Institution: Newcastle University

Unit of Assessment: UoA5 - Biological Sciences

1. Unit context and structure, research and impact strategy

1.1 Overview

UoA5 scientists deliver transformational biological discoveries that underpin new clinical and industrial applications. To achieve this, we work in large multidisciplinary teams, and actively engage with local partners, the global academic community and the pharmaceutical industry. Of the 117 Newcastle University (NU) based UoA5 outputs, 95% feature internal or external collaborations. We have made major investments in external recruitment at senior professorial level (**Palmer**, **Trost**); early career researchers (ECRs, **Greaves**, **Holden**, **Hudson**, **Lowe**, **Melnikov**, **Nicholls**, **Strahl**, **Wollman** and **Connolly**); together with >£9.4million in scientific facilities, research infrastructure and state-of-the-art technologies that underpin our research. Consequently, our REF2021 UoA5 return is significantly expanded to 58 staff (56.6FTE) versus 32 (30.6) in 2014.

UoA5 research income in this REF period was £58million. This includes five new Wellcome Investigator Awards (**Errington**, **Higgins**, **Trost**, **van den Berg**, **Zenkin**), two Wellcome Senior Fellowships (**Murray**, **Sanz**), three Wellcome Sir Henry Dale Fellowships (**Davies**, **Holden**, **Nicholls**), two Wellcome Collaborative Awards (**Salgado**, **Quinn**), an MRC Career Development Award (**Madgwick**), a BBSRC/Innovate UK Catalyst grant (**Lakey**) and a CRUK programme grant (**Perkins**). In addition to other external recognition of UoA5 staff, **Embley**, **Gilbert** and **Palmer** were elected as Fellows of the Royal Society (FRS).

1.2 Research and Strategy

UoA5 research activity is grouped into three major research domains: ***Bacterial Cell Biology and the Human Microbiota***, ***Structural Biology*** and ***Eukaryotic Cell Biology, Signalling and Disease***. Two key goals from our REF2014 research strategy were '*developing our research groupings through key appointments and appropriate investment*' and '*fostering interactions between different research groups'*. We have achieved this through key appointments of senior staff and recruitment of ECRs, together with investment in our facilities. New technologies associated with these appointments have stimulated collaborations. Furthermore, activities such as Friday lunchtime PI talks, Institute Research Away Days, summer BBQs, focused workshops (including on genome editing and mouse models of cancer) and research groupings (the 'Fungal forum', 'Cell Cycle and Mitosis') have combined to create a collaborative atmosphere.

1.2.1 Bacterial Cell Biology and the Human Microbiota

Microorganisms play critical roles in all major aspects of life on earth such as human health, infectious diseases and global ecology. Bacteria are ideal experimental models to unravel the complexity of crucial cellular mechanisms and organismal interactions. Our scientists have an international profile including three current (**Errington**, **Palmer**, **Embley**) and one recently retired (**Gilbert**) FRS. Many researchers are also members of the Centre for Bacterial Cell Biology (CBCB) (Director: **Errington**), an internationally recognised centre of excellence.

UoA5 scientists use bacteria to:

- Discover the fundamental mechanisms underpinning cellular processes such as growth, the cell cycle, environmental sensing and signalling. Example: work from **Palmer** (with **Strahl** and **Trost**) identified a Staphylococcus aureus toxin that can inhibit the growth of bacterial competitors in vivo (PNAS2020).
- *Uncover the mechanisms that underpin the beneficial effects of the commensal microbiota*. Example: research from **Bolam**, **Lowe**, **Cuskin**, **Gilbert** on the microbiota has provided new insights into the mechanisms underlying the breakdown of complex glycans in the gut (PNAS2017; Nature2017).
- *Understand bacterial and eukaryotic evolution, and the evolution of bacteria as symbiotes*. Example: **Embley** redefined our understanding of evolution by demonstrating that eukaryotes derived from archaea prokaryotes in a two domain 'Tree of Life' (NatEcolEvol2020).
- *Determine the mechanisms that important bacterial pathogens use to cause disease and resist antimicrobial treatment*: Examples: **Errington**'s work, with **Aldridge** and **Hall**, on L-form bacteria has demonstrated their importance in antibiotic resistance and recurrent urinary tract infections (Cell2018, NatCommun2019); **Zenkin,** with **Yuzenkova** and **Errington**, has revealed the role of RNA polymerase in antibiotic resistance (MolCell2018).
- Translate these discoveries to real-world applications such as combatting antibiotic resistance, developing new therapeutics, diagnostics, bioprocessing and synthetic biology. Example: research by **Murray** into the mechanisms of bacterial DNA replication (Nature2016) is providing the basis for ongoing antibiotic drug discovery (see s4).

Recruitment: During this REF period, we have built capacity through the recruitment of **Palmer**, a world-leading bacterial cell biologist (NatMicrobiol2016). There has also been strong recruitment of ECRs. **Lowe** and **Cuskin** have strengthened research into the microbiota (Nature2015). **Holden** has brought cutting-edge expertise in super resolution microscopy and used this to make fundamental insights into bacterial cell division (Science2017). **Strahl** investigates the role of membrane curvature and fluidics on protein function (NatCommun2015). **Melnikov** strengthens research on the evolution of parasites (PNAS2018 x2), an area where **Hirt** and **Embley** provide existing expertise (Nat Commun2018). Scientists in this area work closely with infectious disease researchers and clinicians to give their research clinical context (PNAS2019; CellHostMicrobe2017). This has been further strengthened through the recruitment of **Connolly** (NatCommun2018).

Notable grants:

- Wellcome Trust Investigator Awards: **Errington**, **Palmer**, **Zenkin**, **Vollmer**
- Wellcome Trust Senior Research Fellowship: **Murray**
- Wellcome Trust Sir Henry Dale Fellowship: **Holden**

1.2.1 Eukaryotic Cell Biology, Signalling and Disease.

We investigate the molecular basis of cell signalling in both normal cellular function and in disease using model and pathogenic organisms. These mechanisms underpin many areas of biology and allow cells to sense and respond to both the extra- and intra-cellular signals that are critical to maintain organismal homeostasis. Defects in these systems compromise development

and contribute to infertility, ageing, pathogenicity, cancer and other diseases. Targeting these pathways forms the basis of many current and future clinical therapies *(*Impact Case Study (ICS) '*Erdafitinib, a first-in-class treatment for bladder cancer'). This area's research provided the underpinning research for two further ICSs '*Peptest, a quick and simple test for reflux*' (**Pearson**) and ' *aProximate, a renal in vitro cell culture model to better predict toxicity during drug development*' (**Brown**)). UoA5 researchers in the Wellcome Centre for Mitochondrial Research (WCMR) (**Greaves**, **Hudson**, **Lightowlers**, **Nicholls**), study the molecular basis of mitochondrial disease. WCMR scientists pioneered the clinical technique of mitochondrial donation, with **Lightowlers** contributing to the essential underpinning biology of UoA1 ICS "*A new technique to prevent transmission of mitochondrial disease*". NU is also a **CRUK Centre**, and the development of the Centre for Cancer (NUCoRE *1.3.2***)** brings together all cancer-related investigators and research activities from across the University, including several UoA5 staff (**Higgins, Huang**, **Greaves**, **Perkins**, **Schneider**, **Veal**).

Research in this area focuses on:

- *Dissecting and understanding cell signalling in normal cellular function and disease*. Example: **von-Zglinicki**, **Passos**, **Korolchuk**, **Saretzki** have shown how inflammation, cell senescence and telomere loss contribute to defects in cell signalling, ageing and the development of cancer and other diseases (NatCommun2014; NatCommun2014; JCellBiol2017; NatCommun2017).
- *Chromosome replication, cell division and genome stability*. Example: research in this area brings together the groups of **Higgins**, **Huang**, **Lydall**, **Madgwick**, **Maringele**, **Rodriguez**, **Davies**, **Whitehall**, who investigate the fundamental mechanisms underlying the cell cycle, genome stability, mitosis, meiosis and cell polarity (DevCell2019; JCellBiol2019; DevCell2017; GenesDev2019; NatCommun2014).
- *Epigenetic signalling, transcriptional regulation and RNA processing*. Example: **Schneider** and **Watkins** discovered that the Utp24 endonuclease cleaves pre-ribosomal RNA at two coupled sites in yeast and humans (NuclAcidsRes2016).
- *Understanding the role of mitochondria in human health and disease*. Example: work from the **Greaves** laboratory, with **Perkins**, **Hudson** and other NU colleagues, has revealed that age-associated oxidative phosphorylation defects caused by somatic mitochondrial DNA (mtDNA) mutations result in metabolic remodelling of cells that accelerates intestinal tumorigenesis (NatCancer2020).

Recruitment: **Trost** whose research focuses on innate immunity and macrophage biology (EMBOJ2018), has also brought the application of state-of-the-art proteomics to NU. Recruitment of ECR **Nicholls** has brought expertise in mtDNA replication to the WCMR (MolCell2018, 2019). Complementing the recruitment of **Holden** (see above), **Wollman** brings expertise in single-molecule microscopy that he used to describe clustering of transcription factors in cells (eLIFE2017).

