards). This activity benefits from collaboration with the Clinical Trial Service Unit (Collins, UOA2), which consolidates Oxford's position as the largest clinical trials centre in the UK. The new **Centre for Clinical Therapeutics** (Richards, ex GSK) is part of the OCTRU and focusses on early phase experimental medicine trials.

Clinical facilities and data analysis: Oxford Biobanks include multiple patient collections in our UOA, including the Transplant Biobank (Ploeg), Oxford Radcliffe Biobank (Verrill), the Prostate Cancer repository (Hamdy), the Botnar-Kennedy Biobank of joint tissue and the Oxford Biobank of pre-genotyped individuals (Karpe).

We have invested in **huge scale research computing facilities (£7m+)** through our new Biomedical Research Computing platform, which now offers support beyond UOA1 to more than 20 departments (including UK Biobank, Wellcome Centre for Integrative Neuroimaging and within UOA1 to remote groups including our Thailand unit). This capability includes as the single largest cluster (~7,000 CPU cores, >80 GPU cards), the largest (>20PB) and fastest (~50GB/s) storage facilities, the fastest networks (100Gbit/s Ethernet and InfiniBand) and, significantly, the only production on-premise cloud facilities in Oxford (~1,500 CPU cores, >40 GPU cards). The OpenStack cloud capability includes an isolated platform developed to support the partnership with Novartis and approved for secure handling of very large sets of clinical data. Future plans include moving to carbon-neutral data centres and advanced security and governance to allow otherwise unrestricted commercial and clinical data use. The MRC WIMM hosts a Centre for Computational Biology using computational approaches to **data visualisation and artificial intelligence** to understand complex biological systems and treat human disease. Our substantial computational infrastructure allows us to undertake research using massive datasets, especially those derived from clinical activity, multi-omic approaches and digital imaging. These analyses offer potentially rich insights into disease mechanisms and drug target prioritisation, as well as advanced diagnostic approaches through AI.

Our UOA benefits from comprehensive library support allowing our researchers broad access to scientific literature. The **Radcliffe Science Library** (part of the Bodleian Library [IES 4.2]), has sites on both the John Ratcliffe and Old Road campus and delivers extensive electronic access to conference proceedings and journals from professional societies, including ACM, IEEE, SIAM, and AMS, and all major publishers. It gives extensive practical support and training to researchers, especially those developing their research skills alongside clinical duties.

3.4 Capability to support research and innovation

This REF period has seen **transformational change in our capabilities to support research and its translation** through growth in our support teams, funding and space.

Our extensive **Research Services** provision [IES 4.1] includes a team dedicated to the medical sciences, who handled over 2,000 grant applications, over 300 fellowship applications, 2,600 collaboration agreements, over 4,000 material or data transfer agreements and 68 memoranda of understanding for UOA1 over the REF period. This major growth in grants and contracts activity mirrors the growth in our research portfolio and as such we have expanded the team to better support the volume. The Clinical Trials and Research Governance Unit supports our many clinical trials, including large numbers of overseas and first-in-human trials (including 578 funded clinical trials and 2,081 clinical trial site agreements).

3.4.1 Expertise to support translation and innovation

We have **expanded and evolved our support teams**, supporting an expert Research Services and Technology Transfer Office, expanding our Business Partnering Office and launching a Translational Research Office. Together these teams have facilitated a step change in the funding available to achieve impact from our research.

Our **Technology Transfer** company Oxford University Innovation (OUI) [IES 2.1] provides technology transfer support to researchers and promotes the wider impact of their research and intellectual property. The University has **arrangements in place to incentivise academics to translate and commercialise their research,** including support in protecting intellectual property as well as the allocation of royalties and equity [IES 2.2].

The **Business Partnerships Office** (BPO) provides support for collaboration with businesses. The team support the diversification of research income by securing funded research partnerships with large and small businesses and securing access to 'in-kind' research resources, proprietary technologies and tools. The office also delivers a range of academic-industry knowledge exchange, innovation training and business networking opportunities, facilitates the presence of visiting industry fellows and explores opportunities for co-localisation of companies on campus.

To maximise the translation of our world-class discovery science portfolio at the earliest stages we established a **Translational Research Office** (TRO) in 2019. This £200k/year (3.5 FTE) investment in translational support infrastructure ensures researchers have access to expertise from the academic, clinical and commercial sectors to enrich research programmes and maximise their potential for clinical uptake and commercialisation. It has provided support to 67 early stage translational projects in UOA1, creating a pipeline of opportunity for investment and commercial uptake. Funding from the MRC Confidence in Concept scheme (£2.5M) has been used to provide short term project funding for translational acceleration.

We have supported our **Royal Society Entrepreneur in Residence** (Carey) to establish an **Industry Expert in Residence programme,** managed by the TRO, the BPO and OUI. It aims to give researchers access to world-leading expertise and advice across multiple industry sectors. Approximately 20 experts from a range of sectors can discuss researchers' ideas and projects in confidence to help them develop an appropriate translational strategy for their technologies.

3.4.2 Funding and space for innovation

The availability **of capital for spin-out companies** has substantially increased through Oxford Sciences Innovation (OSI), which has supported nine of our UOA spinouts during this REF period with over £80M investment: *MiroBio* (2019, Cornall, Davis), *Evox Therapeutics* (2016, Wood), *Base Genomics* (2018, Song), *Vaccitech* (2016, Hill, Gilbert), *Nucleome Therapeutics* (2019, Hughes), *Theolytics* (2017, Seymour), *Orbit Discovery* (2015, Ogg), *PepGen* (2018, Wood), and *Caristo Diagnostics* (2018, Antoniades).

Our business incubator, the BioEscalator, opened in 2019 and was purpose-built to incubate high-potential start-up bioscience companies adjacent to academic laboratories and clinical research centres on our Old Road Campus. An entry criterion is that companies must be engaged in collaboration with University of Oxford research, so that co-location enriches the research environment. A total of 17 companies used the BioEscalator in the first two years; as of July 2020 there were 13 resident companies employing 110 scientists, innovators and entrepreneurs developing of novel diagnostics, therapeutics and platform technologies. Three companies have graduated from the BioEscalator into larger premises at the Oxford Science Park. Current and former occupants include MiroBio (Box 6), MoA Technology and Theolytics. BioEscalator tenants have already attracted £116M investment since moving in.

The BioEscalator is also a focal point for the entrepreneurial biosciences community in Oxfordshire: it has hosted 85 events in its first 2 years, bringing together researchers, entrepreneurs, clinicians, regulators, funders and industry colleagues. Demand for space in the BioEscalator is very high and so plans for BioEscalator II are underway.

Our partnership with Novo Nordisk evolved into the Novo Nordisk Oxford Research Centre (NNORC), hosted in the same Innovation Building that houses the BioEscalator. This is the largest on-campus co-located pharma facility in the UK, representing a 10-year, £100M investment by Novo Nordisk. We have developed new approaches to hosting NNORC staff and visiting industry fellows on campus. The Director of the NNORC (Haynes) is a visiting professor in UOA1 and an industry Expert in Residence.

Box 6: MiroBio
MiroBio is a novel therapeutics company based on insights into the regulation of receptor signalling in immune cells from the research of UOA1 researchers Davis and Cornall. MiroBio started operations in May 2019 at the BioEscalator with an initial £16m investment and a team of two people. It was supported in the BioEscalator to grow rapidly to 15 people and, following exciting lab results, raised a further £11m investment. It has now graduated from the BioEscalator to the nearby Oxford Science Park where it continues to grow and move its auto-immune disease therapeutics rapidly towards the clinic. MiroBio continues to license patents, fund collaborations and pay to use equipment in the University.

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

4.1 Partnership with the NHS

(also Sections 1.2.5, 2.3.1 and 3.4)

Our research benefits greatly from a **tightly woven and nurtured interaction between the University and the NHS**, including joint research administration, shared estate and clinical trial facilities on our shared hospital campuses and joint capital master planning. UOA1 is highly integrated with the **Oxford University Hospitals NHS Foundation Trust (OUH)**. OUH is one of England's largest university teaching hospital trusts, with hospitals across several sites and now hosting some 2,000 active clinical studies. It has ~1,100 consultant staff, of whom more than 230 are University employees with Honorary NHS contracts. Two of the acute general medical on-call team during this REF period are FRS (Ratcliffe and White), and other FRS lead specialist NHS clinical services (Watkins, Thakker, Wilkie).

