Institution: Institute of Cancer Research (ICR)

Unit of Assessment: UOA5 Biological Sciences

1. Unit context and structure, research and impact strategy

Biological Sciences research at ICR focuses on the genetic and cellular mechanisms that underlie and drive cancer development and progression, and the response and resistance to cancer treatment.

The research in this submission takes place in the Divisions of Cancer Biology, Structural Biology, Breast Cancer Research and the Centre for Evolution and Cancer (CEC) in the Division of Molecular Pathology. This grouping consists of 35 independent researchers and their associated research teams, totalling 222 staff on the REF census date including 98 postdoctoral researchers, 22 analytical scientists, 79 scientific officers/specialist technical staff and 58 postgraduate research students/clinical research fellows.

At the time of the REF 2014 submission we planned to:

- Expand programmes in **cancer heterogeneity and evolution**, since this has a major impact on treatment resistance and outcomes.
- Continue work into the **causes and treatment response of breast cancers**, with a renewed focus on advanced disease.
- Undertake **structural analysis of molecules and molecular complexes** relevant to cancer to provide insights into molecular mechanisms and guide therapeutic design.
- Increase understanding of **cancer cell signalling pathways** using new proteomic and imaging techniques for pathway and biological network analysis.
- Study alterations in **cancer metabolism** to provide new molecular diagnostic and therapeutic opportunities in collaboration with Imperial College London (Imperial) within the then newly established joint Centre for Systems Oncology and Cancer Innovation.

We achieved much against these objectives whilst also going through a period of significant change and reinvestment (see also sections on People and Infrastructure below).

In 2015, we conducted an organisation-wide consultation resulting in the ICR and our clinical partner, the Royal Marsden NHS Foundation Trust (RM) publishing a new joint **Research Strategy 2016–2021**. Fundamental biological research predominantly sits in Pillar 1, **Unravelling Cancer's Complexity**, but the delivery of our strategy also depends on extensive collaboration between researchers in UOA5 with the translational and clinical researchers returned to UOA1 and RM colleagues. The ICR's appraisal and reward systems recognise those contributing to our collaborative and team science values.

The consultation took place following several senior departures and the death of Professor Chris Marshall FRS. In our strategy we confirmed our intention to recruit world-leading cell, molecular and structural biologists and in addition to:

- Establish new strategic relationships with other academic organisations.
- Invest in cutting-edge microscopy.
- Expand knowledge of how cancer cells develop, and cope, with genome instability, and apply this understanding to identify new therapeutic targets and/or drugs.

What we did:
Professor Sir Mel Greaves FRS **established the ICR's CEC** with funding from the Wellcome Trust (£2.15M) and investment by ICR. Successes to date include:

- Development of mathematical models/algorithms for predicting cancer clonal progression (Sottoriva).
- Development of deep learning tools for integrating spatial heterogeneity of tumour ecosystem and relating to prognosis (Yuan).

- Single cell genetics and clonal architecture/phylogeny in acute lymphoblastic leukaemia and acute myeloid leukaemia (Greaves).
- Aetiological drivers of clonal evolution in childhood leukaemia (Greaves).

In the **Breast Cancer Division,** where multidisciplinary research spans from fundamental cell biology through to the identification of therapeutic targets and monitoring of therapeutic response leading (as described in UOA1) to innovative clinical trials, we:

- Identified *BRCA1/2* hotspot mutations associated with the development of PARP inhibitor-resistant reversions (Pettitt, Lord).
- Demonstrated that ROS1 inhibitors are synthetically lethal in E-cadherin-deficient breast cancers (Lord).
- Elucidated a role for Wnt7a in the recruitment and activation of stromal fibroblasts to promote tumour aggressiveness (Isacke).
- Revealed that PIM1 kinase regulates cell death and chemotherapy response in triple-negative breast cancer (Meier, Tutt).
- Demonstrated the utility of circulating tumour DNA (ctDNA) sequencing to monitor the emergence of therapy resistant mutations (O'Leary).
- See also Strategy for Impact for examples of how these findings were translated.

Professor Laurence Pearl FRS returned as Head of the **Structural Biology Division and** we invested over £4M, in addition to successful grant applications, to renew instrumentation to upgrade to cryo-electron microscopy (cryo-EM). Selected research highlights include:

- Crystal structures of the Brf2-TBP complex bound to natural promoters and demonstrating a Brf2 redox-sensing module capable of specifically regulating RNA polymerase III transcriptional output in cells (Vannini).
- Visualisation of transcription initiation by the RNA polymerase III complex and accessory molecules (Vannini).
- Elucidation of the structural basis of Cullin 2 RING E3 ligase regulation by the COP9 signalosome (Morris).
- Revealing the molecular mechanism and function of filamentous polymerisation of the PARP enzyme tankyrase (Guettler).
- Elucidation of phosphorylation-dependent interactions in protein complexes controlling the G1 DNA damage checkpoint (Pearl).

We recruited Professor Jonathon Pines FRS as the new Head of the **Cancer Biology Division** who has rebuilt the Division to have significant strength in genome damage research. We invested significantly in advanced light microscopy and proteomics facilities to support these activities and created a centre of excellence for Genome Stability Research (see People and Infrastructure sections). Our developing strength in the area of genomic instability is exemplified by our discoveries that the cohesin complex has an important role in repressing transcription at DNA breaks to prevent large scale chromosome rearrangements (Downs), and that the EXD2 nuclease protects stalled replication forks and has a synthetic lethal relationship with BRCA deficiency that can be exploited (Niedzwiedz). Our investment in proteomics enables us to identify signatures for specific cancers, for example non-smoking related lung cancer (Choudhary). Our investment in cutting-edge microscopy combined with proteomics analysis revealed that Cyclin B1-Cdk1, the major regulator of mitosis, has an important role in maintaining genomic stability through binding and releasing the Spindle Assembly Checkpoint protein MAD1 from the nuclear envelope (Pines).

We developed approaches to quantify the phenotype of single cells imaged in high-throughput which can be used during digital pathology to predict signalling activity in patients, and combined these approaches with mathematical modelling to understand how emergent behaviours such as cell cycle progression or size control are due to signalling dynamics (Bakal).

We discovered that the PARK2 protein is altered in one third of all cancers and its loss activates the PI3K pathway through S-nitrosylation and ubiquitylation of PTEN. We further showed that

activated PI3K signalling regulates arachidonic acid metabolism, uncovering a targetable metabolic vulnerability that largely depends on dietary fat restriction (Poulogiannis).

Collaboration in the ICR/Imperial Centre for Systems Oncology and Cancer Innovation has continued successfully, and has led to Cancer Research UK (CRUK) Grand Challenge funding (£16M) for the Rosetta project (see Collaborations). Building on this experience of partnership working, ICR and Imperial established a joint Cancer Research Centre of Excellence (CRCE) as a vehicle for a broader strategic collaboration. Together we were awarded a CRUK Major Centre (£13M), in Convergence Science, to enable us to take a convergence approach to cancer research, harnessing the power of the engineering, physical and data sciences to transform understanding, detection, diagnosis, treatment and prevention of cancer. We jointly recruited a Director for the **Convergence Science Centre** (Professor Axel Behrens) to take over from the founding Director Professor Paul Workman FRS.