Notable grants:

- Wellcome Trust Investigator Awards: **Higgins, Trost**
- Wellcome Trust Sir Henry Dale Fellowship: **Nicholls**
- Wellcome Trust Collaborative Award: **Quinn** and **Trost**
- Wellcome Trust Senior Research Fellowship: **Sanz**

- MRC Career Development Award: **Madgwick**
- CRUK Programme Grant: **Perkins**

1.2.3 Structural Biology

Knowledge of the structure of biomolecules is essential for understanding all biological processes and is the basis for the development of novel therapeutics, materials, diagnostics. Structural biology research at NU goes far beyond the UoA5 staff listed here, and is, for example, at the core of **FMS cancer drug discovery research** (see ***Erfatinib*** ICS). This area incorporates the Newcastle Structural Biology Lab (**SBL**), which encompasses five research groups (*UoA5: van den Berg, Salgado, Marles-Wright; UoA1: Endicott, Noble*), supported by a modern facility with over 50 users. Specific interests of UoA5 structural biologists include:

- *Structural microbiology, focused on bacterial organisms, from human pathogens to gut microbiota.* Examples: **van den Berg** continues to make significant new insights into membrane transporters and structure (NatMicrobiol2020; NatMicrobiol2017). In addition, **van den Berg** has collaborated with **Bolam** to determine the structural basis for nutrient acquisition by dominant members of the human gut microbiota (Nature2017) and with **Rutherford** to describe the structural basis for regulation of Mep2 ammonium transceptor activation by phosphorylation (NatCommun2016). **Lewis** and **Vollmer** collaborated to determine the structure and function of a spectrin-like regulator of bacterial cytokinesis (NatCommun2014). **Dennison** and **Waldron** discovered that copper storage requires a four-helix protein bundle (Nature2015).
- *Using structural biology to investigate mammalian cell division*. Example: **Davies,** with **Madgwick,** has provided new structural insights into meiosis (NatCommun2016) and the synaptonemal complex (NatStructMolBiol2016).
- *Understanding biomolecules, their function, structure and interactions.* Example: **Lakey**'s research has revealed new structural models for the gram negative bacterial outer membrane, which is known to reduce antibiotic effectiveness (PNAS2018).
- *The development of new biomaterials*. Example: **Lakey**, in collaboration with **Perkins** and NU colleagues from UoA8 and UoA12 (*4.5.2*), is developing the *Yersinia pestis* Caf1 protein as a novel biomaterial (Chem2020).

Notable grants:

- Wellcome Trust Investigator Award: **van den Berg**
- Wellcome Trust Sir Henry Dale Fellowship: **Davies**
- Wellcome Trust Collaborative Award: **Salgado**
- BBSRC/Innovate UK Catalyst Award: **Lakey**

1.3 Organisational Structure

The Faculty of Medical Sciences (FMS) restructured in 2019 to facilitate inter-disciplinary working and now comprises three interconnected research institutes, the Biosciences Institute (NUBI), Translational and Clinical Research Institute (NUTCRI) and Population Health Sciences Institute (NUPHSI). These play a key role in supporting our research with state-of-the-art facilities, training and career development. This UoA5 return comprises 56 scientists from NUBI together with two members of the Faculty of Science, Agriculture and Engineering (SAgE) whose research focus is biological sciences.

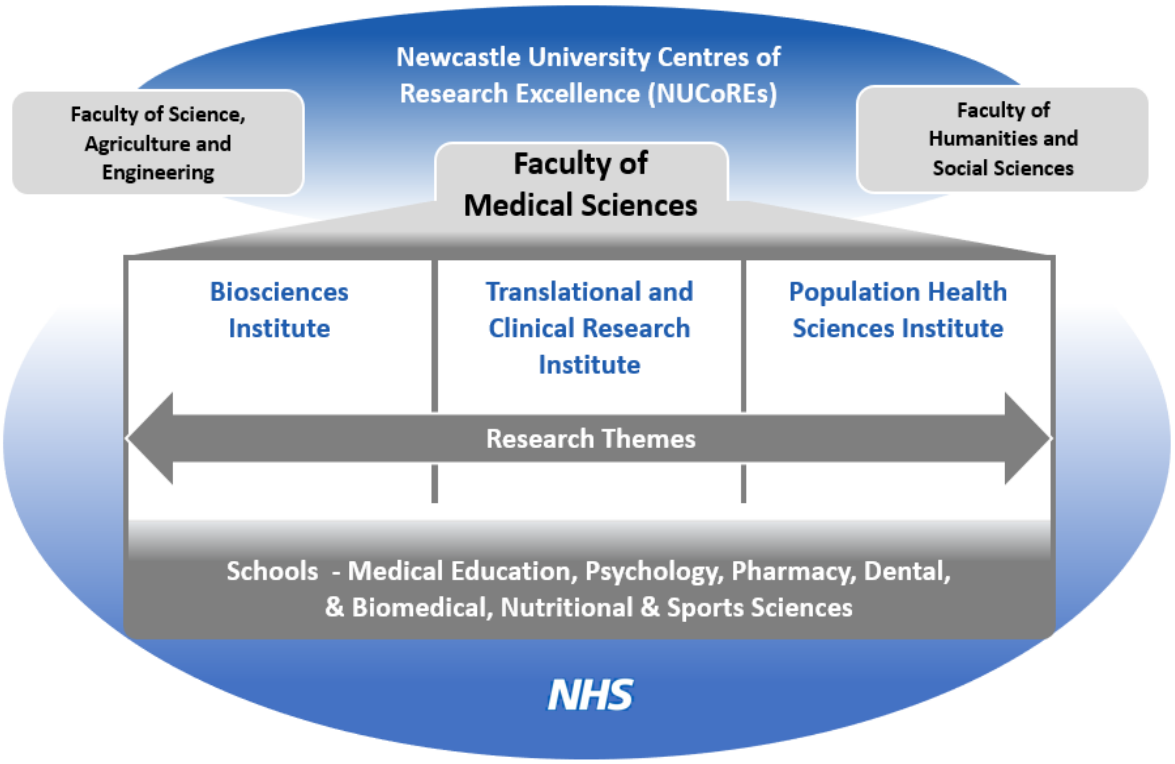

Figure 1. Organisational Structure

1.3.1 Research Themes

To build on our existing strength of collaborative research and we created research themes which pull together multi-disciplinary teams of researchers, allowing new fields of expertise to be recognised and nurtured. We designed themes to be bottom-up and flexible so that they are responsive and can evolve over time.

- All staff in FMS choose membership of a Theme that best aligns with their research interests and are typically affiliate members of up to two others.
- Themes organise a range of events designed to promote inter- and intra- theme collaboration that include internal and external seminar speakers, PI retreats, research in progress talks from PGR students, postdocs and technicians, as well as regular meetings to discuss relevant topics such as the research funding landscape or industrial links.
- Shared Theme membership, joint activities such as lunchtime research talks given by Theme members and the support of Institute-wide activities, such as Research Days, combine to support a collaborative spirit and approach.

1.3.2 Newcastle University Centres of Research Excellence (NUCoREs)

NU also promotes **cross-faculty**, interdisciplinary research through the NU Centres of Research Excellence (NUCoREs REF5a 2.2.1)). The NUCoRE model encourages grass-roots establishment of research networks operating across the three university faculties.

1.4 Future Research Strategy

1.4.1 Creating a collaborative and interdisciplinary research environment

In what will be a challenging funding landscape, we believe that continuing and enhancing our collaborative approach will increase the impact of NU biological sciences research and create new opportunities to secure external funding. We aim to further develop interdisciplinary research, an area we have identified where improvement is needed. This will be facilitated by the **Research Themes** that create a more collaborative research culture. In parallel, NUCoREs link UoA5 scientists to other faculties, NHS colleagues and patients, to local and national research structures, industry and businesses. UoA5 staff are already members of the NUCancer and Rare Diseases NUCoREs. A '**Host and Microbes**' NUCoRE is currently in development that will further create collaborative opportunities between colleagues working in Microbiology and Immunology. Interdisciplinary research will also be promoted through the development of the IMA incubation Incubator (*3.3*) and SIGs (*1.4.2*).

1.4.2 Enabling technologies and methodologies for life science research

The Innovation, Methodology and Application (IMA) Theme, which spans all 3 FMS Institutes and has >260 members, has developed **Special Interest Groups** (SIGs), focused on different enabling technologies and methodologies (Figure 2). These are a crucial element of our future strategy to develop and optimise new approaches and to connect the most appropriate technologies and methodologies to the right research questions. These will also contribute to **research integrity** by establishing a culture of best practice in data generation, annotation, analysis and presentation. See also IMA Innovation Incubator (*3.3)*.