Our relationship with the NHS is of critical importance and during this REF period, we have made significant progress in **forging a closer relationship with OUH.** Our co-location with the hospitals is fundamental to this relationship and promotes mutual understanding and coherence around our training, research and clinical activities. We continue to embed research on clinical campuses and develop joint activities, especially through **Oxford's two NIHR Biomedical Research Centres**. In 2015, we agreed further integration with the acquisition of foundation status for the hospital trust and a **change of name to OUH to reflect the strong collaboration.**

A **Strategic Partnership Board** links OUH and the University to develop local healthcare. Our **researchers are integral to NHS management** and have played major roles in the Trust since 2014 as Directors on the Trust Board (Bell, Screaton), Director of Research and Development (Channon), Strategic Partnership Board (Watkins), Directors of three major divisions of the OUH (Hamdy, Kennedy, Carr, all also heads of UOA1 departments), and as Clinical Director Gynaecology (Granne). A **Joint R&D Committee** has been established between OUH and the University to strengthen research opportunity and infrastructure, with governance provided by a formal **OUH-University Joint Working Agreement**. We have a number of mechanisms to invest in new capabilities or maintain facilities including internal funds, a minor capital programme based on strategic need, and bids to external funders and philanthropists.

The Unit and OUH co-lead the NIHR **Oxford Biomedical Research Centre** (NIHR BRC), a £23M/year NIHR centre, awarded the biggest funding uplift nationally during this REF period, to accelerate research translation into clinical practice. The Director (McShane) and most Theme Leaders are from UOA1. The Centre has 20 research themes, most led by UOA1 researchers and supporting 400 staff working on over 700 studies and **bringing in over £200M of industrial funding.** We collaborate further with the NHS through the **Thames Valley and South Midlands NIHR Local Clinical Research Network (LCRN)** hosted by OUH to support clinical patient-centred research across the region (£16M per annum; 63,649 patients recruited to 779 studies in the year 2018/19) and our staff lead national (Glyn-Jones) and regional (Pollard, O'Callaghan, Tomlinson, Leeson, Ogg) specialty CRN groups.

Our **Joint Research Office** brings together the University and NHS research administration teams to facilitate biomedical and translational research across the partnership**,** and was recognised by the Academy of Medical Sciences in 2019 as a national exemplar. The number of **clinical research studies** hosted by the OUH on behalf of the partnership has grown from 1,450 in 2014 to 2,000 in 2020, with an aggregate of **3,106 clinical research studies initiated and/or active during this**

REF period. Of these 2,000 research studies, more than 600 are formally sponsored by the University of Oxford, 970 are led by a University of Oxford PI and 800 are led by an OUH PI, reflecting the **high level of research leadership across both University and NHS partners**.

This close and multi-faceted partnership enabled **joint structures and governance to be rapidly implemented during the pandemic** to allow fast initiation and execution of major COVID-19 clinical studies. 20 Urgent Public Health studies were hosted at Oxford and the RECOVERY trial recruited its first patient 9 days after the protocol was finalised (ICS-30RECOV-1, Box 1).

Our relationship with the NHS has been further strengthened with the **designation of Oxford Academic Health Partners as one of the national Academic Health Sciences Centres**, which underpins joint working in translational infrastructure, clinical research training, streamlined clinical research management, and early phase clinical research facilities. It brings together the University of Oxford, Oxford Brookes University, OUH and Oxford Health NHS Trust. It also engages with the Oxford Academic Health Science Network and the Buckinghamshire, Oxfordshire & Berkshire Integrated Care System to ensure **links to social and community care**. Board members (Chair, Bell; Director, Channon) are all key decision makers in their own organisations at Chief Executive level or equivalent. This allows **regional integration of our research infrastructure**, especially the NIHR Biomedical Research Centres and our clinical research facilities.

4.1.1 Supporting research active NHS clinicians

The interaction with the NHS is essential to our research activity and we seek to **support our local NHS clinicians to undertake research** with us across the different stages of their careers and have over 200 Category C researchers in our UOA (Section 2.3.2). Through OUCAGS we provide mentoring and research experience and training opportunities for junior clinicians (Section 2.4.3). At consultant level, we provide honorary university contracts with access to university infrastructure and through the BRC provide research time buy-out, mentoring and support for external grant acquisition. We support NHS clinicians in early career (e.g. MRC CARP fellowship: Shapiro, Curry) and established leaders (e.g. NIHR Senior Investigator Awards: Crook, Peto). **More than 200 OUH NHS consultants** are either specifically supported by the NIHR Oxford Biomedical Research Centre to undertake research, and/or have specified research sessions in their job plans and most undertake that research with us (Category C). Senior NHS staff play a major role in UOA1, with exemplars including: Crook and Peto (microbiology), Travis (translational gastroenterology), Banning (interventional cardiology) and Willett (trauma surgery and national acute service planning). Of the 740 OUH NHS consultants working in UOA1 specialties, 207 are the formally-designated Principal Investigators (PIs) of research studies. NHS clinical researchers are regularly awarded Full Professor and Associate Professor titles.

The involvement of NHS staff is central to much of our research and examples include:

- Collaboration with the NHS (Peto, Crooke) to advance the **Modernising Medical Microbiology** agenda, with real impact on clinical practice and delivery of state-of-the-art sequencing technology into clinical microbiological practice (ICS-01WGS, 02TB). Beyond our UOA and OUH, this Consortium involves 3 other hospitals, the Health Protection Agency, and the Sanger Institute. The established infrastructure and expertise garnered government-commissioned work (Crook, Eyre) on optimal laboratory testing strategies for COVID-19 (ICS-33COVIDTEST).
- Our researchers, with NHS colleagues, have undertaken major practice changing **Trials in Orthopaedic Surgery**, including the CSAW trial (ICS-07SHOULDER).
- The WHiTE study (Costa) is an **Oxford-led partnership with 40 NHS Trusts**, 24,000 participants to date and 9 embedded RCTs in the Trauma field.
- In collaboration with OUH, we have developed a new NIHR-supported academic unit to address major NHS priorities through research and innovation in **multimorbidity, integrated care and acute medicine** (O'Callaghan).
- We are investing in research to accelerate the integration of **digital pathology** into routine

practice, including through our NIHR BRC Molecular Diagnostics Theme and appointment to a statutory chair (Leedham, 2020) to deliver next generation pathology. Our recruitment of an NHS-embedded research pathologist (Easton) will drive translation in the clinical service.
- In collaboration with OUH we have created the **Oxford Centre for Haematology** (Vyas).
- The NIHR BRC-funded **Oxford Experimental Cancer Medicine Centre** (Blagden) and **CRUK Centre** (Lu, then Middleton) coordinate early phase medical and radiotherapy trials, and through the national **Clinical Research Network** incorporates >30 further hospital Trusts.
- The **National Consortium for Intelligent Medical Imaging** (Gleeson) gathers data, develops image analysis algorithms and translates these into practice with industry partners and 14 NHS Trusts.
- **The Arthritis Therapy Acceleration Programme** (A-TAP, 2018, £7M) brings together 7 NHS trusts with the Universities of Oxford and Birmingham to create an academic-NHS-industry partnership for novel experimental medicine approaches to enable early Go/No-Go decisions in drug discovery.
- **Vaccine Trials**, including COVID-19, operating through multiple NHS partners in primary and secondary care and influencing vaccination policy and practice internationally.
- The **RECOVERY Trial** was undertaken in multiple hospitals including OUH (recruiting the first patient), with major roles played by NHS staff (ICS-30RECOV-1).

4.2 Partnership with industry

Our industry interactions are all supported through our investment in **dedicated and expanded support functions** (Section 3.4), through **funding for translation and spin outs** and **physical co-location of commercial and academic activity** (Section 3.4.2). Researchers in UOA1 produced over **1,500 research outputs with industrial collaborators**, with an average of 79 citations for these outputs.

We **drive ground-breaking innovative industrial partnerships.** The Structural Genomics Consortium has accelerated drug discovery through an **open source model, sharing data, reagents, tools and expertise** as widely and as early as possible. It is now evolving into the Centre for Medicines Discovery, to bring together all our activity in drug and therapeutic discovery, in both pre-competitive and proprietary science, building relationships with industrial partners, with planned expansion of medicinal chemistry. The ARUK Oxford Drug Discovery Institute and Target Discovery Institute work with multiple industrial partners (Pfizer, Takeda, Bayer, Boehringer Ingelheim, Abbvie, Janssen, Merck, Ag, MSD, Novartis, Genentech). The creation of the Big Data Institute has enhanced a **commercial focus for health informatics** in the UK, exemplified by a 5-year alliance with Novartis (£1M/yr from 2019) to apply AI and advanced analytics to large healthcare datasets and clinical trial data to predict disease risk and patient response, especially in multiple sclerosis, dermatology and rheumatology. A $10M collaboration with BMS includes a joint project team with staff from Oxford, BMS and Evotec. LAB10X (2019) is a new partnership including the University, Sensyne Health (an OU/ OUH spinout), Evotec and OSI to accelerate translation of AI and digital health solutions and data-driven drug discovery and development.