Research plans for the next period

Tumour evolution and treatment resistance

In November 2020, the CEC moved into the newly opened Centre for Cancer Drug Discovery to be co-located with the Cancer Therapeutics Unit to work jointly towards finding novel ways of overcoming or thwarting drug resistance. We will (1) continue to develop predictive algorithms for cancer evolutionary progression and model cancer clonal progression and drug resistance; (2) track emergence of drug resistance in patients through circulating tumour DNA; (3) develop artificial intelligence approaches to understanding cancer ecosystems through digital pathology; and (4) model (in mice) prevention of childhood leukaemia.

The Breast Cancer Division will focus on therapy resistance to CDK4/6 inhibitors in estrogen receptor-positive (ER+) disease and sensitivity to CDK4/6 inhibitors in other breast cancer subtypes, and continue work in identifying therapeutic vulnerabilities in (1) lobular breast cancers; (2) PARP inhibitor resistance disease; (3) tumour-stroma crosstalk pathways; and (4) in DNA repair deficient and genomically unstable cancers, linking to the Centre of Genome Stability Research (see below) and translation into clinical trials.

Convergence Science

The initial focus of the convergence science research will be on developing technologies and methodologies that facilitate discovery research into fundamental principles of cancer biology, for example:

- Visualisation and characterisation of biological processes in longitudinal studies of cancer progression—including patient derived cancer organoid models—to track tumour heterogeneity and evolution.
- Understanding of the physical relationship between the tumour and its environment.
- Visualisation of therapies *in vivo* to understand mechanism of action, emergence of resistance and combination strategies.

We are developing **cross-cutting Centres** to provide a platform for collaboration between investigators, both internal and external to ICR/RM, to address key areas of the scientific strategy, without changing our Divisional structure.

Centre of Genome Stability Research (CGSR)

The ICR is forming a CGSR to consolidate and enhance interactions between the ICR teams working on genome stability and DNA Damage Response (DDR). Research co-ordinated in the CGSR will exploit our understanding of genome stability deficiencies to identify novel targets, synthetic-lethal interactions and over-reliance on DDR pathways and other checkpoints that lead to selective effects on cancer cell viability. The CGSR builds on our track record in exploiting DNA repair vulnerabilities as a therapeutic approach (see Strategy for Impact).

The Radiation Research Centre of Excellence (RRC)

The ICR has been world leading in optimisation of radiotherapy regimes. Based on radiobiological studies, we challenged orthodox views on tumour and normal tissue radiation

responses and re-defined optimal dose-fractionation regimens. We plan an intensive research programme studying the biology and immunology of the radiation response, capitalising on our involvement in the nationwide **£56M CRUK Radiotherapy Network (RadNet)**, the emphasis in the CGSR on genome instability and DDR pathways and research in our newly formed **Centre for Translational Immunotherapy,** which aims to expand the crosstalk and collaboration between UOA1 and UOA5 clinicians and scientists at ICR and RM working on cancer immunology and immunotherapies.

Strategy for impact

Our highest priority is to achieve direct improvements for cancer patients through earlier diagnosis, more targeted and effective treatments, the reduction in side effects and enhanced quality of life. We aim for the most appropriate and effective exploitation and dissemination of our research to maximise speed to patient benefit; our approach to impact is driven by this philosophy. We participate in national policy development and work with cancer charities to support public awareness, political lobbying and fundraising. In pursuing our aims, we have considerable commercial impact in the biotechnology and pharmaceutical sectors.

To facilitate the translation of fundamental research discoveries we take whichever of the following approaches are necessary and most appropriate:

- **Make the discovery widely available** through open access publication rather than commercialisation.
- **Develop our discoveries ourselves**. The ICR has a strong culture of team working and is well-equipped to carry out drug discovery, translational research, experimental medicine and all phases of clinical trials to enable the swift translation of research for patient benefit and we work closely with the RM. Examples are:
    - The identification of synthetic lethality between E-cadherin deficiency and inhibition of the tyrosine kinase ROS1 by crizotinib (Lord) led to a phase II clinical trial (Turner, Okines (RM), (UOA1)) in E-cadherin negative lobular breast cancer.
    - The development of ctDNA molecular analysis in breast cancer (O'Leary) evaluated in biomarker-led patient selection and efficacy endpoint clinical trials led by the ICR CRUK Clinical Trials and Statistics Unit such as plasmaMATCH. This has shown that ctDNA testing offers accurate, rapid genotyping that enables the selection of mutation-directed therapies for patients with breast cancer, with sufficient clinical validity for adoption into routine clinical practice (Bliss, Turner (UOA1)).
- **Accelerate the translational development of projects by supporting feasibility studies** to establish the viability of an approach.
    - ICR researchers have access to Medical Research Council (MRC) Confidence in Concept (CiC) funding and internal ICR Faringdon Fund awards, which provide £50k-£100k for initial proof-of-concept studies.
- **Partner early with industry** to give access to increased resources, research tools and complementary skills.
- Set up commercial agreements that maximise ICR researchers' **freedom to operate** and therefore ability to help multiple companies in the same field to increase the chances of success.
- **Collaborate with biotechnology companies and the pharmaceutical industry** to take research ideas through all phases of drug development and work with instrument manufacturers to develop the technologies for diagnostics and imaging.
    - Researchers in the Breast Cancer Division led ICR's partnering with RM, King's College London (KCL) and biotech/pharma companies to co-develop the use of PARP inhibitors in new combination therapies and indications.

Relationship to UOA5 Impact Case Studies

<u>Non-exclusive licencing</u>

- The AKT inhibitors impact case study is an example of issuing multiple licenses and in parallel pursuing an ICR-driven drug discovery programme to maximise the chances of

patient benefit. Six international pharmaceutical companies were licensed with reagents for their drug discovery programmes. The collaborative ICR and Astex Pharmaceuticals drug discovery research programme resulted in one lead series that was licensed to AstraZeneca who then selected capivasertib for clinical development. Capivasertib is now being evaluated in three phase III trials.

- Following the discovery that mutant *BRAF* is an oncogene, ICR and the Wellcome Trust Sanger Institute filed a BRAF patent. Twelve non-exclusive licences were granted leading to the development of multiple BRAF inhibitors, several of which now have global regulatory approval in multiple cancers as single agents and in combination with MEK inhibitors.