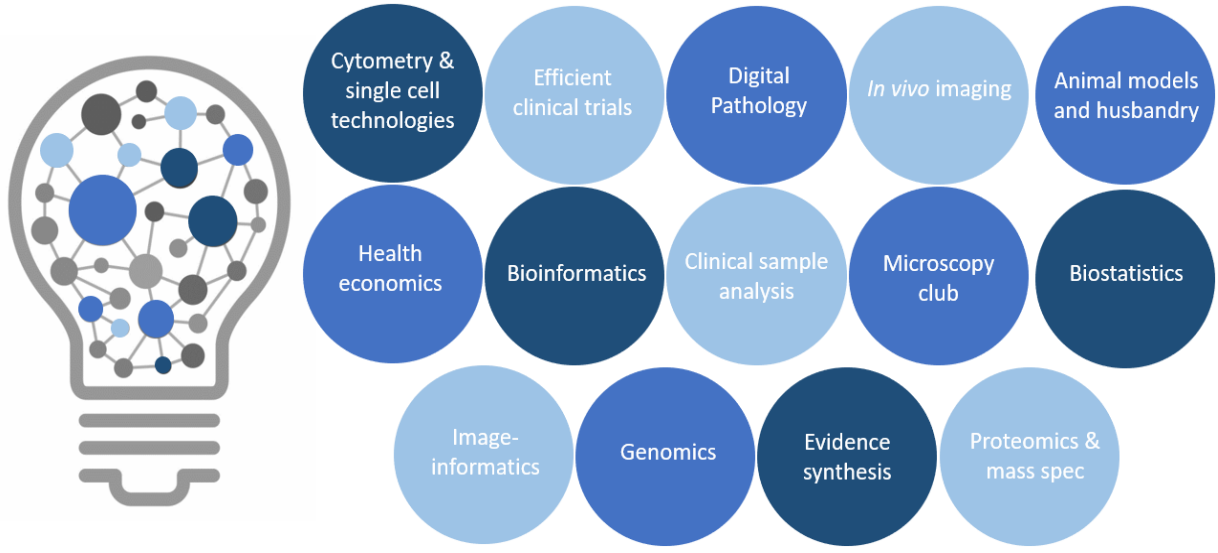

Figure 2. Special Interest Groups

1.4.3 Building capacity

We have identified three areas where we aim to build capacity over the next REF period, through a combination of establishing collaborations, increased grant income and, recruitment.

- **Metabolomics analysis** provides a detailed understanding of changes to cellular metabolism resulting from metabolic diseases, drug treatments, genetic mutations or cell signalling pathways. These provide insights required to understand the nature of disease, reveal new drug targets and diagnose biomarkers. Building capacity in Metabolomics will add value to our recent investments in proteomics, contribute to many of our existing strategic areas such as cancer, mitochondrial disease, infection and inflammation, and link to biologists in SAgE.
- **Single cell technologies and methodologies** now underpin significant and high impact discoveries across several biological disciplines. NU has already invested in this area (*Genomics Core Facility, 3.2*), has world-leading expertise (ECR recruit **Wollman**, **Haniffa** - UoA1) and has formed strategic links (*e.g.* **Sanger Institute**).
- Underpinning future research in areas such as genomics, proteomics, metabolomics and single cell technologies is a requirement to integrate and mine the data generated, using innovative machine-learning approaches and high-throughput computing. Investment in **Data Science** is therefore critical for us to build further capacity in other areas.

1.5 Impact Strategy

UoA5 has an impact champion (**Pearson**), who works closely with FMS impact officers to identify potential impact from research, including impact beyond the current REF ICSs (*4.5*). The nature of the fundamental biosciences research performed in UoA5 typically generates impact through:

- providing the molecular basis for target identification in drug discovery and subsequent mechanistic analysis that underpins successful clinical application (**Erfatinib** ICS "*Erdafitinib, a first-in-class treatment for bladder cancer"*
- development of a process, technique and unique expertise that can be used by the pharmaceutical or biotechnology industries (ICS '*Fibrofind, a stable human alternative for testing anti-fibrotic drugs*' and ICS '*Skimune, a test for adverse immune reactions to compounds including chemicals, cosmetics and novel pharmaceuticals'*).
- Commercialisation of novel reagents generated in the laboratory (*4.5.2*).

A common theme of the UoA5 ICSs is a foundation in fundamental laboratory research that can be developed for therapeutic or commercial benefit:

- With ICS **Peptest**, **Pearson** and colleagues created a pepsin ELISA assay that was then further developed by Technostics, to create '*Peptest, a quick and simple test for reflux*'.
- The development of **Erdafitinib**, the "best-in-class" FDA approved, pan-FGFR inhibitor currently used for the treatment of bladder cancer, relied on our expertise in **Structural Biology**. Here, structural analysis of a target protein, combined with characterising the binding of low molecule weight drug-like fragments using X-ray protein crystallography

and/or Nuclear Magnetic Resonance spectroscopy, provided the foundation for the rapid development of candidate FGFR inhibitors.

- Basic fibrosis research by **J Mann**, **D Mann**, **Oakley** and **Borthwick** led to the development of an improved bioreactor that maintains the viability and function of precision cut tissue slices (PCTS) derived from *ex vivo* human organs. **FibroFind** uses this expertise to generate *in vitro* fibrosis models that are used for drug target validation and determination of efficacy by a wide number of pharmaceutical companies.
- **Dickinson** found that an adapted graft versus host assay could accurately predict the immune reaction to novel compounds. This led to the development of **Skimune*,*** a skin-based assay that predicts allergic reactions to pharmaceuticals and other compounds *in vitro*. The Skimune series of predictive assays have been successfully commercialised by the biotechnology company Alcyomics.
- Research by **Brown**, resulted in the development of **aProximate** cells, *in vitro* cell culture models of human and animal kidney proximal tubule. These models provide substantial new mechanistic and species-specific data about the nephrotoxic potential of new drug molecules. Newcells market the aProximate system and to date over 50 new drug molecules have been screened for major Pharmaceutical companies.

These UoA5 ICSs principally map onto two areas as defined in the REF:

- Impacts on the health and wellbeing of people and animal welfare: **Peptest & Erdafitinib**
- Impacts on commerce and the economy: **FibroFind, Skimune & aProximate**

1.6 Research Integrity and Openness

The University is a signatory of the **Concordat for Research Integrity** and, as outlined in REF5A 2.3, has identified **Professor Simon Woods** (UoA21) as its expert convenor on research integrity, while **Professor Candy Rowe** (UoA4) has been appointed **Dean for Research Culture and Strategy** with oversight of integrity. We maintain policies and procedures compliant with the Concordat to Support Research Integrity, subscribe to UKRIO, and are members of the **Russell Group's Research Integrity Forum**. We have several approaches to promote these aims:

- All PGR students, as part of their first year induction, attend 'Research Ethics – Theory' and 'Recording your Research' workshops. Our PGR Development programme (*2.6.1*) includes a compulsory session on 'Academic Integrity and Plagiarism'.
- The 'PI Development Programme' and 'New PGR supervisor training workshops' both feature sessions on Research Culture and Integrity.
- Colleagues are supported by our Research Data Manager in the development of data management plans for research proposals, including making use of the University's Research Data Repository (REF5a 2.3.3).
- The University's ePrints repository ensures research outputs are made Green Open Access, while we make best use of RCUK/UKRI and COAF, together with Faculty and Institute funds, to increase the proportion of Gold open access publications.

2. People

2.1 Recruitment

We have taken a balanced approach towards recruitment that combines external appointments with continued nurturing of Newcastle-trained scientists.

2.1.1 Recruitment of senior staff

The recruitment of **Professor Matthias Trost** in 2017 strengthened our research in ***Eukaryotic Cell Biology, Signalling and Disease*** and required investment in state-of-the-art proteomics. In addition to his own research group focused on innate immunity and macrophage biology, Trost also provides leadership as the academic lead for Proteomics. **Professor Tracy Palmer**, recruited in 2018, strengthens our expertise in ***Bacterial Cell Biology and the Human Microbiota*** and leads our Microbes in Health and Disease Theme. Palmer's research was recognised by her election as an FRS in 2018.

The retirement of **Lewis** (in 2019) resulted in loss of leadership in the area of ***Structural Biology***. As part of our succession strategy, **Marles-Wright** was recruited in 2016 as a Senior Lecturer in Microbial Biotechnology in the SAgE Faculty where he researches bacterial stress responses and metal acquisition, and strengthens our research in this area. In addition, we have just completed the recruitment of **Professor Wyatt Yue** who uses structural biology for drug discovery in the treatment of rare diseases. Yue will join NU in 2021.

2.1.2 Recruitment of ECRs

In our REF2014 UoA5 submission we highlighted the then recent development of the five-year tenure-track Independent Researcher Establishment Scheme (IRES), an initiative driven by the Institute for Cell and Molecular Biosciences (ICaMB, now incorporated into NUBI). From that initial cohort, **Davies** and **Rodriguez** have both progressed to open-ended contracts and full academic positions.