We **collaborate with industry to scale up our technologies for impact**. Recent examples include COVID-19 diagnostics (ThermoFisher) and vaccine development (AstraZeneca), which were established rapidly to accelerate translation of expertise and academic research to address urgent societal need. With ThermoFisher, we developed a high throughput robotic serology platform to support the ONS COVID-19 surveillance programme (ICS-33COVIDTEST). We developed our Ebola Vaccine with Janssen (part of Johnson and Johnson). Planned development of the Institute for Global Health and the Institute for Pandemic Preparedness is progressing with industrial collaborators.

We **co-develop therapeutics with industry, including local biotech SMEs**, such as Immunocore (Middleton), throughout the drug discovery and development pipeline. Our cancer researchers have

worked closely and productively with 47inc (Vyas), Nucana (Blagden) and Celleron (Church) to develop their therapeutics, and in partnership with AstraZeneca on an innovative experimental medicine clinical trial of immunotherapy in oesophageal cancer (Lu; Middleton). Vaccitech Oncology Limited is a partnership with Vaccitech to produce the vaccine for a CRUK-funded clinical trial to boost anti-tumour responses. We are co-developing viral vectors for cystic fibrosis (Gill, Hyde) in a £10M collaboration with Boehringer Ingelheim and Oxford BioMedica; targeted therapy for infant leukaemia (Roy) with Evotec; needle-free delivery of a novel plague vaccine (Rollier) with SME ENESI Pharma; a stool test for TB in high burden settings (Song) with 42 Technology; anti-sense oligo therapy (Rinaldi) with WAVE (Boston, USA); and genetic therapies and nucleic acid drugs (Wood) with Takeda and Pfizer respectively.

We have **co-developed industry-sponsored postdoctoral fellowship schemes**. These include UCB Pharma, Celgene (now Bristol-Myers Squibb, Box 7), Novo Nordisk and Elysium Health. These support approximately 12 fellowships per year and are characterized by close collaboration, industry mentors, and encouragement for fellows to spend some time at the company.

We **lead national-level industry collaborations,** exemplified by the National Consortium for Intelligent Medical Imaging (NCIMI) with ten companies including GE Healthcare and Alliance Medical and supported by £17.5M from the Industry Strategy Challenge Fund (Gleeson). NCIMI supports a network of academic researchers, NHS hospitals, clinical leaders, industry experts, charities and patient groups to bring AI to clinical imaging analysis.

Transfer of technology and knowledge: During the REF2021 period, OUI has supported 19 new spinouts, made 737 patent applications and overseen 231 deals and 1,487 consultancy agreements for UOA1. Our support structures and networks have allowed UOA researchers to generate multiple successful **spinouts** during the period including *OxStem Cardio* (Patient); *Zegami* (Taylor); *iOx Therapeutics* (Cerundolo); *Scenic BioTech* (Nijman), *SpyBiotech* (Draper), *Myon* and *Orfin* (Wood), *Ultromics* (Leeson) and 9 others listed in 3.4.2.

We **create networking opportunities with industry.** Our **Academic Industry Meeting (AIM) days** are a cornerstone of our strategy to increase the number of companies (especially SMEs) connected to our research and clinical base. These address sector-specific industry questions (e.g. antimicrobial resistance, imaging or ageing) by engaging academics with industry to explore how working together can solve common development challenges. During this REF period they **have involved 208 academics and 80 companies**, 58% of which were SMEs. For 50% of companies, the AIM day is their first introduction to researchers and clinicians from Oxford. Direct outcomes have been consulting, joint grant applications, and publications. **Monthly Industry Insights Seminars** are scientific talks from industry hosted at the BioEscalator, with speakers from our strategic partners, our spin-outs, and other local companies. Through networks we also support **training**, including for over 70 early career researchers from our fellowship programmes and

Box 7: Partnership with Bristol Myers Squibb
The partnership between Oxford and Bristol Myers Squibb (BMS) supports a wide range of research collaborations tackling challenging questions in acute myeloid leukaemia, fibrosis and inflammatory diseases. The company has invested >£25M into a Translational Research Fellowship Programme, supporting 5 fellows per annum, in addition to clinical studies, a drug development accelerator programme, studentships and a visiting professorship. Projects involve cutting edge translational and clinical research and high level support through the direction and mentorship of BMS project leads. Both BMS and the University draw value from skills transfer between researchers in academia and industry and the stimulation of new scientific discovery and translation. One research highlight from the partnership was the discovery that BMS's enasidenib restores normal blood cell production in 40% of AML patients with an IDH2 mutation who had failed previous treatments. These data supported the approval of enasidenib by the US Food and Drug Administration (FDA) in 2017.

industry-funded projects. Training and development events are held termly and topics have included making the move from academia to industry and working in a spin-out.

4.3 Support for interdisciplinary research

Through Aim 4 (Section 1.2.4), we are committed to strengthen interdisciplinary research across the breadth of medicine and **our strength of collaborations and crosscutting technology provides a strong platform to launch new ideas**. New areas of clinical research would stall without the interdisciplinarity that we have nurtured. Notably in the response to the COVID-19 pandemic, we brought together groups in basic science vaccinology (Gilbert) and clinical vaccine testing (Pollard); epidemiology, modelling, apps and devices (Fraser), emerging infection expertise (Horby), large scale trials design (Landray, UOA2); drug discovery (Stuart, Jones, von Delft); diagnostics (Screaton, Crooke, Peto); antibody therapy (Screaton, Thwaites); disease mechanisms and pathology (Knight, Mentzer, Dong, Ogg, Klenerman); and pathogen evolution and sequencing (Todd, Fraser, Carroll).

4.3.1 Nurturing themed networks

We support a set of interdisciplinary networks.

- We have **established three new university wide interdisciplinary themed networks** in **Immunology** (2017)**, Metabolism** (2018)**,** and **Global Health** (2020), each supported by a research facilitator. We provided £157k from our internal John Fell Fund to support networks, collaborations and partnerships and £392k to support research facilitators.
- We continue to support established themed networks of **Cancer** (CRUK Cancer Research Centre), and **Cardiovascular Science** (BHF Centre for Research Excellence). The British Heart Foundation Centre of Research Excellence (£6M, renewed 2019), is an interdisciplinary network of researchers in **cardiovascular sciences** across the University, from population health (UOA2, Collins), genomics (UOA1, Watkins), target discovery (UOA1, Channon) to developmental biology and regenerative medicine (UOA5, Riley).
- **The Oxford Martin School** [IES 2.6] includes programmes in UOA1 on infectious disease, pandemic genomics, antimicrobial resistance and electronic health records.
- **NIHR Oxford BRC** supports cross-cutting themes including clinical informatics and big data, imaging, genomic medicine, molecular diagnostics, technology and digital health.
- We facilitate greater awareness across disciplines with a common platform for advertising seminars, publicising over 3,000 talks from the UOA1 departments during the REF period.

4.3.2 Co-location of researchers.

We bring researchers together to promote interdisciplinary work (Sections 1.1 and 3.2).

- We **co-locate researchers with shared interests,** as exemplified by the Big Data Institute (£46M, opened 2015). This institute brings together researchers from the departments of medicine, public health and statistics and the **benefits were evident in our rapid COVID-19 response with impact through clinical trials** (ICS-30RECOV-1, 31COVIDVAC)**, epidemiology** (33COVIDTEST) **and contact-tracing** (32COVIDAPP).
- We **co-locate researchers using similar scientific approaches** to develop scientific critical mass as exemplified by the Wellcome Centre for Human Genetics, where we integrate genetics with a range of interests including diabetes, paediatrics, women's/reproductive health, metabolic and cardiovascular medicine.
- We actively encourage interdisciplinary work with **interdisciplinary joint appointments,** described in 2.3.1.