Developing our discoveries ourselves, systematically taking the findings of discovery research through translational steps

Biology researchers (Ashworth, Lord, Tutt, UOA5) expanded the understanding of BRCA function and provided evidence of sensitisation to PARP inhibition in *BRCA*-mutated cells. This idea was rapidly taken into phase I trials of olaparib (Tutt, de Bono (UOA1)). The ICR patented this discovery (Patent No: US8143241) and olaparib is now being used to treat ovarian, prostate, breast and pancreatic cancer patients across the world.

Open research environment

We support science being open, transparent and collaborative. The ICR is working towards compliance with the Concordat on Open Research Data. We promote the principle through our Good Research Practice Guidelines (see below), through discussion, for example the topic of the 2020 ICR Postdoc Conference was “Open and collaborative science” and by providing public access to many of our unique tools and resources. Relevant examples include:

- Reversion mutations in *BRCA1* or *BRCA2* are associated with resistance to PARP inhibitors and platinum; we collated, codified, and analysed more than 300 reversions in a freely available database.
- Resources for the protein motif community: ProViz, PSSMSearch, SLiMSearch, SLiMPrints, switches.ELM and articles.ELM.

Research integrity

The ICR subscribes to, and is committed to upholding, the **Concordat to Support Research Integrity**. The ICR’s Good Research Practice Guidelines were developed and are promulgated to emphasise the importance of integrity and rigour in research carried out at, and in partnership with, the ICR, and to ensure that all researchers are aware of their obligations with respect to proper scientific conduct.

A full review and update of the ICR Guidelines was carried out in 2017. Open discussion sessions were held on (1) publication and authorship; (2) robustness and reproducibility; and (3) openness, each led by a senior academic. All three sessions featured substantial research integrity content and their outcomes fed into the revision of the Guidelines. ICR’s **Our Values** were launched in Autumn 2018 and include “Acting with integrity”, our commitment to promote an open and honest environment that gives credit and acknowledges mistakes, so that our actions stand up to scrutiny.

The ICR is committed to enhancing public understanding of the need for animals in cancer research and has signed the Concordat on Openness on Animal Research. In 2019, the ICR was named as a **Leader in Openness by Understanding Animal Research**, an independent organisation whose mission is to achieve a broad understanding of the humane use of animals in medical, veterinary, scientific and environmental research in the UK. Following the creation of regional Animal Welfare and Ethical Review Body (AWERB) Hubs by the Animals in Science Committee to share best practice, the ICR is a member of the AWERB South East Hub.

2. People

Staffing strategy

Team Leaders are recruited to support the aims of our research strategy; there is no fixed number of teams in our scientific divisions. Where we need to cement collaborative working we make joints appointments (Behrens, ICR/Imperial; Tutt, ICR/KCL). We also offer fractional contracts to grow expertise in particular areas (Brisken, Pearl).

We maintain a healthy and sustainable demographic: in July 2020 our REF independent researchers fell into the following age bands: 26–40 (28.6%), 40–50 (28.6%), 50–60 (31.4%), >60 (11.4%).

The ICR's research staff are recruited from throughout the world. Of those independent researchers returned to UOA5, and the postdoctoral scientists in their teams, 62.5% are non-UK representing 32 different nationalities.

We have returned all staff with significant responsibility for independent research. Those involved in the review of outputs received training covering responsible use of citation analysis, unconscious bias in the assessment of research outputs, and other relevant equality issues. Choices of outputs for submission will not be used in relation to the assessment, career progression or promotion of individuals.

Recruitment and career progression of Team Leaders
Research excellence is the overriding criterion for academic recruitment.

Over the period of assessment we recruited six tenure track Team Leaders and nine Team Leaders at the tenured, Reader or Professorial level.

We have a bespoke pay policy which has enabled the recruitment of senior scientists from the UK and abroad and to attract the most promising early career researchers (ECRs). We also have a strong track record of successfully supporting the development of ECRs to grow into internationally recognised researchers.

ECRs are appointed as ICR Fellows or as tenure-track Career Development Faculty (CDF). ICR Fellows are researchers with independent funding or an initial ICR-funded period to allow them to establish their research programmes and apply for fellowships and/or transition to CDF positions. CDFs are recruited on six-year contracts to lead their own teams, win grant funding and studentships and are reviewed at five years for transfer to a non-time-limited (NTL) Faculty contract.

We provide all ECRs with support packages to enable them to “hit the ground running” and they have access to the Core Research Facility infrastructure (see below). ECRs gain supervisory and leadership skills through the EMBO Laboratory Leadership for Group Leaders course, Effective Research Degree Supervision, mentorship and peer-support through the CDF forum. The tenure success rate over the last seven years has been 70%.

In 2015, the new Head of the **Cancer Biology Division**, **Professor Jonathon Pines FRS**, joined us from the Gurdon Institute at the University of Cambridge as the Chris Marshall Chair of Cell Biology. His research focuses on how the spindle assembly checkpoint controls the destruction of cell cycle regulators to ensure that the two daughter cells receive an equal and identical set of chromosomes when a cell divides; this equal segregation of chromosomes is essential to ensure cells remain genomically stable. **Professor Jessica Downs**, who joined in 2016 from the Genome Damage and Stability Centre at the University of Sussex, studies the dynamic interplay between chromatin structure and genome stability, to understand how epigenetic disregulation promotes tumourigenesis. Two more teams joined in 2017. **Professor Jyoti Choudhary** moved from the Wellcome Trust Sanger Institute to become Head of the Proteomics Core Research Facility and leads a team applying leading edge proteomics and proteogenomics technologies. **Professor Wojciech Niedzwiedz,** who was recruited from the University of Oxford’s MRC Weatherall Institute of Molecular Medicine, focuses on

understanding how DNA replication and repair machineries function to help prevent tumourigenesis.

Since 2018 we recruited a further five Team Leaders into this Division, all of whom are supported by personal fellowships. **Dr Gideon Coster**, recruited from the Francis Crick Institute (Crick), holds a Wellcome Trust Sir Henry Dale Fellowship. His work investigates how difficult to replicate regions of the genome are copied accurately in healthy cells and how this goes wrong in cancer cells. **Dr Norman Davey**, recruited from University College Dublin, holds a CRUK Senior Cancer Research Fellowship and focuses on the role of short linear motifs within intrinsically disordered regions in directing protein-protein interactions in cell regulation. **Dr Max Douglas**, recruited from the Crick, holds a CRUK Career Development Fellowship, and focusses on the replication and processing of telomeres. **Dr Christian Zierhut**, recruited from the Rockefeller University, New York, also holds a CRUK Career Development Fellowship to study genome stability and innate immunity. **Dr Jörg Mansfeld,** recruited from the Technical University, Dresden, holds an ERC Starting Grant; he combines cell biological and biochemical approaches to reveal how the ubiquitin system controls cell cycle progression and exit into quiescence and differentiation.

Professor Axel Behrens was recruited from the Crick to a joint appointment at ICR and Imperial as the Scientific Director of the **CRUK Convergence Science Centre**. His ICR-based research team uses multi-disciplinary approaches to study stem cell biology and the mechanisms underlying tumour cell heterogeneity.