The success of the IRES scheme allowed FMS to broaden this scheme across the whole faculty as the **Newcastle University Research Fellowship (NURF**). Like the IRES, these are five-year fellowships to support ECRs with emerging reputations for innovative research. In this UoA5 return, six members of Category A staff were recruited as NURFs: **Greaves**, **Holden**, **Hudson**, **Lowe**, **Nicholls**, **Strahl.** Of these, Greaves, Lowe and Strahl came from our existing pool of Newcastle postdoctoral researchers. Greaves, Holden, Hudson and Strahl have all progressed to open-ended contracts and full academic positions. The NURF programme was so successful that it served as the model for the University-wide NUAcT (Newcastle University Academic Track) Fellowship scheme (REF5a 3.2.4). Two of our UoA5-returned staff are current NUAcT fellows (**Melnikov**, **Wollman**).

This major investment in highly talented and successful ECRs meets and exceeds a key strategic objective of our REF2014 UoA5 return. The adoption of the FMS fellowship model by the University ensures that we continue to do so.

2.2 Staff Development and Mentoring

2.2.1 Overview

Since 2014 we have invested in mentoring, support and training for our staff, with the aim of creating an integrated strategy to develop scientific careers through all stages (Figure 3). This includes career development opportunities, mentoring and financial support for all levels and categories of staff.

We adopt a Team Science approach to ensure that our technical staff, technologists and methodologists are properly acknowledged for their contribution to our research and have a stable and rewarding career structure, with opportunities for promotion and development.

The university is committed to the ***Concordat to Support the Career Development of Researchers*** and actively manages career progression. A dedicated Career Advisor and Organisational Development Specialist at University level work with our **Research Career Development Group** to ensure that our **Research Staff Career Pathways Framework** and training is reflective of the needs of the Faculty. Consequently, the university has retained its ***Vitae HR Excellence in Research Award*** through multiple reviews since the original award in 2010. The launch of our Skills, Enterprise, Policy and Global Academies ensures the co-ordination of training at all career levels (REF5A 3.2). Together these represent a successful outcome to our UA5 REF2014 goal of '*emphasising personal development programmes'*.

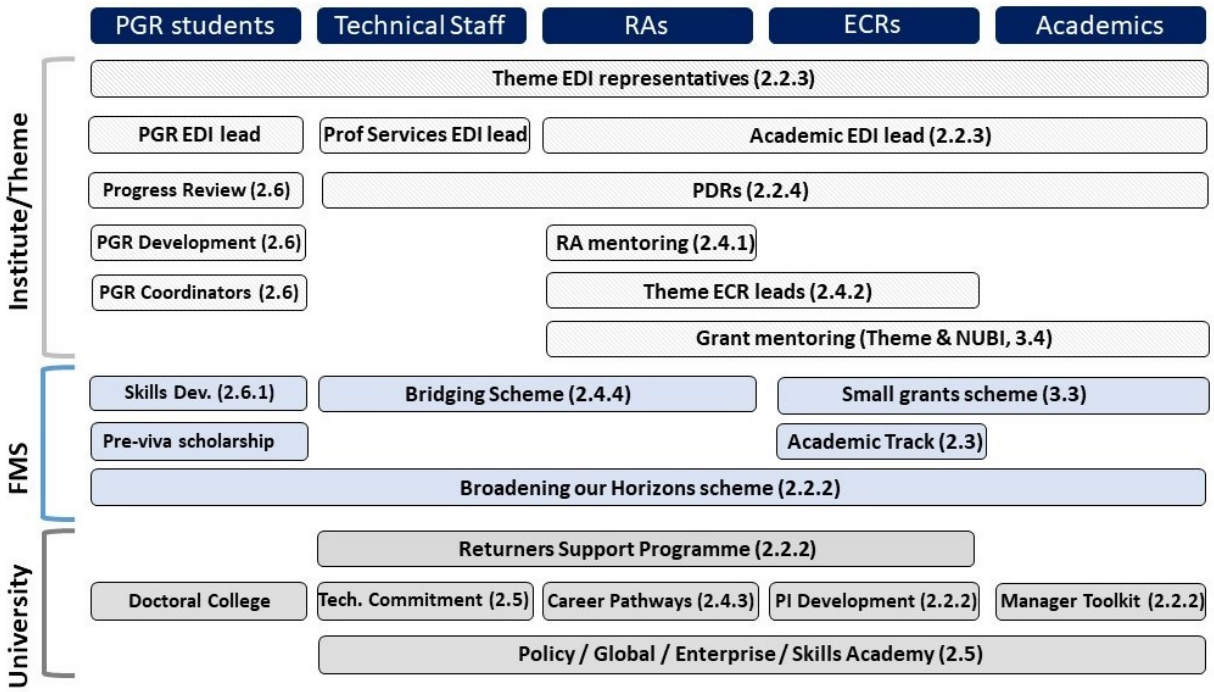

Figure 3. Summary of Support Programmes

2.2.2 Career Development Support

The NU **Organisational Development Team** (OD, REF5a 3.2.5) delivers support and coordinates resources to help researchers learn and develop. Academic staff are entitled to 10 days for professional development, which includes a variety of training courses and workshops.

In particular, the NU **Manager Toolkit** is a suite of workshops, online training and short videos to help both academic and non-academic managers. These include **Aurora**, an advanced HE women-only development initiative for women early in their careers.

Twice a year OD run the **PI Development Programme,** which is attended by all our ECRs who have been appointed to NURF, NUAcT or lectureship positions. Consisting of six one-day courses, it is designed to support PIs at an early stage in their role as managers and includes people and project management skills, how to become an effective research leader and their responsibilities under the Concordat.

Our programmes also provide practical support at different career stages. The Returners Support Programme is a University programme that can, where appropriate, be supplemented by FMS funds. This provides additional support to members of academic or research staff who are returning to work after a long period of leave, including sick leave or carers leave. *For example, in February 2020, after a period of maternity leave, an RA working with Perkins was provided with technical support to assist with their return to lab work.* Our Broadening our Horizons scheme enables researchers and PGR students to present their work at conferences, visit other research groups to gain new techniques or mentoring and consequently raise their personal profile and that of Newcastle internationally. *For example, in August 2019 £2,228 was awarded to an RA with Lightowlers to visit the University of Gothenburg as part of a collaborative project*.

2.2.3 Equality, Diversity and Inclusion

Our return includes 58 members of staff. 15 are women (25% up from 9% in 2014); 3 are Black, Asian & Minority Ethnic (BAME) with one staff member declaring a disability. Seniority levels are: Chair 40%, Mid-career 48% and ECR 12%. The gender split at career stage shows a gradual increase in the proportion of women with 13% of Chairs, 33% of mid-career and 43% of ECRs being women, although we acknowledge that we still have work to do.

We hold University Athena Swan status at the University level, are a signatory of the Advance HE's Race Equality Charter, a Global Stonewall Diversity Champion and member of the Business Disability Forum. This commitment is reflected in our policies and programmes and we have built on these foundations at local level as outlined in 2.2.2. Following successful Athena Swan awards for ICaMB (Bronze 2015) and FMS (Silver 2018), we have sought to maintain and built on our commitment to Equality, Diversity and Inclusion (EDI) through our Faculty restructure, building on the positive practices developed during these awards.

Our physical workspaces are configured for colleagues with sensory and physical access requirements and our buildings have baby changing facilities and designated breastfeeding rooms. Flexible working is accommodated; pre-COVID some colleagues chose to work remotely part of the week or had flexible or compressed working hours to accommodate their personal circumstances. Meetings and seminars are arranged around flexible work patterns, religious needs and ensure a gender balance of presenters. We also ensure gender balance on our decision-making committees and in seminar programmes.

The NUBI Academic EDI Lead, **Khan**, is a member of the Institute Executive Board and Faculty EDI Committee. He provides EDI feedback and reports together with regular updates on EDI in

the NUBI Monthly Newsletter. He is also a member of the University BAME Steering Group. NUBI has created an EDI Steering Committee, which meets monthly and includes the NUBI PGR and Professional Services (including technical staff) EDI Leads, together with EDI Representatives from the Research Themes most closely affiliated with NUBI.

We monitor gender and ethnicity at each career stage to inform our recruitment and career development activity. Although 38% of promotions have been women, and 33% of those to personal chairs, this is below the Faculty average. Our **future EDI strategy** therefore focusses on:

- Continuing to seek to achieve gender balance across all career stages;
- encouraging all colleagues, particularly women, to seek promotion;
- supporting and enabling colleagues to declare disabilities;
- scrutinising our recruitment processes and improving our accessibility to diverse applicants, addressing our gender balance and the relatively low proportion of BAME colleagues (5%).

To enable critical scrutiny of our recruitment processes, “blind” triaging of NUAcT applications is now undertaken; subsequent monitoring will determine whether this effects meaningful change. We will continue to work on University initiatives to create research cultures, activities and environments where people from varied backgrounds can thrive.

We have ensured that EDI considerations are embedded throughout our submission. For example, our outputs have been selected through an open process of self-nomination using our Research Management System followed by anonymous evaluation by at least two other senior academics with both an indicative score and reasons. The REF lead moderated the scores across disciplines. Selection of the return was by paper, not author, in line with our code of practice.