4.3.3 Medicine working with other disciplines

Interdisciplinary research between **mathematics** and genetics (Myers, Palamara, Davies), cardiovascular medicine (Watkins, Farrall), diabetes (Todd, Knight, Dendrou, Bashford-Rogers), cancer (Lu, Harrington, Byrne), metabolism (Lindgren), paediatrics (Servais, Wood, Snape, Besser) and women's health (Zondervan), has generated several of the most highly cited genome wide association studies (GWAS) since 2014.

Building on work recognised by the **Nobel Prize for Medicine** to Ratcliffe (2019) for the discovery of the mechanism of hypoxic gene regulation, groups in **medicine working with chemistry** (Schofield) have made new advances in the control of erythropoiesis leading to the development of prolyl hydroxylase inhibitors as oral erythropoietin-stimulating agents, now at the Phase 3 stage. Their work has also led to developments in cancer biology with significant investment by the pharmaceutical industry in major drug discovery programmes. We established the **Target Discovery Institute** (£24M, 2013) at the interface of drug target exploration and chemistry and have since equipped it with £12M major equipment focusing on drug target discovery and early stage validation. Our integrated interdisciplinary project teams in the **Oxford Drug Discovery Institute** include geneticists, structural biologists, medicinal and computational chemists, biochemists, pharmacologists and clinicians. These interdisciplinary teams enable collaborations with, for example, a $35M consortium including Oxford and a syndicate of US universities to translate genomic findings into drug discovery.

Collaborations with **physics and artificial intelligence (AI)** include work within the Big Data Institute (with Novartis); in diagnostics/radiology/cardiology e.g. NCIMI (Section 4.2); spinouts including cardiac ultrasound (*Ultromics*), CT coronary imaging (*Caristo*), stroke imaging (*Brainomix*); real-time monitoring (Sensyne Health); and digital pathology (Phillips, Innovate UK). Our new Institute for Developmental and Regenerative Medicine (Section 3.2.1) will be a biomedical, mathematical and AI-driven systems biology hub to accelerate genome-based drug discovery programmes in cardiovascular, immunological and neurological disease. AI is central to a major multi-centre

Box 8: Oxford Immunology Network

We established the Oxford Immunology Network in 2017 to provide a central hub for the hundreds of immunologists who are physically dispersed in the University. Our community now encompasses over 400 researchers from 17 departments in medical and physical sciences. Led by Klenerman, and supported by a dedicated research facilitator, the Immunology Network has two broad aims; to facilitate communication and collaboration. We run events such as symposia and theme days, we identify and facilitate collaborative funding applications and we communicate regularly through our mailing list, website and Twitter feed.

Immunology cuts across many fields and the Immunology Network has provided a mechanism to bridge disciplines. With £1M of Oxford BRC funding, we established the Human Immune Discovery Initiative (HIDI), to facilitate access to immunological expertise. Through increasing staff capacity in core immunology labs and awarding pump-priming funding we have supported 30 projects within 6 departments, linking immunology with neuroscience, oncology, metabolism, orthopaedics and transplantation. Several of these projects have secured follow on funding and have resulted in new collaborations.

The structure of the Immunology Network enabled a very rapid response to the COVID-19 pandemic. We were able to structure the immunology response into a series of linked work packages, ensuring effective oversight of activities and communication across work packages. Working alongside the vaccine development and antibody testing teams, we coordinated an ambitious project, COVID-19 Multi-omics Blood Atlas (COMBAT), to define the nature, drivers and predictors of severe COVID-19 through the deep immune phenotyping of patient blood samples.

research programme to improve the diagnosis of lung cancer and other thoracic diseases (Gleeson) and thus reduce the need for lung biopsies, which brings together researchers in metabolomics, digital pathology, radiology, computer vision and lung cancer clinicians. Clinical scientists (Neubauer, Choudhury) and physicists (Robson) have revolutionised applications of MR imaging and spectroscopy including clinical high field imaging, and hyperpolarisation, especially in cardiology. CT imaging and AI have been combined to measure fat attenuation associated with coronary artery plaques (Antoniades), predicting outcome with clinical implications (spinout *Caristo Diagnostics*).

We have incorporated **structural biology** into medicine on our Old Road Campus, recognising its importance in driving discovery. Through collaboration between structural biology and physics, immunology and infectious disease, stabilised virus-like particle technology for a foot-and-mouth disease virus vaccine has been developed from basic science to animal trials through long-standing collaborations with Diamond Light Source, the Pirbright Institute and the University of Reading. CryoEM structure of a mature flavivirus and the immature particle to unprecedented resolutions are underpinning vaccine design (Grimes, Screaton). Strong links with Diamond Light Source and the Rosalind Franklin Institute (Group 9; Section 2.3.1) facilitate structural biological approaches to drug development. The MRC WIMM Wolfson Imaging Centre provides facilities for high resolution cellular imaging.

The Institute of Biomedical Engineering (UOA12) on our Old Road campus embeds a **critical mass of engineering expertise** on campus and promotes interactions between medicine and engineering. The value of this is evident in the development of normothermic organ preservation for transplantation (Friend, Coussios, ICS-19ORGANOX) leading to a NICE-approved technology and spinout; work on foetal monitoring technology (Noble); and patient app-to-clinician software (MacKillop, Tarassenko) for managing gestational diabetes. It has also led to establishment of the Oxford Centre for Drug Delivery Devices ($OxCD^3$); Oxford Centre for Innovation and Interventional Technologies (OCIT, Hamdy, Coussious); The Marcella Wing of the Botnar (£10M, opening 2021) will include a new GMP Biomanufacturing Facility For Biomedical Devices in parallel with the appointment of a new statutory chair in Biomaterials (Stride, UOA12, with Engineering) to lead a new interdisciplinary group with the Oxford Centre for Drug Delivery Devices (£9M).

Through the NIHR Oxford BRC, we support on-campus fellowships in **ethics** and our researchers have worked with ethicists on diverse real-world problems such as research consent in emergency situations (Channon with Sheehan) and, recently, on the ethical implications of mobile phone apps in the control of the COVID-19 pandemic (Fraser with Parker, ICS-32COVIDAPP).

Box 9: Interdisciplinary research on vaccines
We take an integrated interdisciplinary approach to **vaccine development**. Groups with expertise including infectious disease medicine, paediatrics, vaccine design and testing, immunology, pathogen biology and structural biology interact fluidly to create the largest vaccine development grouping in the UK. The Centre for Clinical Vaccinology is co-located with the Clinical Biomanufacturing facility and includes vaccine design scientists, a GMP facility for manufacturing, phase 1-4 clinical trials expertise and state-of-the-art immunology for fast evaluation of vaccine responses. Our recent outputs include a rapidly developed and deployed COVID-19 vaccine (ICS-31COVIDVAC), an Ebola vaccine now deployed in Africa (ICS-03EBOLA) and deployed typhoid vaccines (ICS-05TYPHOID).

4.4 Encouraging and developing best practice in research

We have invested heavily in training and support for our researchers to ensure that they are able to conduct research that is robust, reproducible, ethical and so engenders trust and impact.

Our research students complete mandatory courses in ethics, plagiarism and good laboratory practice. We have developed new courses for our researchers on fostering good research practice, research integrity (now compulsory), and reproducibility in research. Within our UOA we have extensive mathematical and statistical expertise and networking infrastructure to support the development of robust experimental designs and analyses. For example, the initiation of the COMBAT project, building a multi-omics blood atlas for COVID-19, has exemplified a very structured approach to complex data to enable a wide range of studies (Box 8).

We maintain oversight of all research in line with legislative and regulatory requirements and support specific regulatory understanding and compliance through specialised support [IES 2.7] including teams in Clinical Trials and Research Governance, Human Tissue Governance Team, and Biomedical Services (overseeing studies involving animals). Our NIHR BRC supports medical ethicists who work with our researchers to develop their studies appropriately. We engage extensively with patients and the public (Section 4.10), again supported by our NIHR BRC. We have developed critical mass across multiple disciplines, which allows our researchers to present their ideas and results to peers for early critique and where appropriate, for reproduction by other workers independently.

Box 10: Equitable research in practice

The Coronavirus Modelling (CoMo) consortium, established in 2020 (lead, *Lisa White*) demonstrates Oxford's approach to responsible research. White trains and supports modellers from endemic countries to engage with decision makers and implementers at multiple levels of governance, with the ambition of putting policy-facing modelling groups in every country. White's work is participatory, developing models in close collaboration with national control programmes and international decision makers. The consortium is training a new cohort of modellers to postdoctoral level in multiple countries (e.g. Cambodia, Lao PDR, Myanmar, Bangladesh, Cameroon and Brazil), with new research groups established in Thailand, South Africa and Nigeria. Intrinsic to our approach is capacity building of personnel, nurturing infrastructure already present in LMICs and sharing data with policy makers such that evidence-based policy making supports health decisions. Oxford recently established a new Masters degree course in Modelling for Global Health to support this endeavour.