Investment into cryo-EM has facilitated the recruitment of three new Team Leaders to the **Structural Biology Division**. **Dr Claudio Alfieri**, recruited from the MRC Laboratory of Molecular Biology in Cambridge, holds a Wellcome Trust Sir Henry Dale Fellowship to investigate the structure and function of the DREAM complex, which assembles at cell cycle gene promoters. **Professor Vlad Pena**, recruited from the Max Planck Institute for Biophysical Chemistry, Göttingen, and funded by the Wellcome Trust, studies the structural basis of pre-mRNA splicing and its mis-regulation in disease. **Dr Basil Greber**, recruited from the University of California, Berkeley, holds an MRC Career Development Fellowship and studies nucleotide excision repair.

Dr Marco Bezzi joined the **CEC** from Harvard Medical School with the mission to leverage clinical data and build pre-clinical models for the identification of tumour evolutionary pathways that can be exploited for the improvement of patient care. He is generating a biobank of murine prostate cancer organoids with complex genetics that can be used to recreate heterogeneous tumours both *ex vivo* and *in vivo*.

The Breast Cancer Division has supported the career development of **Dr Ben O' Leary** through a PhD and into a National Institute of Health Research (NIHR) Academic Clinical Lectureship where he focuses on the response and resistance to therapies in breast and head and neck cancers. **Professor Cathrin Brisken** was recruited from Ecole Polytechnique Fédérale de Lausanne (EPFL) Switzerland, on a part-time contract to catalyse work in ER+ breast cancer, particularly in identifying and targeting mechanisms of resistance to hormonal therapy. Brisken's expertise in generating patient-derived pre-clinical models of treatment-resistant ER+ breast cancer delivers benefit across all the ICR and RM breast cancer research activities.

During the assessment period Gerlinger, Guettler, Sottoriva, Vannini, Yuan were promoted from CDF to non-time limited (NTL) Faculty positions whilst others moved to more senior roles at other research organisations: Claus Jorgensen, CRUK Manchester Institute; Andrew Reynolds, Principal Medical Scientist at AstraZeneca; and Stephen Whittaker, Head of Oncology at Engitix Therapeutics.

Senior researchers recruited to leadership positions elsewhere include: Alan Ashworth, President, Helen Diller Family Comprehensive Cancer Centre, University of California San Francisco; David Barford, Head of Structural Studies Division, MRC Laboratory of Molecular

Biology, Cambridge; Montse Garcia-Closas, Deputy Director, USA National Cancer Institute Division of Cancer Epidemiology and Genetics; and Dale Wigley, Chair in Protein Crystallography, Imperial.

Staff development
The ICR has held the HR Excellence in Research award from the European Commission since 2010 for our ongoing work in supporting researcher career development as defined by the Researcher Development Concordat. We have just successfully completed our 10 year review.

The ICR provides a comprehensive **framework to support the development of researchers** at all levels including Team Leaders (see above), postdoctoral researchers, scientific officers, analytical scientists and students. Training is provided through a portfolio of courses supporting academic and personal development, including scientific techniques, statistics and bioinformatics training, presentation skills, project management and research methodology; it is delivered in various formats including e-learning and webinars to maximise accessibility. We have a research entrepreneurship and industry engagement programme to support our strategy for impact.

We have a particular focus on **supporting transition from PhD to postdoctoral researcher and postdoctoral researcher to independent researcher.** An innovative residential programme, "The Pathway to Independence; Developing Future Scientific Leaders", was initiated by the ICR and developed in collaboration with the Biotechnology and Biological Sciences Research Council (BBSRC) and the Wellcome Trust Sanger Institute. The programme supports outstanding postdoctoral researchers at the point in their career when they are seeking their first independent research position. ICR attendees that now have independent positions are: Ahmet Acar (Team Leader, Middle East Technical University, Turkey); Alessandro Annibaldi (Team Leader, University of Cologne, Germany); Alexis Barr (Group Leader, MRC London Institute of Medical Sciences at Imperial); Katiuscia Bianchi (Senior Lecturer, Barts); Jerome Gouge (Sir Henry Dale Fellow, Birkbeck); Ute Jungwirth (Lecturer, University of Bath); Barrie Peck (Group Leader, Barts); Amine Sadok (Biology Director, Monte Rosa Therapeutics); and Chris Tape (Group Leader, UCL Cancer Centre).

We surveyed our postdoctoral researchers who left ICR between 2009 and 2018: 93% of these alumni are in science or education-related roles with over 15% achieving independent academic roles.

Research students
We aim to create the biology research workforce of tomorrow: computationally literate, driven to create patient benefit, and skilled to work in a team science environment. Over the REF period, 62 research students were awarded their research doctorate degree within UOA5. The ICR PhD programme offers studentships from CRUK, MRC and BBSRC (including four iCASE awards with industry over the assessment period), the Wellcome Trust, NIHR, EU training networks and other cancer charities as well as three studentships a year from the ICR itself. The ICR has taken the strategic decision to fund all science students for four years to allow sufficient time to complete high-quality research projects and skills training, and to match stipends to those awarded by major cancer charities to ensure we attract the brightest applicants. The ICR therefore supplements external awards where necessary. The ICR won funding for a Clinical PhD Programme in Cancer Research from the Wellcome Trust (2017, five intake years) and a joint CRUK Clinical Academic Training Programme with Imperial (2019, five intake years) which includes funding not only for clinical training fellowships but also an intercalated MBPhD programme.

The ICR has a centralised two-day recruitment event, which involves the selection of students by supervisors and of supervisors by students (seeking an optimal match for both).

The Academic Dean's Team, under the leadership of the Dean of Academic and Research Affairs (Professor Clare Isacke), together with the ICR Registry, is responsible for the

management of all education and training activities and ensuring that all students receive appropriate supervision, have adequate resources at their disposal and keeping a regular check on student welfare. All ICR supervisors undertake training in Effective Research Degree Supervision and attend refresher training every five years. Student progression is tracked via a bespoke iProgress platform. After their first year, PhD students submit transfer reports detailing their progress and outlining future plans. At the viva, an internal assessor, who is independent of the project, provides feedback on work achieved so far and plans for the future, and evaluates training needs. All students submit a report after 2.5 years highlighting progress and project risks, which is also independently assessed internally.

Research students, who come from a wide variety of subject and educational backgrounds, are provided with two e-learning resources to develop the knowledge and skills that are necessary to excel in cancer research. “Perspectives in Oncology” is a modular e-learning website providing a basic grounding in cancer epidemiology, cancer genetics, cell biology, bioinformatics, medical physics, structural biology, cancer treatment and drug development. “Skills” is a blog-style resource giving advice in transferable skills at appropriate times throughout the four years.

All students participate in mandatory Research Integrity training, which examines the issues and practicalities involved in ensuring their research meets the highest ethical standards.