2.2.4 Performance and Development Review (PDR)

Every member of staff undergoes an annual PDR, to review last year’s performance, agree objectives, identify priority tasks and outline personal development plans. The PDRs for academic and research technical staff take place within the individual’s primary research theme with sign-off by the Theme Lead and Dean of Institute. This approach allows the Theme Lead to gain a greater understanding of the academic staff within their Theme, provide them with appropriate support staff and build a thriving research culture. A key part of the PDR process is to encourage staff to apply for promotion.

2.2.5 Recognition and Reward

Formal recognition for excellent performance happens via an annual promotion round, a fully open process which encourages all academics to submit their case for promotion. NU signed the Declaration on Research Assessment in 2018 and therefore does not use journal impact factors for promotion or evaluation of research staff. Achievements are based on quality evaluations and non-contextual citations, not journal names. In 2021, we move to a year-round engage and aspire programme with mentoring at all levels, rather than an annual one-off review. The university has also committed that the impact of personal circumstances during the COVID-19 pandemic will be considered as part of the reward and recognition process.

Since 2017 an annual meeting between 'women's promotion champion' (**Quinn**) and the ICaMB (now NUBI) Director preceded each annual round of promotions. Potential applicants were encouraged and mentored during the application process. In this REF period, 13 members of staff have been promoted (**Hall, Korolchuk, Murray, Quinn, Rodriguez, Salgado, Sanz, Shanley, Strahl, Yuzenkova, Holden, Schneider, Waldron, Davies**). This includes three promotions to Professor, three fellows to Principal Research Associate and one fellow to Principal Research Fellow.

2.2.6 Support during COVID-19 (REF5A COVID-19 Annex)

During lockdown, NUBI arranged well-attended (>100 per session) regular virtual PI, PGR and RA Q&A sessions to keep staff in touch and updated with the latest developments. These were supplemented by virtual drop-in sessions, regular mailings and newsletters.

For students in their write-up year, a three month fee-free extension to their thesis submission deadline is awarded if requested. PGR students can also apply to the NU COVID-19 Impact Scholarship Scheme, run through the Doctoral College, for an additional stipend if additional funding from their normal sponsor is not provided.

2.3 Fellowship Schemes

FMS has a well-developed programme to support applications for non-clinical fellowships and to provide an academic track for researchers who wish to transition to academic contracts. Fellowship applicants are provided with personalised support to develop applications from Themes, Institutes, and our dedicated RFDMs, overseen by the **Director of Non-Clinical Fellowships** (**Higgins**).

2.3.1 Junior Fellowships

We provide competitive **Faculty Fellowships** that provide salary and research funds for 2 years (with optional third year extension) to allow RAs to develop applications for external fellowships. This programme provides mentorship and a supportive assessment of progress by an academic panel, which can recommend a further year of funding if appropriate. This programme has been highly successful: out of 33 completed FMS Faculty Fellows, 80% have since secured full academic positions, more senior fellowships or additional external junior fellowship funding. Members of FMS who secure external junior research fellowships are given similar status and oversight to Faculty Fellows. In UoA5, **Connolly** is a current Faculty Fellow, while **Greaves**, **Strahl** and **Waldron** are former Faculty Fellows who have now progressed to open-ended academic contracts.

2.3.2 Academic Track Fellowships

Support for Fellows, which includes NURFs (2.1.2) and those with equivalent external fellowships (e.g. Wellcome Trust Sir Henry Dale), is provided by the Academic Track programme. This provides a pathway for ECRs to develop their own independent research programme and to secure open-ended academic positions. The programme includes mentorship, formal peer-to-peer networking, training such as the PI Development Programme, "ACTION for Impact", and the Newcastle Educational Practice Scheme. Annual formal reviews of fellowship progress are undertaken, starting with a mid-term review during Year three. The review panel includes external academic members and can recommend that a Fellow should move to an open-ended academic position based on transparent written criteria. Successful

Fellows will be well-placed to subsequently apply for promotion to Principal Research Associate on the Research and Innovation pathway, or to Lecturer or Senior Lecturer on the Teaching and Research pathway.

Overall, in this REF period, 20 fellows in UoA5 have been recruited (four IRES, nine NURF, two NUAcT, 3x Royal Society URF, two other). Of these, 11 have now progressed to open-ended contracts and remain in Newcastle, four are still part of the Academic Track, while five have progressed to faculty positions elsewhere (two IRES, three NURF).

2.3.3 ECR Support

The **Research Career Development Group**, meets regularly to discuss and plan support for research careers. This group includes academic staff of all career stages including ECRs, Organisational Development and Careers Service colleagues, an EDI representative and a representative of the FMS Postdoctoral Association. The committee is chaired by the Director of Non-Clinical Fellowships (**Higgins**), a senior academic who co-ordinates support for FMS ECRs. Induction events for new research staff signpost the support available for personal development, making funding applications, and generating impact through commercial and clinical interactions.

Examples of our support for ECRs include:

- **Madgwick** was awarded a prestigious Wellcome Career Re-entry Fellowship that enabled her to return to scientific research in Newcastle in 2013 after a career break. When this fellowship expired, she was supported through direct salary funding from FMS before successfully applying for an MRC Career Development Award (£1,172,509) and being awarded an open-ended contract.
- **Murray** started in Newcastle as a RA and was originally appointed as an independent PI with a Royal Society University Research Fellowship (URF). More recently he was awarded a Wellcome Senior Research Fellowship, followed by promotion to Professor.
- Other successful ECRs returned as part of this UoA5 submission include **Yuzenkova**, who was funded by a Royal Society URF and has now been promoted to Senior Lecturer; **Rodriguez**, initially recruited as an IRES fellow and now promoted to Senior Lecturer; **Strahl**, initially recruited as a NURF, and now promoted to Senior Lecturer; **Waldron**, who held a Wellcome Henry Dale Fellowship and **Schneider** who held a Royal Society URF, are both now appointed as Principal Research Associates.

2.4 Supporting Research Associates (RAs)

2.4.1 RA Mentoring Scheme

In Sept 2017, ICaMB created an RA mentoring scheme, assigning all new RAs joining the Institute a mentor PI who was not their direct supervisor. Over the next two years, 29 RAs were assigned a mentor through this scheme. Feedback was positive and used as evidence for the 2018 FMS Athena Swan application. We have continued this scheme following FMS restructuring. **Quinn** acts as NUBI mentor co-ordinator, working alongside the ECR leads of NUBI-led Research Themes to assign RAs a mentor. To date, 56 RAs and 50 mentors have been enrolled on this scheme.

2.4.2 Research Theme Support

Research Themes provide additional support for RAs through several initiatives. Each theme also has one or more ECR leads. In addition to arranging RA mentoring, ECR leads liaise with RAs and ECR fellows to identify any concerns or problems and arrange bespoke theme meetings on subjects of particular interest to this group (such as fellowship funding). Themes also host 'Research in Progress' talks that give RAs (as well as PGR students and technical staff) constructive feedback on ongoing projects and experience at giving presentations.

2.4.3 Career Pathways Framework

The NU Organisational Development team offer RAs a range of workshops that provide a Career Pathways Framework. These include two sessions on Career Guidance together with the Transitions Programme, a series of three interactive workshops for researchers in the last six months of their research contract to help them search and apply for non-academic jobs.

2.4.4 Bridging Scheme

Bridging is a core element in our delivery of the Concordat for the Career Development of Researchers. By providing funds to bridge between grant funding this has supported the retention of key skills and added to equality and diversity by preventing some RAs from dropping out of a scientific career. In the last REF period, there were 95 instances of bridging support provided in FMS, with 27 being to UoA5.

2.5 Technical and technologist career development

UoA5 technical and technologist staff provide a reservoir of expertise and experience that is the backbone of our research. Our commitment to Team Science includes recognising these contributions; 23% of the outputs in this UoA5 return have technicians as co-authors while technicians are also co-author on papers underpinning 40% of our ICSs. Of these authors, seven have also registered for or completed PhD studentships. Technical staff are the backbone of our Facilities (*3.2*) and are active members of **Special interest groups** and the **IMA Innovation Incubator**.

We are creating a research environment that breaks down the barriers between technical and academic staff. An example of this is **Dr Andrew Filby**, a member of the Professional Services technical community and head of the Flow Cytometry Core Facility (*3.2*). Filby is recognised by the International Society for the Advancement of Cytometry as a Shared Resource Laboratory "Emerging Leader" and serves on their council. He is also a Wellcome Multi-user Equipment Grant panel member. In November 2019, he applied successfully to lead the newly established **IMA Research Theme**.

FMS technical staff are supported by several NU programmes (REF5A 3.2.6). These include the formation of NU TechNet in May 2016, a "for-technicians, by-technicians" organisation that provides a university-wide forum for technicians to share resources, information and experiences. Technicians are included in the University's strategic vision and, for example, the newly established Skills Academy includes a technical focus. NU is a founding signatory of the Technician Commitment, which aims to ensure that technicians receive career development advice, visibility and recognition for their work, and that technical skills are retained across organisations. NU provides financial resource to support a wide spectrum of activity including

opportunities for Technicians to travel to other institutions and to become a partner affiliate of the National Technicians Development Centre.