4.5 Societal contribution through responsiveness to emergencies and emerging risks

The flexible organisation of our UOA enables us to respond rapidly and with our critical mass of expertise to address new healthcare challenges. This is exemplified in our response to the **COVID-19 pandemic** as detailed in Box 1 and ICS-30RECOV-1, 31COVIDVAC, 32COVIDAPP, 33COVIDTEST and through leadership of ISARIC (Box 11) and contributions to national advisory panels (section 4.13.1.1).

During the earlier **H1N1 and H5N1 flu pandemics** and the **Ebola epidemic** in West Africa, rapid research from our group informed WHO guidelines (Horby). The Oxford Vaccine group (Pollard) carried out a rapid H1N1 Swine flu vaccine trial, enabling the Department of Health to recommend immunisation of over 3 million children in the UK within 6 weeks of the study approval being obtained. Research on the Ebola vaccine led to licensure by the EMA in 2020 (ICS-03EBOLA).

Box 11: Global leadership of ISARIC
Horby leads the International Severe Acute Respiratory and Emerging Infection Consortium (ISARIC), a network of 132 countries working on emerging infectious threats and underpinned by the Global Support Centre at the University of Oxford. Through Horby's leadership as Chair, the ISARIC research tools were ready for just such an eventuality as the COVID-19 pandemic. Since January 2020, the ISARIC tools have been downloaded more than 12,000 times by 118 countries; and with almost 200,000 participant records from 566 sites in 42 countries, ISARIC has assembled the world's largest prospective COVID-19 clinical database. Standardised clinical data for emerging epidemic diseases have been a huge need for many decades and this have finally been achieved through these efforts. The ISARIC COVID-19 clinical database, hosted at Oxford, is used routinely by the UK Government and provided the earliest evidence of hospital transmission of COVID-19 in UK. The ISARIC patient cohort has been used to develop a risk stratification tool to support the COVID-19 response and, most recently, described genetic factors that increase susceptibility to severe COVID-19.

4.6 Leadership of national and international consortia

We encourage our researchers to play leading roles beyond Oxford to maximise the value of their work and to enable them to develop and propagate the impact of their work.

Notable examples include:

- **Vaccines:** the National Immunisation Schedules Evaluation Consortium (NISEC); Strategic Typhoid alliance across Africa and Asia (STRATAA); the typhoid vaccine acceleration consortium (TyVaC), co-leader with University of Maryland.
- **Cardiovascular Medicine**: leading roles in the global CARDIoGram+C4D coronary artery disease and INTERSTROKE genetics consortia; the Hypertrophic Cardiomyopathy Registry (HCMR, NIH-funded); the NIHR-BHF Cardiovascular Partnership (Chair, Channon); international studies in atrial fibrillation (Casadei); contributions to UK Biobank phenotyping.
- **Metabolic Disease:** The Novo Nordisk Foundation Immunometabolism Consortium (led from Oxford, ~£14M since 2015, Choudhury, Monaco).
- **Transplantation:** The COPE (Consortium on Organ Preservation in Europe, ICS-19ORGANOX) and QUOD (Quality in Organ Donation) are both led by Ploeg (£14M), as well as Department of Health COVID-19 biobanking facility.
- **Tropical Medicine**: The World-Wide Antimalarial Resistance Network (WWARN, White, Bell); Southeast Asia Infectious Disease Clinical Research Network (SEAICRN, Day); the Tracking Resistance to Artemisinin Collaboration II (TRAC II, White); the multinational COPCOV study of chloroquine/hydroxychloroquine as prophylaxis against COVID-19 (White), and the DeTACT (Developing Triple Artemisinin Combination Therapies) malaria treatment Programme which has clinical study sites in 13 countries across Asia and Africa (Dondorp); ISARIC (Horby, Box 11); co-ordination of the African Coalition for Epidemic Research, Response and Training (ALERRT); founding member of the European Clinical Research Alliance for Infectious Diseases (ECRAID), leadership of the CHAIN international child nutrition network (Berkley).
- **Genetics**: leadership in the Genomics England Clinical Interpretation Partnerships (GeCIPs) (Taylor, Whiffin); and the International Endometriosis Genomics Consortium including 25 research groups globally (Zondervan).
- **Arthritis Therapy Acceleration Programme** (A-TAP), an Oxford-Birmingham and NHS collaboration (£7M); STEpUP OA, an international consortium integrating clinical and proteomic data to define molecular endotypes in 2,000 individuals with osteoarthritis.
- **Rare Diseases.** The Oxford-Harrington Rare Diseases Centre (Wood, Hollander) will share capabilities, resources and expertise with the University Hospital, Cleveland, Ohio to develop new treatments for rare diseases.

- **Reproductive Medicine**: INTERGROWTH-21st [ICS-20INTERGROWTH] and INTERBIO-21st (Kennedy, Papageorghiou, Villar) are $24.1M population-based studies across 8 countries, led from Oxford in collaboration with the WHO to produce postnatal international growth standards, and identify the causes of intrauterine growth retardation and pre-term births. IMI-PainCare is an EU-funded consortium (£19M) involving 40 academic and industry partners from 14 countries (Vincent).
- **The COVID-19 RECOVERY trial** exemplifies our leadership and was only achievable through a collaboration with 176 university and hospital partners across the UK (ICS-30RECOV-1).
- Our **Africa Oxford initiative** (Box 12) and **Oxford-Berlin Research Partnership** [IES 2.6] have both supported activity to germinate new collaborations. 11 awards of seedcorn funding were made to UOA1 researchers for projects with universities in Berlin.

Box 12: Africa Oxford Initiative
We established the Africa Oxford initiative (AfOx) in 2016 and have invested £1.7M to provide University-wide support for academic and research collaborations between Oxford and African researchers and institutions to develop equitable collaborations. We support researchers and students with grants, scholarships and fellowships to enable travel, in both directions, between Oxford and African countries and have 2,300 members across the UK and in Africa. Equitable research and capacity building is at the core of AfOx, through conferences, a 'find a researcher' database, research development awards, internships, and joint grant applications and student supervision. AfOx has strategic partnerships with 187 institutions and organisations across 30 African countries.

4.7 Contributions to specialised knowledge and training

- **Genetics**: We have led in developing approaches using whole genome sequencing and sequence data analysis and support these collaborations through access to our core facilities and capacity for the functional analysis of variants. This is increasingly important in drug target discovery.
- **Structural Biology:** We are one of the major structural biology centres in Europe and through the Instruct Hub (Box 13) have played a key role in promoting development of structural biological approaches and techniques.
- **Clinical Trials**: The multiple UOA1 clinical trial centres (together with UOA2) constitute the largest capacity for clinical trials in the UK (Section 3.3); the Diabetes Trial Unit in OCDEM (Adler, formerly Holman) is the largest academic research organisation in the world specialising in large diabetes-related trials. Our UOA researchers have conducted multiple first-in-human trials in this REF period, with at least 15 in oncology alone.
- **Oxford Vaccine Centre** hosts the largest clinical trials unit focused on vaccines in

Box 13: The Instruct Project, initiated by our UOA1 (Stuart and Jones), served as a model for sharing expertise and resource. Instruct brings together expertise in structural and cell biology and is the major strategic voice for integrative structural biology across Europe; members share access to, and training, in state-of-the-art facilities. The project grew from a recognition that facilities at the cutting edge of structural biology are expensive to build and maintain, and will become more so in the future; no single European country possesses the equipment and corresponding expertise across all structural biology technologies, making sharing critical to success.

Europe and its impact is evident in the development, testing and use of our COVID-19 vaccine.

- **Malaria modelling:** we have trained researchers in countries where malaria is endemic to model its spread and engage with policy-makers (Section 4.4, Box 10).
- **Seminars**: We have arranged an average of over 600 talks or seminars each year, many by international speakers, which provide a platform for our researchers to discuss their research with these many visitors.

4.8 Sharing physical infrastructure, resources and people

We contribute to and engage with the wider research community by sharing physical resources, including clinical material, equipment and buildings, with multiple partner institutions (Section 4.1). We see sharing of large items of equipment as an essential aspect of developing our own infrastructure base and collaborations for everyone's benefit (Section 4.8). Our researchers **collaborate extensively with researchers in the UK and globally using our facilities and equipment** to undertake work that could not otherwise be done. This is evident in the collaborative outputs arising from use of our infrastructure in sequencing and genomic studies, structural biology, Structural Genomics Consortium probe tools, advanced microscopy and overseas facilities.