In the **Postgraduate Research Experience Survey (PRES) 2019**, Advance HE’s sector-wide survey, the overall satisfaction rate of ICR students was at an all-time high of 92%, compared to 87–88% in surveys from 2013 onwards. This was top nationally (out of 103) for satisfaction in research degree experience and research culture. The ICR also performed well in other categories including professional development, research skills, supervision and resources. The ICR uses the survey results to work with our Student Committee to continue to enhance the learning experience and student support at the ICR.

An ICR key performance indicator for non-clinical PhD students is thesis submission within four years and our submission rates are consistently >90%: of those who submitted in 2017/18 100% submitted within four years, in 2018/19 this figure was 97.3% and it was 93.0% in 2019/20.

A specific focus over the period has been on the design and delivery of a **Succeeding in Academia programme**, aiming to support the transition from student to postdoctoral researcher. It is delivered by ICR Team Leaders and includes development of leadership skills and advice on funding applications and panel interviews.

ICR student alumni can access **career support** for up to three years after graduating, and we hold regular career development workshops and events as well as alumni networking events, to maintain engagement of the community with ICR. Over the REF period, 88% of non-clinical students moved into science-based roles in academia or industry as a first destination post-graduation.

Although the majority of clinical academic trainees are associated with UOA1, some opt to undertake their research in the UOA5 biology labs. We have a strong development programme for clinical researchers, which is significantly shaped by their input. Activities include:

- The Clinical Academic Forum—a network for ICR/RM clinical academics of all career stages promoting discussion on current challenges and career ambitions.
- Mentoring from senior clinical academics to support the transitions between clinical training and research.
- Bridge funding to help make the transition from research degree to clinician scientist.
- Post PhD, the ICR/RM lead the competitive residential programme: “Pathway to Independence: clinical academics in cancer research”. This biennial programme provides intensive coaching to prepare for academic independence and applications for clinician scientist awards. It has been attended by 52 participants nationally since its launch in 2016. 50% of all 2016 participants now hold clinician scientist fellowships, clinical lectureships or principal investigator awards.

A 2018 survey of ICR clinical alumni (PhD and MD(Res)) who completed their studies between 1983 and 2017 showed that 98% of clinicians who studied at the ICR were research active in their first role following speciality training with 38% of PhD respondents involved in laboratory-based biomedical research in their current roles.

Equality and diversity

We committed to an "open, equal and collaborative culture" as part of our 2016–2021 research strategy, in recognition that equality and diversity of staff and students is integral to our research success. The ICR Equality Steering Group has oversight of all ICR equality programmes and ensures that they are integrated, and aligned with the ICR's other strategies and programmes.

The ICR renewed its Athena Swan Charter Silver Award in 2019; we apply as a Research Institute and do not hold separate departmental-level awards.

We have three equality networks, all run in collaboration with the RM: The BAME Forum, The LGBT+ Network and the Network for staff and students with disabilities and health conditions. These groups work with the ICR and RM to develop a welcoming and inclusive culture for all.

In a new initiative, the "BAME: Beyond the Statements" Project Board, in addition to its work on culture, seeks to address the under-representation of Black, Asian and minority ethnic staff in leadership roles and in research careers at the ICR.

Our activities in equality and diversity focus on **three core objectives:**

(1) Increasing the diversity of the student cohort

Analysis of three years of ICR student recruitment data indicates that BAME candidates are less likely to be shortlisted than white candidates. The steps we are taking to address this include:

- Reviewing our guidance for applicants to ensure it is inclusive and clear what our supervisors are looking for.
- Reviewing our application form to focus on competencies statements and developing guidance for supervisors about student selection based on these competencies.
- Selection by the postgraduate tutors of additional applicants for interview from undergraduate Higher Education institutions underrepresented in the shortlisted pool.
- In our recruitment and promotional materials showcasing the diversity of the ICR and our partners.
- In 2020, we appointed Dr Yinyin Yuan as the Ethnic Diversity and Equality Champion on our Academic Dean's team, providing oversight of the ICR-wide equality agendas to the Dean's team and educational committees and acting as a point of contact for students about equality, diversity and inclusion issues.

(2) Team Leader recruitment and promotion

We monitor equality data and know we need to increase the number of female Team Leader applicants:

- We are applying a more proactive search to ensure diverse shortlists of candidates.
- We take career breaks/other circumstances into account in recruitment and promotion. For example, we support our female Team Leaders through the Women in Science Network, mentoring, and "stopping the tenure clock" for those who take career breaks.
- We provide maternity cover funding for Team Leaders. Dr Rachael Natrajan was the first to benefit from this scheme using the funding to recruit an individual to oversee her team and keep her research progressing which enabled work for two publications to be completed.
- We ensure that in all promotion and recruitment forms we provide the opportunity for applicants to declare any circumstances that may have affected productivity.
- We launched a new senior leadership development programme, which focuses on building and leading in a positive research culture to deliver ICR values.

(3) Equality training and guidance

- All staff and students attend mandatory equality and supportive workplace training, covering bullying and harassment, equality and diversity and active bystander training. We completely revised the ICR's equality training to include an annual refresher and emphasis on addressing issues through practical case studies.
- In 2018, we significantly revised our policy on bullying and harassment, commissioned a new independent hotline service to allow staff and students to raise issues in confidence, and introduced Wellbeing Advisors.
- Recruitment training, including addressing implicit biases, is mandatory for recruiting managers and all those participating in the student recruitment process.
- New policies and major revisions are subject to an Equality Impact Assessment.
- We offer all students and staff support mechanisms: employee welfare support, Wellbeing Advisors, maternity coaching, grants covering costs of childcare at conferences and training courses (including online conferences) and parent groups/support schemes.
- The "Women in Science Network" supports women to reach their potential and to help address the inequality in the number of women in the most senior research leadership roles. Topics explored include supporting high-performance teams, influencing skills, personal brand, leadership, and mentoring.
- We introduced training to equip us to hold conversations about race.

3. Income, infrastructure and facilities

Income

UOA5 received £120.0M of research income over the REF period (£17.1M mean average p.a.), including £97.8M from UK-based charities, £5.9M from Research Councils, £6.6M from UK government and health research funding bodies, £3.2M from UK industry and other UK sources, £4.5M from EU sources and £2.1M from non-EU sources.