2.6 Postgraduate (PGR) students

Our PGR doctoral students are a vital part of the research performed in UoA5 and have made a major contribution to our research environment, demonstrated by 33% of our REF submitted papers featuring at least one PhD student author (47% of which are first or joint first author). Over the REF period we have either supervised (either completely or partially with supervisors in other UoAs) 199 individuals to completion and we currently supervise or co-supervise 203 students. 55% or our doctoral students are women, 33% BAME (13% excluding international students) and 25% international students.

We are committed to ensuring that during their PhD study, our students obtain a diverse range of core skills, together with specialised subject-specific science skills, to maximise their potential for future employment. In the 2019 **HEA PRES** survey, the UoA5 PGR student body responded very positively about their research supervisors: 95% of students agreeing strongly that "my supervisor(s) have the skills and subject knowledge to support my research"; 90% strongly agreeing that "my ability to manage projects has developed during my programme"; and 88% strongly agreeing that "as a result of my research degree programme I feel better prepared for my future career".
A strong commitment to research student culture is evidenced by:

- FMS PGR financial support (e.g. pre-viva scholarship funds to enable papers to be written after thesis submission, annual symposia for 2nd/3rd year PhD students, social events).
- FMS PGR performance targets are routinely met or exceeded. As a representative snapshot, in 2018-19 the student progression rate was 92% (Faculty target 90%), and our 4-year submission rate was 90% for Home/EU students (UKRI target 70%) and 86% for International students.
- The North East PG (NEPG) Conference (one of the largest such conferences in the UK with >600 registrants each year), was co-organised by our students in 2017-2020. This is largely supported by UKRI DTP sponsorship but allows free participation to all PGR students in the North of England. As lead organiser of the 2018 NEPG conference, one UoA5 student introduced crèche facilities, (funded by Newcastle University EDI funds), which are now a regular feature.
- A UoA5 student was a member of the winning team in the Engineering YES National Competition in 2018.
- UoA5 students have also formed the Biosciences Institute Social Committee (BISCit) which organises research and career symposia and social events.
- PGR first career destinations include: prestigious national and international research institutions (e.g. Universities of Cambridge & Oxford; NIH, Bethesda; Danish Cancer Society Research Center); industry (e.g. AstraZeneca, GlaxoSmithKline); medical writing (e.g. Articulate Science); management consultants (Marakon; Catenion); global policy analysis (Rand Europe); The Home Office (Forensic Science Laboratory); and a medical charity (Wellcome).

To foster the best possible students, we invest in research-led undergraduate teaching with emphasis on project work in our research laboratories. Carefully selected basic science graduates and intercalating medical students proceed to a range of focused PGR Masters (MRes and MPhil) programmes which have supported 322 students during this REF cycle. These Masters students spend >6months working on research projects, with 91% reporting overall satisfaction with their programme (PRES 2019). This training "conveyer" generates a pool of research-motivated postgraduates who can compete successfully for funded doctoral studentships.

2.6.1 PGR student training, monitoring and support (REF5A 3.2.2 & 4.1.1)

The University operates a Code of Practice for research degrees, compliant with the QAA code of practice. Our Research Student Development Programme maps to the **Vitae Researcher Development Framework,** which complements students' research and provides activities that build transferable skills and confidence. Students across the Faculty are provided with excellent pastoral support through a network of **Postgraduate Student Coordinators** (**Cheek**). To ensure any problems with academic progress are identified and, where possible, rectified, students undergo a formal annual progress review with two independent members of academic staff. Each new student is allocated a mentor as well as a senior PGR student 'buddy', to help them to settle in.

2.6.2 Doctoral Training Awards

UoA5 members have helped secure four external doctoral training awards over the REF period totalling £15.74m (£3.95m **NLD BBSRC DTP2** 2015-19; £7.44m **NLD BBSRC DTP3** 2020-24; £3.30m **DiMeN MRC DTP1** 2016-2020; £1.05m **Leverhulme Trust** 2018-2020). Consequently, UoA5 supervisors can consistently recruit approximately 20 high-quality students per year to fully funded 3.5-year (MRC) and 4-year (BBSRC, Leverhulme) studentships. The **WCMR** also supports PhD students who are supervised by UoA5 PIs. A further source of PhD funding are the pan-EU training schemes (**Marie Curie ITN or ERC**) held by **Embley**, **Errington**, **Lewis**, **Lightowlers**, **Trost**, **Vollmer**. During this REF period we have also focused on the application of technology and impact generated by our PGR students. UoA5 supervisors have secured >20 **UKRI-funded CASE studentships** with multinational pharma (*e.g.* GSK, AstraZeneca), manufacturing companies (e.g. Procter & Gamble, Thermo-Fisher) and SMEs (*e.g.* Demuris, Pall Europe, Technostics).

3. Income, infrastructure and facilities

3.1 Research income

UoA5 staff returned in REF2021 have generated £58M in research income during the last REF period, which includes many highly competitive grant and fellowship awards:

- **Vollmer** (2014), **Zenkin** (2014, 2019), **Higgins** (2016), **Palmer** (2016), **Errington** (2018), **Trost** (2019) and **van den Berg** (2019) received **Wellcome Trust Investigator Awards** (total: £12.2m).
- Additional programme level funding comes from the **ERC** (**Errington**, 2015, £1.8m), **CRUK** (Perkins, 2016, £1.2m) and **BBSRC/Innovate UK** (**Lakey**, **Perkins** and others, £2.5m, *4.5.2*).

- **Salgado** (2017) and **Quinn/Trost** (2019) are co-PIs on two **Wellcome Trust Collaborative Awards** (NU received £1.3m).
- **Lightowlers**, **Greaves** and **Hudson** all contributed to the 2017 renewal of the **WCMR** (£6.3m).
- **Davies** (2014), **Holden** (2017) and **Nicholls** (2019) received Wellcome Trust Sir Henry Dale Fellowships (total: £2.8m).
- **Madgwick** was awarded an MRC Career Development Award (2020, £1.2m).
- **Murray** (2017) and **Sanz** (2019) were awarded Wellcome Trust Senior Research Fellowships (total: £3m).
- **Salgado** (2015) was awarded an MRC New Investigator Research Grant (£568k).
- Other Academic Track PI grants include: two BBSRC New Investigator Awards (**Strah**l, 2018, **Rodriguez**, 2019, total: £893k); an AMS Springboard Award (**Connoll**y, 2020, £85k); and a Marie Skłodowska-Curie Individual Fellowship (**Melnikov**, 2020, €225k).

3.2 Infrastructure and Facilities

Our state-of-the-art technical facilities underpin our research. To ensure they meet demand and deliver cutting-edge analytical technologies and methodologies they have received >£9.4m since 2014, secured from external income sources and FMS, with over 18 additional permanent core facility staff employed. We have created an **Analytics Hub** to coordinate and maximise their efficiency (Figure 4). Analytics hub facilities are involved in over 600 projects from over 200 research groups per year, with over 750 publications where facility contributions were acknowledged by authorship.

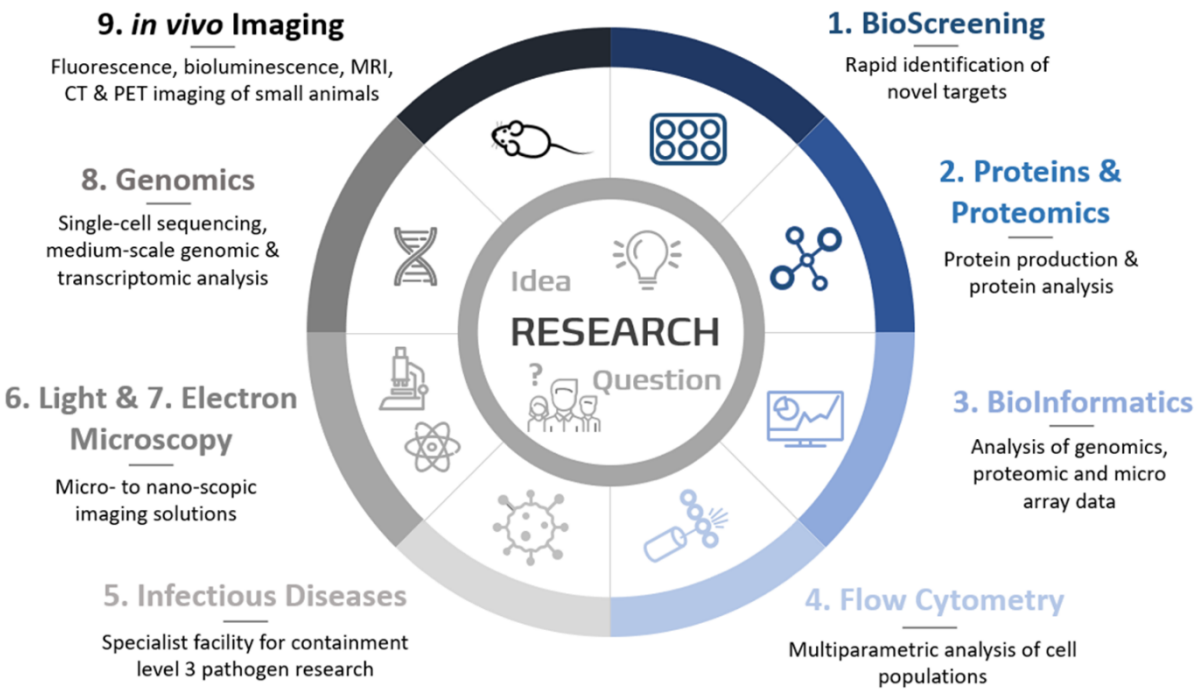

Figure 4. Analytics Hub.