- **Clinical Material**: Examples include the Botnar-Kennedy Biobank which has an extensive collection of curated joint tissue samples from patients with inflammatory disease, osteoarthritis and sarcoma coupled to data from multiple imaging platforms; the Prostate Cancer repository with over 60,000 sample sets shared with the International Cancer Genome Consortium (ICGC), the international Pan Prostate Cancer Group (PCGC), and the international PRACTICAL genomic consortium.
- **Equipment and Resources**: We share equipment nationally and internationally, including those for structural biology (e.g. via Instruct, Box 13) and genomics.
- **Oxford Buildings**: We share physical space and infrastructure in Oxford and elsewhere through formal partnerships, including partnerships with the Wellcome Sanger Institute, Diamond Light source and Rosalind Franklin Institute involving investigators in immunology and infectious diseases, tropical medicine, and genetics.
- **Overseas Facilities**: Our Tropical Medicine units (Figure 6) strive to be as inclusive as possible, hosting PIs from a number of other UK institutions and from local institutions, such as our long term collaborations and space sharing with Thailand's Mahidol University, the Ho Chi Minh City Hospital for Tropical Diseases and the Kenya Medical Research Institute.
- **Sharing People**. Senior researchers in our UOA hold leadership positions in other institutions, and this enhances the reach and impact of our research and shares their leadership and contributions with our colleagues in other institutions. Notable examples include
    - Diamond Light Source (Stuart, joint appointment as Life Sciences Director) and the associated electron Bio-Imaging Centre, eBIC (Zhang, joint appointment as Director),
    - Rosalind Franklin Institute (RFI, Naismith, Director),
    - Arthritis Therapy Acceleration Programme (A-TAP, Buckley, Director, with the University of Birmingham),
    - Public Health England Porton Down (Carroll, Director),
    - Francis Crick Institute (Ratcliffe, Director of Clinical Research),
    - Wellcome Sanger Institute (Kwiatkowski, Head of Parasites and Microbes programme)
    - the Centre for Genomic Pathogen Surveillance (Aanensen, Director).
    - The new £30M UKRI Nucleic Acid Therapy Accelerator, 'NATA' (Wood, Interim Director).

4.9 Global Outreach

While examples have already been given of our outreach programmes and global collaborations, other global partnerships in this REF period include those in Uganda (Atkinson, Pollard); South Africa (Goulder, Song, Pollard); India (Roy, Song); Nepal, Bangladesh, Malawi, New Zealand and Brazil (Pollard); Tanzania, Mozambique, Malawi, Kenya, Peru, and Australia (Song); and in the USA Stanford (Holländer) and Massachusetts General Hospital (Rollier).

We have also developed a **major collaboration with China**. We have built on existing individual scientific collaborations with the Chinese Academic of Medical Sciences (CAMS) to develop a major strategic collaboration between the University and CAMS in this REF period. The **CAMS Oxford Institute** (COI) (Director: Dong) was launched in 2018, to develop collaborative research of mutual benefit through an innovative funding model that provides research and studentship funding to Oxford. In its first two years, 23 DPhil studentships and research projects were funded (£5.3M) mostly for clinical students in UOA1. A further £18M and 10 studentships per year are planned for the following three years. COI also supports collaboration through thematic networks and a seminar series. COI was critical at the beginning of the COVID-19 pandemic and enabled immediate strategic realignment of collaborative China-Oxford projects.

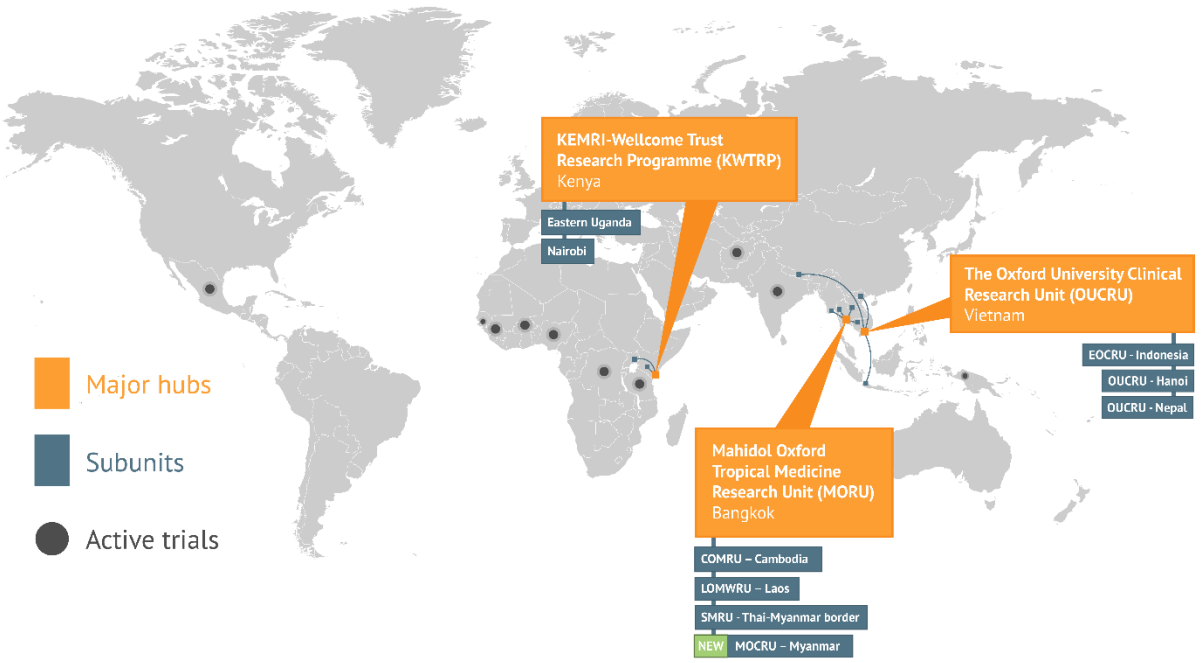


Figure 6 Locations of overseas research centres and active trials

4.10 Public engagement and involvement

We value and support both public engagement with research (PER) and patient and public involvement (PPI). We see this involvement and engagement with our research as integral part to the development of our research agenda and the sustenance of high standards in our research—these processes can enrich and improve our work at every level.

In line with the University of Oxford strategic plan, we are committed to **fostering a culture where both PER and PPI are embedded as part of normal academic practice** [IES 2.2]. We do this through close collaboration across departments, the wider Medical Sciences Division and the

University, while also being sensitive to the specific conditions and needs within our departments. We provide training and support to equip our researchers with the skills, confidence, and opportunities to engage with the public to ensure mutually beneficial engagement happens throughout the UOA.

We have invested in almost twenty **public engagement practitioners** (PEPs) embedded within departments and research units across the UOA, in both our Oxford and our overseas research centres. These PEPs work with the divisional public engagement co-ordinator and the central University PER Team to tailor training and support for each context. Our engagement takes many forms, depending on the goal and the intended audiences, from podcasts, websites, Twitter, Facebook, Instagram, blogs and other social media platforms, to in-person events at festivals, museums, schools or public spaces such as local shopping centres. Training is often delivered 'locally' based on specific needs or specific events, e.g. training for researchers taking part in the Cheltenham Science Festival or Big Bang Fair, or training in stand-up comedy for researchers taking part in a 'Science Stand-up' comedy night at the Oxford Ideas Festival. The PEPs can assemble training for complex, PER projects such as the Royal Society Summer Science Exhibition, which requires researchers from multiple departments to develop hands-on activities, school resources, talks, and digital interactives. Supporting and training researchers ensures that the benefits of PER and PPI, both in terms of new skills and connections, are propagated and flow into our research.

We **reward and recognise** high quality activity through the University's Vice-Chancellor's Public Engagement with Research Awards. UOA1 winners include Snape, who worked with **children in Sierra Leone** on a radio broadcast answering their questions **about the Ebola epidemic**; Cheah who engaged with **45 Cambodian village communities around malaria research** (Box 14); the Kenya Medical Research Institute for outreach programme to local schools to develop Kenyan research role-models; and the WIMM for their institute-wide programme of support and training.

Box 14: Village Drama Against Malaria: engaging rural communities in Cambodia

The project was aimed at supporting malaria elimination and raising awareness of malaria research in rural villages, where literacy is often low so leaflets and posters are of limited value. Our researchers (Lead, Cheah) used Cambodian drama to engage villages with especially high incidence, incorporating local stories and language.