Research in this UOA is underpinned by peer-reviewed external grant funding including:

- Breast Cancer Now (BCN), which accounts for £48.9M of the UOA's income over the REF period, including the BCN Research Centre, project grant funding and a fellowship (Natrajan). After a successful review of the BCN Research Centre's achievements and future strategy, funding was renewed in 2015 for five years and again for the period 2020 to 2025.
- Cancer Research UK, which accounts for £30.4M and is derived from project grants and programmatic awards including: fellowships (see also People section); multiple Programme Grants (Downs, Greaves, Lord, Meier, Morris, Niedzwiedz, Pearl, Pines); one Grand Challenges Award (Poulogiannis); three CRUK Programme Foundation Awards (Bakal, Guettler, Vannini); two Career Establishment Awards (Sottoriva, Yuan); one Clinician Scientist Fellowship (Gerlinger); and collaborative Accelerator Awards with Fondazione Centre San Raffaele (Sottoriva) and with Imperial (Bakal).
- Wellcome Trust income of £12.6M, derived from multiple Investigator Awards (including Guettler, Pines, Sottoriva, Vannini), fellowships (see also People section) and a £2.1M award supporting the ICR's CEC.
- Research Council funding including multiple MRC and BBSRC project grants, fellowships (see also People section), MRC CiC awards and one BBSRC Discovery Fellowship (Martin).
- European Commission funding including one ERC Consolidator Grant (Gerlinger) and ICR involvement in Innovative Training Networks.
- Project grants from funders including NIHR, Blood Cancer UK, the Lister Institute of Preventive Medicine, Sarcoma UK and Worldwide Cancer Research.

Major infrastructure funding underpins out programmatic and project funded research:

- The **ICR CRUK Centre award** (£16M) supports technical and research posts that are crucial to the management and operation of our microscopy, proteomic, sequencing and flow cytometry facilities and bioinformatics core support.
- The **NIHR Biomedical Research Centre (BRC)** at the RM and ICR provides infrastructure for translational and experimental medicine research and is critical to enabling the impact of our biological sciences research to be realised. **Substantial research income in-kind** has been received from the NIHR over the review period including £72.4M associated with the NIHR BRC at the RM.
- The **CRUK Convergence Science Centre** (£13M) provides infrastructure posts, equipment and facilities available free to Centre-funded researchers and at cost or reduced cost to other ICR users.
- The **Centre for Cancer Drug Discovery** building (UK Research Partnership Investment Fund £30M, total cost £70M) has enabled the CEC to move to be co-located with the Cancer Therapeutics Unit. The new 7,325m^2 of multidisciplinary research space houses cancer biologists, medicinal chemists, pharmacologists, clinicians, data scientists and evolutionary scientists.

Infrastructure and Research Facilities

There has been a major change since REF 2014 in consolidating and providing high-quality facilities and technical support for key resources including the formation of a Core Research Facilities unit, overseen by a Head of CRFs, operating across both sites to improve co-ordination and strategic decision-making.

Over the period, ICR has invested over £10M in addition to grant funding from the CRUK Centre Core Grant and Major Centre grants in microscopy, proteomics, metabolomics, structural biology, genomics and bioinformatics.

Core Research Facilities

- The **Light Microscopy Cores** (2.5 FTE) can analyse fixed and living cells at high spatial and temporal resolution using deconvolution wide-field fluorescence microscopy, total internal reflection microscopy, confocal laser-scanning microscopy, spinning disk confocal microscopy, and single plane light sheet microscopy. We were one of the first research organisations in the UK to acquire a lattice light sheet microscope.
- Through the **Flow Cytometry and FACS Cores**, researchers can access a range of flow cytometers/sorters, including two Becton Dickinson Symphony A3 flow cytometers and a Beckman Coulter MoFlo that can all measure up to 28 colours (seven lasers), and our expert team (2.5 FTE) provides help and support with experimental design and set-up.
- The **Proteomics Core** (3.5 FTE) offers three Orbitrap Fusion Lumos and one Fusion mass spectrometer and specialist experimental and data analysis expertise with strategic direction provided by an academic lead (Choudhary). This instrumentation enables both large-scale quantitative analysis of mixtures measuring 10,000 proteins and post-translational modifications per sample, and targeted analyses of cross-linked residues to map protein and macro-molecular structures. The Core supports projects from experimental design through to bespoke bioinformatics analysis of results. Recent projects included whole-proteome analysis to study the impact of mutations on cellular processes, proteomic post-translational profiling to monitor dynamic remodelling of tumours, and large-scale identification of protein-protein interactions.
- The **Genomics Core Facility** (formerly the Tumour Profiling Unit) provides access to state-of-the-art sequencing technologies and expertise in the molecular characterisation of tumours. Staff at the Core (6.8 FTE) apply a range of cutting-edge techniques to genomic, transcriptomic and epigenomic analyses. Through a partnership with Illumina, the ICR was the first academic centre in the UK to provide researchers with access to the NovaSeqTM 6000.
- The **Core Bioinformatics Facility** provides bioinformatics and software development support to our research projects (4 FTE). The Core helps prepare preliminary data for grant applications and has supported over 75 funded projects.

- **Laboratory Support Services** provide first line support to scientists including the collection of dirty glassware, wash up and sterilisation, biohazard waste collection, sterilisation and disposal, specialist sterilisation, pure water supply and media preparations.

The **Structural Biology Division** manages research facilities for protein production, X-ray crystallography and electron microscopy. The ICR is part of the London Consortium for cryo-EM, with Imperial, KCL and Queen Mary University of London, which in 2017 was awarded Wellcome Trust funding for a Titan Krios cryo-electron microscope equipped with a Gatan K3 direct electron detector, housed at the Crick. The ICR has a 30% share of the total experiment time of this microscope, which has been operational since the end of 2019. We upgraded our in-house cryo-EM capability, with the delivery in 2020 of a new Glacios cryo-electron microscope dedicated to efficient cryo-EM sample screening and data collection. The instrument streamlines the cryo-EM workflow and vastly expands our in-house data collection capabilities enabling us to use experiment time at the Titan Krios most effectively.

Major benefits in-kind
The Structural Biology Division is awarded data collection time for macromolecular crystallography and small-angle X-ray scattering experiments at the Diamond Light Source in Didcot, UK, and the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. In total, UOA5 researchers received access time worth £1.02M from Diamond and ESRF. These facilities provide X-ray beam lines specific for the investigation of macromolecular complexes and electron microscopy data collection time at the Electron Bio-Imaging Centre (eBIC) at the Diamond Light Source, equipped with four Titan Krios microscopes. During the review period, ICR researchers were awarded a total of 2,673 hours and additional access time to the synchrotron and a total of 696 hours of cryo-EM time.

The RM/ICR **BRC Generic Biobank**, is a stand-alone, ethically approved sample resource which includes plasma collected for ctDNA analysis. It has been pivotal to the delivery of a number of key national programmes, e.g. 100,000 Genomes Project, and is available to researchers for both discovery and translational studies.

CRUK Convergence Science Centre Facilities
The CRUK Convergence Science Centre supports infrastructure capabilities to address bottlenecks and facilitate translational research.

An **Organoid Culture and Biobank Facility** for the advancement of patient-derived organoid cancer models and associated technology and the dissemination of organoid lines and novel techniques (2 FTE). Initial projects are improving the derivation rates of tumour types and subtypes that are not amenable to organoid growth under standard conditions. It will also focus on developing methods to increase the complexity of cancer organoid models, for example through co-culturing with immune cells. The facility will standardise new derivation methods and disseminate these to ICR and Imperial cancer research groups.