The **Bioimaging Unit** (**Laude**) provides routine and cutting-edge imaging modalities, ranging from conventional brightfield, widefield–fluorescence and confocal imaging techniques through

to high-content, super resolution, light-sheet and multi-photon microscopy (Equipment funding £2.91m, internal £1.27m, external: £1.64m).

The core technologies of the **Flow Cytometry Core Facility** (**Filby**) are mass cytometry, fluorescence cytometry, metabolimetry and imaging cytometry. With 16 instruments, this facility caters to a wide variety of needs, from single colour assays to complex multi-colour panels, mass cytometry and cell sorting (Equipment funding £1.77m, internal £0.8m, external: £0.97m).

The **Genomics Core Facility** (**Coxhead**) was established in 2016 through a £1.7m grant from the MRC. The GCF offers state-of-the-art services and advice in single cell studies, next-generation sequencing, real-time PCR, Droplet-Digital PCR and laser-capture microdissection. The GCF can also provide Spatial Transcriptomics analysis, a powerful technology allowing the whole transcriptome to be analysed within a positional context, enabling sequencing data to be visualised directly on a tissue histology section. This facility benefits from the recruitment of **Veltman** (UoA1) in 2017, a world-leading expert in genomics.

Electron Microscopy Research Services (**Davey**) has a range of specialist equipment that produces scanning and transmission electron microscopy data of specimens from both biological and material sciences. Cutting-edge equipment provides cryo-EM capabilities and tomography (£544,589 BBSRC equipment grant).

Preclinical *In Vivo* Imagining (PIVI) (**Luli**) provides equipment and support for MRI, PET and fluorescence/bioluminescence real-time imaging that permits investigation of biological processes in comparative animal models.

The **Bioscreening Facility** (**Martin-Ruiz**) provides high-throughput screening and biological reagents to cater for researchers working with both mammalian and microbial cell-based systems, enabling the rapid identification of novel targets. Services include sample handling and processing, siRNA library screening and small molecule drug screening. LifeArc, a non-profit drug discovery company, collaborates with NU researchers through the BioScreening facility and provides a series of carefully curated compound libraries free of charge for any NU researchers.

Staff in the **Bioinformatics Support Unit (BSU)** (**Cockell**) help with both experimental design and data analysis. These include RNA-Seq, ChIP-Seq, microarrays, genome sequencing, single cell sequencing and proteomics. Additional advice is provided on statistical power and sample size, batch effects and other confounding factors, database design, custom software engineering and data management and curation, including repository deposition of high-throughput data sets.

Services provided by the **Protein and Proteome Analysis (NUPPA)** facility (**Porter**) include identifying single proteins and proteins in complex protein mixtures, characterising proteins**,** finding post-translational modifications and quantifying proteomes. NUPPA offers a wide range of protein analysis techniques: analytical ultracentrifugation, protein ligand binding calorimetry and protein production. This facility benefits from the recruitment of **Trost**, an expert in proteomics, which required a £3M investment with the purchase of new mass spectrometers and remodelling of laboratory space.

The **Comparative Biology Centre (CBC):** (**Murphy**) provides a modern, multi-species facility for the use of animals in biomedical research. Working closely with the Home Office and NU Animal Welfare Ethical Review Body, the CBC advises researchers on the Animal (Scientific Procedures) Act and ensure the principals of the 3R's are applied to all animal research work. The Centre offers all modules of the Home Office training courses plus tailored training and competency on an individual level. The recruitment of **Mellor** (UoA1) involved a £7m refurbishment of the CBC in 2014/2015, which also benefited UoA5 researchers using mouse models (**Greaves**, **Madgwick**, **Perkins**, **von-Zglinicki**).

In 2015, the University invested £929k in the **Newcastle Structural Biology Lab** for a Metlajet D2 diffractometer, the first of its kind in the UK. Structural biology researchers also have access to Diamond Light Source, Daresbury, ISIS Neutron and Muon Source and Central Laser Facility. **Basle**, from the SBL, is involved in discussions of future developments and new technological advancements. **Salgado** has been a member of and chaired the Diamond Light Source Review Committee.

3.3 Increasing Research Income

To increase future research income and impact for UoA5 scientists we have the following strategies:

- Increased opportunities for collaboration and links with translational researchers and clinicians arising from Research Themes and NUCoREs will create new funding opportunities for UoA5 researchers, such as collaborations with clinicians to create opportunities for NIHR funding where we currently receive little grant income.
- The development of the IMA Innovation Incubator has provided a collaborative space for researchers with very different expertise to form multi-disciplinary teams to address key research questions. These teams will also provide natural structures to innovate and develop collaborative grant applications. An example of the latter is a 2020 Wellcome Multi-user Equipment Grant for spectral cytometry valued at £490,000, on which **Filby** was the PI with nine NU Co-Is including **Trost**.
- Access to cutting-edge in-house technologies will generate stronger preliminary data, increase the scope of grant applications and improve success rates. Examples are state-of-the-art **proteomics** (through the recruitment of **Trost**) and **microscopy** (through the recruitment of **Holden** and **Wollman**), with **Trost** providing proteomics expertise on grants with **Quinn** (Wellcome Trust Collaborative Award, £1.2m, 2019), and was PI on a £578k Wellcome Multi-user Equipment Grant 'State-of-the-art proteomics for Newcastle' with **Lightowlers**, **Errington** and others as co-Is. **Holden** was PI on £402k BBSRC 19ALERT grant 'A single cell, single molecule microscopy platform for antibiotics research' with **Strahl** (co-PI), **Vollmer**, **Errington**, **Palmer**, **Zenkin** and **Murray**). To stimulate future growth, we plan to build future capacity in **metabolomics**, **single cell technologies** and **data science**.
- The **Small grant scheme** provides funding to researchers, with a focus on ECRs, requiring preliminary data in support of a grant application. Two recent successful examples are: £7,294 funding for **Madgwick**, leading to the award of an MRC Career Development Award (£1.2m) in 2020; £8,760 funding for **Connolly** (Faculty Fellow), leading to the award an AMS Springboard Award (£85,667) in 2020.

3.4 Income generation support

We provide support for UoA5 scientists in several ways:

- Improved **grant mentoring** through Research Themes. For example, by giving input at an early stage in the grant writing process through running 'Perfect your Pitch' or 'Dragons' Den' sessions. These structures are supported and coordinated by the host institute, who have a designated 'grant champion' (**Perkins**).
- Our **Research Funding Development Managers** (RFDMs) work with applicants and assist with such as career intentions, lay summaries, training plans, Gantt charts, and the overall intelligibility of the application. RFDMs also organise and record mock interviews as needed and provide vital intelligence on forthcoming grant calls.
- Developing industrial collaboration and funding is supported by the Business Development and Enterprise Team via **Business Development Managers** (BDMs). BDMs identify potential industrial collaboration opportunities and support existing ones through performing market intelligence reports on specific sectors of interest; reviewing intellectual property landscapes; ensuring appropriate confidentiality and collaboration agreements are in place; informing industrial collaborators and academics of funding mechanisms; identifying a route to market for university technology; and managing protection and commercialisation of university intellectual property. To further assist with this, **Connon** (UoA1) has been appointed as **FMS Director of Business Development**. He will liaise with BDMs and Industry Leads in each Research Theme to facilitate and progress ideas and identify the best way to carry this forward, such as identifying relevant industrial contacts.
- Our Research Support Team colleagues provide a bespoke funding and development service with expertise in specific funders to enable appropriately costed funding applications.

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

4.1 Research Networks and Collaboration

UoA5 scientists collaborate extensively with colleagues across NU and other institutions. Of the UoA5 outputs in REF2021, 18% are authored with researchers in other UoAs, while 71% and 22% feature international and national co-authors respectively. Moreover, 29 (46%) UoA5 scientists are authors on outputs returned in other UoAs. Collaboration is further facilitated by membership of national and international research networks:

- **Von-Zglinicki** is a member of the Alliance for Healthy Ageing (Newcastle, Groningen, Kopenhagen, Mayo Clinic, University of Minnesota). The Alliance holds annual meetings with the objective of bringing together scientists, clinicians and engineers. NU organised the 6th (2015) and 10th (2019) conferences.
- **Von-Zglnicki** and **Korolchuk** have a long-standing collaboration with the Mayo Clinic Robert and Arlene Kogod Center on Aging (NatCommun2017; NatCommun2018; CellMetab2019).
- NU (**von-Zglinicki**) is the lead partner from a developed country in Multidisciplinary Institute for Ageing Portugal (MIA), University of Coimbra. This consortium includes

UMCG Groningen, Ageing Research Institute Kopenhagen and CECAD Cologne. This has led to funding through H2020 WIDESPREAD: MIA Portugal, €15M 2020-27 (Newcastle PI von-Zglinicki, €760k). This funding has resulted in the appointment of **Miwa** from the von-Zglinicki group to an FMS lectureship in 2021.