Each village had a two-day workshop led by the drama team with a free public performance on the third evening. Local children were given singing and drama training, drawing workshops and education about malaria. Villagers contributed real local stories about malaria which were then integrated into the performance.

This project enabled researchers to **strengthen relationships** with the National Malaria Control Programme, the provincial health departments and also local school teachers, shop owners and village malaria workers. The participants benefited from learning about malaria, its prevention and treatment, and evaluation demonstrated that active participation led to an even better understanding of the malaria research.

Over three years, the project team worked with 45 villages, helping 1,855 villagers put on performances to a total of 34,640 other local people. "*We will remember this our whole lives!*" said a 14 year-old-girl from Battambang province.

Box 15: Vaccine Knowledge Project

A flagship exemplar of public engagement is the OxTALENT award-winning **Vaccine Knowledge Project (VKP**). This website is designed to help people make informed decisions about vaccine issues. It is an internationally recognised source of independent and authoritative scientific information on immunisation, receiving **over 1 million visitors per year** and continuing accreditation from the WHO Vaccine Safety Net. Since 2014, page views have increased from approximately 10,000 per month to over 150,000 per month, with a further rise during the COVID-19 pandemic to more than **250,000 page views in March 2020**. The website has established an international presence with visitors from almost every country: **in 2019, 50% of visitors were from outside the UK,** with the top 5 countries being UK, US, India, Australia and The Philippines.

We **support our researchers to secure funding** for public engagement and involvement, through costed PER and PPI plans for external research grant applications and through internal funding schemes, including the University **PER Seed Fund.** For example, Seed Fund awards supported "*The Mobile Malaria Project Expedition Comic Strip*" (Busby), through partnering with an Oxford based kids comic 'The Phoenix' to tell the story week-by-week of a training expedition to African research partners, and "*Using Ultrasound for public engagement*" (Law), in which children used real ultrasound equipment to take a 'biopsy' of a grape hidden in a block of tofu.

The University of Oxford is the only single institution **approached by Wellcome to pilot a new way of awarding public engagement 'Enrichment' grants**, whereby allocation of Wellcome's funding is devolved to Oxford and the scheme is run locally. The divisional public engagement coordinator and departmental PEPs provided substantial pre- and post-application support to researchers interested in applying, including bespoke workshops and one-to-one feedback, with notable awards to expand the 'Bash the Bug' citizen science project (Crooke); a research-themed escape room at 'Smash-Fest' (Bullocks); and development of hands-on activities at local festivals (Gill). BashTheBug.net won the **NIHR Let's Get Digital Award** (2017). BRC researchers were awarded a €270K EU to study fatty liver disease using a citizen science approach as part of a €2.2M multi-national project.

Box 16: COVID-19

During the pandemic, **UOA1 researchers have been active across multiple media in communicating** vaccine development, treatments, control strategies and more including Gilbert, Pollard, Lambe, Hill, Ramasamy, Ewer, Klenerman and Bell.
This has extended to multiple media outlets in the UK and beyond including BBC TV (inc Panorama, The Race for a Vaccine) and radio (R2, 5live, Today) German national news, Twitter and print media (e.g. The Guardian, Nautre, Ta Nea, Grazia).

Our units engage with patient groups and there is extensive support for PPI through our NIHR Oxford BRC, regional NIHR LCRN and multiple dedicated PPI groups involved in particular projects.

The Communications, Public Engagement and Web team in the Medical Sciences Division (MSD) work with researchers, staff, students and central services to coordinate and facilitate **communications** across UOAs 1-5, managing a variety of external communications channels. They support researchers across MSD to engage non-academic, primarily public, audiences with their research. Between 2015 and July 2020, researchers from the Medical Sciences Division (primarily UOAs 1-5) featured in 120 articles in the international series 'The Conversation'.

4.11 Other notable contributions

4.11.1 Governmental and International Advisory Bodies

4.11.1.1 International and Pandemic Leadership

- WHO Malaria Treatment Guidelines (Chair, White).
- WHO Antimalarial Drug Resistance and Containment (Chair, Dondorp).
- WHO Malaria Policy Advisory Committee (Chair, Marsh).
- WHO Scientific Advisory Group for Emergencies (SAGE, Pollard)
- WHO Pneumococcal And Influenza Vaccine Working Groups (Chair, Pollard)
- European Medicine's Agency Scientific Advisory Group on Vaccines (Chair, Pollard)
- MHRA Clinical Trials, & Biologics, Vaccines Expert Advisory Group (Chair, Misbah)
- UK Government Scientific Advisory Group for Emergencies (SAGE, Horby, Merson)
- UK Government COVID-19 Clinical Information Network (CO-CIN, Horby)
- UK Government NERVTAG -New and Emerging Respiratory Virus Threats Advisory Group (Chair, Horby)
- UK Government Children's Task and Finish Working Group (Horby)
- UK Government PHE COVID-19 Serology Group (Screaton)
- UK Government Vaccine Taskforce (Bell)
- Office for National Statistics COVID-19 Infection Survey (Chief Investigator, Walker)
- Lao PDR Government Health Policy (Newton)
- Vietnam Ministry of Health COVID-19 interventions (Day)

4.11.1.2 Scientific Leadership

- UK Government Life Science Champion (Bell)
- UK Government Office for Strategic Coordination of Health Research (OSCHR, Chair Bell)
- Report for UK Government: Life Sciences: Industrial Strategy - A report to government from the life sciences sector (Bell, 2017).
- Report for UK Government: Life Sciences Industrial Strategy Update (Bell, 2020)
- UK Department of Health and Social Care's Joint Committee on Vaccination and Immunisation (JCVI, Chair, Pollard)
- UK Department of Health and Social Care's New and Emerging Respiratory Viruses Threats Advisory Group (NERVTAG, Chair, Horby)
- Rapid Review Panel for COVID-19 studies (Pollard)
- Life Sciences Director, Diamond Light Source (Stuart)
- UK National Nucleic Acid Therapy Accelerator (Wood, Interim Director)
- International Severe Acute Respiratory and emerging Infections Consortium (ISARIC, Director, Horby)
- President of the European Society of Cardiology (Casadei)
- President of the European Crohns and Colitis Organisation (Travis)
- Transplantation Society's Science Committee (Chair, Issa)
- Vice President, Muscular Dystrophy UK (Wood)
- Royal College of Surgeons Council (Friend)
- National Clinical Director for End of Life Care at NHS England and NHS Improvement (Wee)
- USAID Advancing Nutrition Anaemia Taskforce (Atkinson)
- NIHR – Urgent Public Health group, (Ho, Rahman, Glyn-Jones, Costa)
- NICE Quality Standards Advisory Committee (Chair, Wee)
- NICE Technology Appraisal committee (Chair, Adler, Bhatt)
- NICE Guidance Groups (Co-editor, Nanchalal, Rees, Snape)

4.11.2 Science Funding and Administration

4.11.2.1 Funding Committees and Organisations

- Wellcome Board of Governors (Powrie)
- Wellcome Science Strategy Group (McShane)
- REF 2021 Main Panel A, UOA1 (Watkins, Screaton)
- MRC Strategy Board (Screaton)
- MRC Clinical Training and Career Development Panel (Deputy Chair, Vyas; Members, Ray, Channon)
- MRC Infections and Immunity Board (Dong, Simmons, Osier)
- MRC Population & Systems Medicine Board (Tomlinson)
- MRC Developmental Pathway Funding Scheme (Carr, Wood)
- MRC BMC Major Awards Committee (Hill)
- Wellcome Science Interview panel (Thakker)
- Wellcome Genetics, Genomics and Population Research Expert Review Group (Gloyn)
- Wellcome Physiology in Health and Disease Expert Review Group (Tzima)
- Wellcome Clinical Fellowship Committee (Chair 2015-18, McShane; Member, Roberts)
- Wellcome Public and Population Health (Walker)
- NIHR-BHF Cardiovascular Partnership (Chair, Channon)
- NIHR – HTA CET Funding Committee (Prieto-Alhambra, Rees, Hopewell)
- NIHR HTA scientific panel (Vice-Chair, McCulloch)
- NIHR National Immunisation Schedules evaluation consortium (NISEC, Chair, Snape)
- NIHR Strategy Board (Ford)
- NIHR Postdoctoral Fellowships panel (Holman)
- CRUK Clinical Research Committee (Middleton; Schuh; Chair, Maughan)
- CRUK Experimental Medicine Expert Review Panel (Buffa; Higgins; Vice-Chair, Middleton)
- Bill and Melinda Gates Foundation Scientific Advisory Committee (Chair, Bell)
- Arthritis Research UK (Medical Director, Silman)
- Sir Jules Thorn Trust (Watkins, Higgs)
- European Crohns and Colitis Organisation Grants Committee (Chair, Travis)
- Academy of Medical Sciences Networking Grants (Chair, English)
- Leducq Foundation Scientific Advisory Committee (Casadei, Watkins)
- Well-being of Women Research Advisory Committee (Ahmed, Vatish, Zondervan)
- Kay Kendal Leukaemia Fund Scientific Advisor (Cerundolo)
- ERC Grant Panels (Deputy Chair Lu; Jones; Zondervan)
- Blood Cancer UK, Clinical Trials Panel (Chair, Roberts)