A **microfabrication and prototyping facility** for the rapid production of microscale devices for pre-clinical *in vitro* studies. The Centre purchased an SU8 system for the mask-free production of polydimethylsiloxane multilayer devices at 2-micron resolution. Supported by a 1 FTE dedicated technician, the Imperial-based facility has access to a clean room and a range of equipment for the development of bespoke devices such as microfluidics, biosensors, electrochemical sensors and microneedles. The facility is linked with a larger clean room capability for the manufacture of medical devices, which includes 3D printing, laser cutting and electronics.

A CODEX system with a dedicated technician for multiplex immunohistochemistry to support the development of machine learning and AI methods in **digital pathology**. The Centre also has

access to a Hyperion CyTOF mass cytometry imaging facility at the UK Dementia Research Institute at Imperial.

The Centre supports a Perkin Elmer Muvicyte microscope allowing automated **live cell imaging**. This links with the CRUK Accelerator Award focused on developing advanced 3D culture imaging systems (see Collaborations). The Centre also supports an EVOS M7000 imaging system allowing automated multi-well imaging of cancer organoid cultures, which will be utilised by the Organoid Culture and Biobank Facility.

Other operational and scholarly infrastructure
Over the REF period, the ICR has invested in its **High Performance Computing** (HPC) and **Research Data Storage** (RDS) services, including the recent completion of a full infrastructure refresh (£500k capital investment for HPC, £3M for RDS). This recognises the increased demand for Machine Learning infrastructure, supports new research capabilities in areas such as cryo-EM and provides a new hybrid on premise/cloud capability as part of the ICR's "Unlimited Computing" strategy. Ongoing investment is being made in a programme to further improve the ICR's research data management capability including new Peta-scale storage platforms, new software infrastructure, and specialist staff to support researchers with their data challenges.

The **ICR Library** provides access to over 12,500 journals, with the majority online and the remainder through inter-library loan and publisher downloads. It also provides access to information, guidance on research data management and expertise to assist and train users in making use of the most suitable information available. The Academic Systems team manage the ICR's publication management system, Symplectic, which maintains a record of ICR authored publications, and the ICR's outputs repository, which provides free public open access to a range of ICR-authored outputs.

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

Research collaborations, networks and partnerships
We recognise we cannot achieve our research ambitions in isolation. The ICR and RM relationship is a crucial ingredient in our ability to conduct research for patient benefit and to have the capacity and capability to deliver on our research strategy. During the REF period we reviewed the ways in which we work together and signed a new Joint Working Arrangement.

We revised our **Honorary Faculty appointment** process through which RM staff have a formal academic affiliation with the ICR. Full Honorary Faculty status is equivalent to ICR NTL Faculty. In 2015, we introduced a new level of appointment, Associate Honorary Faculty, to better support those at the early stages of developing their research.

We established:

- Joint Research Operational, Strategy and Executive Groups and a RM/ICR BRC Steering Committee to award project funding, and systematically review progress towards aims.
- BRC Theme Working Groups, combining basic, translational and clinical researchers to facilitate new internal (RM/ICR) and external collaborations. Each reports into the BRC Steering Committee and is supported by a senior operational manager.

We signed two institutional-level strategic partnerships: with Imperial and the Crick. The **ICR-Imperial Centre for Cancer Research Excellence** provides a platform for collaboration across a range of areas including the £13M CRUK Convergence Science Centre. The formal partnership with the **Crick** enables ICR to appoint Crick Team Leaders as Honorary Faculty to support collaborative research and Crick Team Leaders to supervise research degree students registered at ICR.

Under the leadership of Professor Andrew Tutt, **the BCN Research Centre** brings together scientists and clinicians to focus on breast cancer biology, diagnosis and treatment. Professor Tutt also leads the BCN Unit at KCL creating a "BCN London" research programme with the BRCs at Guy's and St Thomas' NHS Foundation Trust (GSTT) and KCL.

The **CRUK Accelerator Award Scheme** launched in 2015 to enable a collaborative approach to develop tools and resources to unlock new research into unanswered questions in cancer research. To date 21 projects received awards up to £5M, and the ICR is involved in 10. Researchers in UOA5 are involved in:

- The Crick-led Accelerator funding Clinical Research Training Fellows.
- The UCL-led Accelerator catalysing progress in cancer immunotherapy network.
- The Leicester-led project to accelerate drug discovery through a networked structural biology resource.
- The Milan-led Accelerator in single-cell cancer evolution in the clinic.
- The Imperial-led project to accelerate the ability to understand and target complexity and heterogeneity in cancer through automated imaging of 3D cancer.

An ICR team is part of a winning consortium that won one of the first CRUK Grand Challenges. The collaborators, from the National Physics Laboratory, Imperial, AstraZeneca, Barts and the University of Cambridge, ICR (Poulogiannis), the Crick, and the CRUK Beatson Institute, received £16M for a project to use a variety of new mass spectrometry imaging techniques and instruments to study individual breast, bowel and pancreatic tumours.

UOA5 staff are part of the **Arizona Cancer Evolution Center,** a US-UK collaboration supported through US federal government awards and aimed at understanding the fundamental nature of cancer by using evolutionary and ecological models. Other major consortia supported by US funding focus on the somatic evolution in breast cancer with American partners (Yuan) as well as on the creation of reference gene annotation for the human and mouse genomes with collaborators in Spain and the US (Choudhary). UOA5 researchers are also involved in international training networks funded by the European Commission with partners all over Europe (Germany, Spain, Sweden, Switzerland, Denmark, Estonia, Finland, France, Italy, Netherlands, Norway and Poland) that aim to tackle the challenges in cancer research in addition to fostering new skills in students (Davey, Guettler, Yuan).

Engagement with key research users, beneficiaries or audiences

To achieve its scientific and strategic ambitions, the ICR seeks to influence the key decisions that shape the funding and regulatory environment. We reconfigured our Communications Directorate to include a greater emphasis on policy and are using our Research England Strategic Priorities Funding to offer research students and staff opportunities for secondments to policy organisations. We communicate with politicians, senior policy makers and funders, to encourage an environment that supports the translation of discoveries for patient benefit. "Search" is the ICR's supporter magazine and features news about research and fundraising achievements.

We promote and increase our interactions with the business community to ensure that our research discoveries are developed in the timeliest manner. We showcase research partnership opportunities for commercial partners at meetings, events and conferences and via the Connections e-newsletter. Our first joint "Science Day" with AstraZeneca was held in November 2019 and featured over 20 presentations from researchers from the ICR, RM and the company and brought together more than 100 delegates.

Wider contributions to economy and society

This UOA grouping has an outstanding track record in delivering against its mission and translating scientific discoveries into new therapeutic approaches, often through collaboration with industry partners (see Impact Case Studies). Other current collaborations with industry include working with Intelligent Imaging Innovations to develop pioneering technology in lattice

light sheet microscopy and Ocello, a biotechnology company, on patient derived tumour organoid cultures.

We work with industrial partners in the training of PhD students to develop a future workforce that can translate science for the benefit of patients and society through iCASE studentships. The ICR's MRC iCASE programme has had students working on projects in double strand break DNA repair and tankyrase regulation. The in-kind contributions are estimated to be over £200k and provide experienced members of industry research staff to co-supervise students, taught training courses in drug discovery and access to specialist industrial equipment, appropriate unpublished datasets, facilities and expertise.

The new Centre for Cancer Drug Discovery forms the cornerstone of plans for a **London Cancer Hub.** The ICR and the London Borough of Sutton are working in partnership to create a global centre for cancer innovation; the Hub can potentially accommodate up to 100,000m^2 of new space for private enterprises to share the Sutton site and could ultimately create 13,000 jobs and contribute £1.2B to the UK economy annually. A high-quality incubator space for life-science companies, Innovation Gateway, will open in late 2021.

Engaging with diverse community
Through our public engagement work, we aim to encourage young people into science and establish lasting relationships with local communities. We work with partner organisations to increase the impact of our engagement work. Over the last three years, we conducted nearly 200 public engagement activities, involving an average of around 150 staff members and students each year. Over 10% of our organisation is involved with public engagement annually.

To drive longer-term change the ICR's public engagement strategy includes activities aimed at groups currently under-represented in research (BAME and those from disadvantaged socio-economic backgrounds). We recognise that diversity in research is key to excellence, and actively encourage a more diverse and inclusive research workforce. We will focus our engagement work on promoting science careers within this group, working with local schools who have a high intake of students from low socio-economic backgrounds.

The ICR collaborates with the London Borough of Sutton on a programme of local engagement, and is supporting a new Cultural Impact Award. In 2018, we worked with Sutton Central Library to create an exhibition of scientific images from the ICR and RM. We worked with the Science Museum to develop content and source exhibits for its new £24M Medicine Galleries and are working with them on a future exhibit "Living with Cancer" scheduled to open in October 2021. We worked with Understanding Animal Research to offer training on engaging with the public about animal research, and created guidance, FAQs and a fact sheet.

Contribution to the sustainability of the discipline, interdisciplinary research, and responsiveness to national and international priorities and initiatives
Our researchers regularly participate in site visit assessments of other organisation and provide expertise for advisory board and conference organisation committees: UKRI Physics of Life External Programme Advisory Board (Bakal); British Society for Cell Biology Committee (Bakal); International Breast Cancer Study Group (IBCSG) Biological Protocol Working Group (Brisken); ELIXIR, Intrinsically Disordered Proteins, Community Lead (Davey); Human Proteome Organisation (HUPO) Proteomics Standards Initiative, Intrinsically Disordered Proteins Working Group (Davey); AZ-CRUK Functional Genomics Centre Triage Panel, Milner Institute (Downs); European Association for Cancer Research (EACR), Conference Committee (Downs); Institut Cochin, Paris, Review Panel 2018–2019 (Downs); EACR, Executive Committee (Isacke); American Association of Cancer Research (AACR), Annual Meeting Scientific Program Committee (Isacke); Academy of Finland, Cancer Research Panel, Chair (Isacke); Wallenberg Centre for Molecular Translational Medicine, Gothenburg, Sweden, Scientific Advisory Board, Member, 2015–2020 (Isacke); CRUK Manchester Institute, Scientific Advisory Board (Isacke); Oncode Institute, International Advisory Board (Isacke); NCRI Breast Cancer Clinical Studies Group (Lord); Chair of Gordon Conference on Cell Death (Meier); 2019 AACR Annual Meeting

Program Committee, Chairperson of the Metabolism and Cancer Section for the AACR Annual Meeting (Poulogiannis); Oxford Early Breast Cancer Trialists Collaborative Steering Group (Tutt); and St Gallen Early Breast Cancer International Consensus Panel (Tutt).
Researchers on editorial boards include: Molecular and Cellular Proteomics (Choudhary); NAR Genomics and Bioinformatics (Davey); DNA Repair (Downs); Trends in Cancer (Gerlinger); Journal of Cell Science (Isacke); PloS Biology (Meier); Cell Death and Differentiation (Meier); Journal of Pathology (Natrajan); Molecular Oncology (Lord); EMBO, EMBO reports, PLoS Biology, eLife, Cell Biology and Editor-in-Chief for Open Biology (Pines).

More widely, we train and support the career development of researchers that take on leadership positions elsewhere in the UK and abroad (see People section).

Indicators of wider influence, contributions to and recognition by the research base

We provide significant contributions to funding panels such as:
CRUK (Downs, Clinical Career Committee; Tutt, Clinical Research Committee and Experimental Medicine Expert Review; Gerlinger, Tutt, Multidisciplinary Expert Review Panel; Lord, New Investigators Committee; Bakal, Pioneer Award Committee; Isacke, New Investigators Committee and Discovery Research Committee); Wellcome Trust (Pines, Chair Molecular Basis of Cell Function Expert Review Group; Choudhary, Multi-User Equipment Committee); European Molecular Biology Organisation (EMBO) (Alfieri, Short Term Fellowships Advisory Board); and BCN (Lord, Natrajan, Project Grant Committee).

UOA5 researchers winning significant prizes and markers of esteem:

- Fellows of the Royal Society (FRS): Greaves, Pearl, Pines.
- Fellows of the Academy of Medical Sciences (FMedSci): Greaves, Isacke, Pearl, Pines, Tutt.
- Elected members of EMBO: Behrens, Meier, Isacke, Greaves, Pines, Pearl.

In 2019, Pines was awarded a Lifetime Achievement Award from SciGenom Research Foundation in recognition of his pioneering contributions in the field of cell cycle research. Other awards include: CRUK Future Leaders in Cancer Research Prize 2015 (Bakal) and 2016 (Sottoriva); Addari Award for contribution to the field of BRCA1 and BRCA2 therapeutic discovery and patient care 2015 (Tutt); Merrimack Pharmaceuticals Prize in Systems Biology 2015 (Bakal); CRUK Translational Cancer Research Prize 2017 (Gerlinger); CRUK Lifetime Achievement in Cancer Research Prize 2015 (Greaves); EMBO Young Investigator 2016 (Vannini) and 2018 (Pena); Novartis Medal, Biochemical Society 2018 (Pearl); and Lister Prize 2017 (Guettler).

In 2017, Professor Mel Greaves FRS was awarded The Royal Society's prestigious Royal Medal and in 2018, was awarded The Society of Memorial Sloan Kettering Prize. The outstanding nature of Professor Greaves' research culminated in a knighthood for his services to children's leukaemia research at the end of 2018.