4.11.2.2 Journal Chief Editorships

- Buckley, Arthritis Research and Therapy
- Elliott, Immunotherapy Advances
- Gilbert, European Biophysics Journal
- Hamdy, British Journal of Urology International
- Harris, British Journal of Cancer
- Kerr, American Society of Clinical Oncology Journal of Global Oncology
- Lu, Cell Death and Discovery
- McCulloch, BMJ Surgery Innovations and Technology
- Pollard, Expert Reviews of Vaccines,
- Taylor, TouchImmunology

4.11.3 Other indices of Distinction

4.11.3.1 Elections to Learned Societies

Over 20 Fellows of the Royal Society, including the following new Fellows in this REF period;

- Naismith (2014)
- Rorsman (2014)
- Thakker (2014)
- Patel (2015)
- McVean (2016)
- Jones (2017)
- Watkins (2017)
- Kwiatkowski (2018)
- Cerundolo (2018)
- Lu (2020)

Over 50 Fellows of the Academy of Medical Sciences, including the following new Fellows in this REF period;

- Ford (2014)
- Cornall (2014)
- Powrie (2014)
- Pollard (2016)
- Holländer (2016)
- McVean (2016)
- Maughan (2016)
- Lamb (2016)
- Berkley (2017)
- Barnes (2018)
- Thwaites (2018)
- Bejon (2019)
- Price (2019)
- Simmons (2019)
- Walker (2019)
- McShane (2019)
- Wood (2020)
- Friend (2020)

Other fellowships or elections this REF period:

- US National Academy of Sciences (Powrie, 2020)
- Fellow of the Royal Swedish Academy of Sciences (Jacobsen, 2019)
- African Academy of Sciences (Marsh, 2016)
- 23 NIHR Senior Investigators (New, Renewal or Emeritus) and NIHR Research Professorships awarded to UOA1 staff during the REF period, from 47 Oxford awardees.

4.11.3.2 Notable invited lectures

- Gloyn (2019) Diabetes UK Dorothy Hodgkin lecture
- Buckley (2017) Heberden Oration: British Society of Rheumatology
- Taylor PC (2016) Heberden Round; British Society of Rheumatology
- Taylor PC (2017) Indian Rheumatology Association Oration
- Wood (2017) Opening Keynote Lecture, Nobel Symposium on Extracellular Vesicles, Karolinska Institute, Sweden
- Bafadhel Goulstonian Lecturer (2019), Royal College of Physicians

- Grossman (2014), Geoffrey Harris Prize Lecture, European Society of Endocrinology
- Gilbert (2020), United Nations, Lecture on ChAdOx1 nCoV-19 for UN Ambassadors
- Wee (2016), Royal College of Physicians of Edinburgh, Sir James Cameron Lecture

4.11.3.3 Notable Prizes

- Nobel Prize in Physiology or Medicine (Ratcliffe 2019)
- Albert Lasker Award (Ratcliffe, 2016)
- Buchanan Medal of the Royal Society (Ratcliffe 2017)
- Massry Prize (Ratcliffe 2018),
- Wiley Prize (Ratcliffe, 2014)
- Gabor Medal of the Royal Society (Stuart, 2020)
- Society of Endocrinology Starling medal (Hodson, 2018)
- Outstanding Achievement in Clinical Diabetes Research Award, American Diabetes Association (Holman, 2018)
- Mackenzie Medal of the British Cardiovascular Society (Watkins, 2018)
- Outstanding Achievement Award of the European Society of Cardiology (Antoniades, 2016)
- Dale Medal of the Society for Endocrinology (Thakker, 2015)
- Rosen von Rosenstein award, Swedish Society of Medicine and Swedish Paediatric Society (Pollard, 2019)
- Royal Society Pifzer Award (Osier, 2014)
- Bill Marshall award of the European Society for Paediatric Infectious Disease (Pollard, 2013)
- Distinguished Award for Education and Communication, European Society for Paediatric Infectious Disease (Pollard, 2015)
- Willy Gregoir Medal, European Association of Urology (Hamdy, 2019)
- Cheryll Tickle Award of the British Society for Developmental Biologists (Sauka-Spengler, 2020)
- Carol Nachmann Prize (Buckley, 2020)
- Arthur Steindler Award, Orthopaedic Research Association (Carr, 2016)
- Society of Endocrinology medal (Ray, 2020)
- Hunterian Professorship, Royal College of Surgeons, (Costa, 2020)
- Hunterian Professorship, Royal College of Surgeons, (Metcalfe, 2020)
- Graham Bull Prize Royal College of Physicians (Bafadhel, 2018)
- Christian Coers Prize, Royal Belgian Academy of Medicine (Servais, 2018)
- Lister Prizes (Rehwinkel, 2017; Chapman, 2019)
- Helen-Clark-JoPPP Award for Pharmaceutical Policy and Practice Research (Newton, 2020)
- Medawar Prize of the Transplantation Society (Wood, 2018)
- Honorary International Fellow, American Society of Tropical Medicine and Hygiene (McCready, 2020)
- European Federation of Immunological Societies, Ita Askonas Prize (Simon, 2018)
- Liverpool School of Tropical Medicine Mary Kingsley Medal (Marsh, 2015)
- British Thoracic Society Medal (Stradling, 2014)
- Al Sumait prize for African development (Marsh, 2016)
- Clotten Foundation Prize (Rabbitts, 2015)
- Gairdner Award (Feldmann and Maini, 2014)
- Sir Rickard Christophers Medal, Royal Society of Hygiene and Tropical Medicine (Wills, 2019)
- Patrick Manson Medal, Royal Society for Tropical Medicine and Hygiene (Warrell, 2019)
- Chalmers Medal, Royal Society for Tropical Medicine and Hygiene (Kinyanjui, 2019)
- UAEGDA International Scientist of the Year (Ahmed, 2016)
- Tobias Prize of the Swedish Royal Academy for Sciences (Jacobsen, 2014)
- Tilden Prize of the Royal Society of Chemistry (Naismith, 2019)

4.11.3.4 Prizes to research students

- American Heart Association: Melvin Judkins Early Career Clinical Investigator Award (Raman, 2019)
- American Society for Human Genetics: Charles J. Epstein Trainee Award for Excellence (van de Bunt, 2014)
- American Society for Bone and Mineral Research: New Investigator Award (Sacitharan, 2016)
- European Society of Cardiology Congress: Young Investigator Award (Margaritis, 2013; Wijesurendra, 2016; Oikonomou and Raman, 2019)
- British Transplantation Society: Sir Roy Calne award (Milward, 2014)
- MRC Max Perutz Science Writing Award (Wiberg, 2019)
- Royal College of Surgeons: Syme Medal (Dean, 2016)

4.11.3.4 Public honours

New knighthoods for our researchers during this REF period:

- Ratcliffe for services to clinical medicine (2014);
- Bell, Knight GBE (2015) for services to medicine, medical research and the life science industry;
- Weatherall, Knight GBE (2017) for services to medicine
- White (2017) for services to tropical medicine and global health
- Donnelly (2019) for services to the understanding of human genetics in disease

CBEs

- Willett, CBE (2016) for services to the NHS
- Bulstrode, CBE (2016) for services to humanitarian medicine
- Wee CBE (2020) for services to end of life care

Overseas honours

- Légion d'Honneur for work to combat malaria (Nosten,2016)
- Order of Canada, for contributions to orthopaedic surgery (Wright, 2016)
- Vietnam Medal for the People's Health (Horby, 2016)
- Vietnam Medal for the People's Health (Wertheim, 2016)
- Government of Lao PDR, Medal of Labour (Newton 2019)