- **Errington** is a member of the Global Mycetoma Working Group, a large international group led by the CDC and formed in 2018 to tackle this neglected tropical disease.
- **Korolchuk** is a member of the EU COST Transautophagy network.
- **Holden** was consortium lead (2016-2019) of the Single Molecule Localization Microscopy challenge, an international assessment of super-resolution microscopy software (publication NatureMethods2019).
- **Lightowlers** and **Trost** are members of EU Marie Curie ITN networks, MCS-ITN and Magic Bullet respectively.

Collaboration and networking are also facilitated by the conferences organised/co-organised by UoA5 scientists:

- **Yuzenkova**: International Frontiers of Science Symposium, Japan (2019); 26th, 29th UK RNA polymerase workshops, NU (with **Zenkin**, 2014, 2017); Royal Society Meeting of Minds Conference (postponed due to COVID-19, 2020).
- **Holden**: Subtillery 2020 virtual international conference (2020); 6th Molecular Microbiology Meeting, NU (with **Yuzenkova**, 2019); Physics of Microorganisms workshop, Institute of Physics, UK (2019).
- **Palmer**: Zing Conference 'Protein Secretion in Bacteria', Florida (2016).
- **Errington**: 3rd Bacterial Cell Biology Conference, Nassau (2020).
- **Perkins**: UK/Ireland NF-kB/IKK workshops (2015, 2017, 2019); European NF-kB subunit workshops (2014, 2016, 2018).
- **Vollmer**: EMBO Workshop "Bacterial Cell Division: orchestrating the ring cycle", Prague (2016).
- **Salgado**: International *C. difficile* Symposium (2019); 11th Clostpath (2018-2019); 7th ICDS conference (online due to COVID-19, 2020).
- **Austin**: International virtual seminar series TOPO2020 during COVID-19 pandemic (2020).
- **Veal**, **Korolchuk**, **Sanz**: Biochemical Society meeting: Redox Signalling in Physiology, Ageing and Disease' (2019).
- **Whitehall**: Microbiology Society Theme Meeting "From Discovery to Impact" (2019).
- **Hudson**: Parkinson's UK Research Conference (2018).

4.2 Contributions to the sustainability of the discipline

UoA5 staff engage with other scientists in their fields, contributing to the vitality and strength of biological sciences. In addition to the common scientific activities of reviewing grants and papers, giving seminars at other institutions, workshops or symposia, this includes the organisation of research conferences and chairing or sitting on national and international grant panels:

- **Palmer**: BBSRC Appointments Board (2017–2020); MRC Infections and Immunity Board (2012-2016); Wellcome Science Interview Panel (2017–2021).

- **Errington**: Wellcome Molecules Genes and Cells Expert Review Group (Chair, 2015-2017).)
- **Zenkin**: Wellcome Molecular Basis of Cell Function Expert Review Group (2020-2023).
- **Austin**: MRC Non-Clinical Career Development (2013-2017).
- **Waldron**: Royal Society Research Grants (2017-2023).
- **Daniel**: BBSRC Committee B (2012-17).
- **Korolchuk**: Midterm review BBSRC Institute strategic funding (2019).
- **Vollmer**: Agence Nationale de Recherche, France (2017-2019).
- **Von-Zglinicki**: ERC Starting Grant Physiology (2020).
- **Lakey**: Finnish Science Academy Cell Biology (Chair, 2017-2020).
- **Perkins**: Science Foundation Ireland, CDA (Chair, 2017).
- **Embley**: Marie Skłodowska-Curie Individual Fellowships (Vice Chair, 2013-2020); Marie Skłodowska-Curie Actions Innovative Training Networks (Vice Chair, 2018-2020).
- **Lightowlers**: NAWA, Poland (2018-present).
- +19 additional panel memberships.

UoA5 investigators also act in an advisory capacity for more than 50 other institutions (for example):

- **Errington**: ARC Centre of Excellence in Advanced Molecular Imaging, Monash (Chair, 2015-present); Biomedical Discovery Institute, Monash (2019-present); Manchester AMR Centre (2017-present); MRC Centre for Molecular Bacteriology & Infection (Chair, 2017-present).
- **Palmer**: Max-Planck Institute for Terrestrial Microbiology, Marburg (2019-2024); Sainsbury Laboratory Norwich (2019-2024; MRC Centre for Molecular Bacteriology and Infection (2013-2019); Institute of Microbiology and Infection University of Birmingham (2017-2019).
- **Austin**: Athena SWAN panel (Chair, 2008-present); Member of Athena Forum (2018-2021); Royal Society of Biology Diversity & Inclusion committee (Chair, 2018-2019).
- **Von-Zglinicki**: Mayo Clinic, Robert and Arlene Kogod Center on Aging (2008-present); Leibniz Research Alliance for Healthy Ageing Germany Advisory Board (2016-present).
- **Perkins**: University of Strathclyde Drug Discovery Group (2011-2017).
- **Trost**: Francis Crick Institute Proteomics facility (2020); Wellcome Centre for Cell Biology, Proteomics facility (2020-2021).
- **Lightowlers**: LabEX, Strasbourg (Chair, 2013-2020).
- **Vollmer**: Centro de Biologia Molecular "Severo Ochoa", CSIC-UAM Madrid (2012-present).
- **Lakey**: STFC ISIS Neutron Source Facility (2015-present); MLZ Neutron Source Munich (2016-present); European Spallation Source Lund Sweden (2019-present).
- **Hudson**: Multiple Sclerosis and Parkinson's Tissue Bank (2015-present).
- **Korolchuck**: Deutsche Forschungsgemeinschaft Collaborative Research Centre review (2020).
- **Salgado**: Diamond Light Source MX Review Panel (Chair, 2015-2017).

UoA5 investigators also act as journal editors:

- ***Editors***: Molecular Microbiology (**Palmer** 2009-2020); Fungal Biology (**Rutherford** 2018); Microbiology (**Strahl** 2018-present); Ageing Cell (**von-Zglinicki** 2005-present); Microbial Genomes (**Harwood** 2016-2020); International Journal of Molecular Sciences, telomeres/telomerase editions (**Saretzski** 2016-present); Frontiers in Genetics (**Hudson** 2018-present).
- ***Associate Editors***: Genome Biology and Evolution (**Embley** 2011-2020); International Journal of Otolaryngology (**Pearson** 2015-present); BMC Biology (**Saretzski** 2009-present); PLOS One (**Saretzski** 2008-present); Oxidative Medicine and Longevity (**Saretzski** 2012-present).
- ***Special Issue Guest Editors***: Cells, "NF-κB in Cancer" (**Perkins** 2019); Pflügers Archiv-European Journal of Physiology: Phosphate transport (**Werner** 2019); Parasitology, “Mucosal microbial eukaryotes in health and disease” (**Hirt** 2018); mBio (**Hirt** 2020); Antibiotics "Bacterial Cell Wall as Antimicrobial Target" (**Vollmer** 2015-2016); PLOS Genetics (**Higgins** 2014): Methods in Molecular Biology (**Nicholls** 2020-2021)
- 18 *Editorial Board* memberships.

4.3 Reproducibility

NU is a member of the **UK Reproducibility Network,** consequently we are adopting procedures and approaches to maintain and improve experimental reproducibility. These include:

- Facility staff provide continuity of expertise and advise on best practice in data generation and analysis. Training on facility equipment and experimental design are first discussed to make sure factors such as using the most appropriate technology, data analysis software, statistical power, sample size and batch effects are considered. The Bioimaging Unit is driving a global project to standardise microscope quality control procedures, with the goal of improving reproducibility.
- Research Themes hold regular ‘Research in Progress’ talks from PGRs, RAs and technical staff. These allow early-stage feedback on research projects and advice on experimental design, aiding reproducibility.
- Experimental reproducibility will be promoted by the development of SIGs (*1.4.2*), which will embed a culture of best practice in data generation, annotation, analysis and presentation.

Examples of papers from UoA5 investigators involving a significant component of reproducibility are:

- Use of telomere length is a biomarker of ageing, morbidity and mortality has been hampered by uncertainty regarding reproducibility between laboratories. To address this, **von-Zglinicki** directed and published the largest international study on reproducibility of telomere length assessment (IntJEpidemiol 2015).
- **Strahl** demonstrated that the fluorescent membrane dye nonyl acridine orange, which had been used for many years as a specific stain for cardiolipin, is not specific and that consequently *B. subtilis* does not form microscopically detectable cardiolipin-specific lipid domains (Microbiology2018).

- **Higgins** reported that the widely used DNA stain SiR-Hoechst induces DNA damage responses and impairs cell cycle progression, with important implications for the field when interpreting data from live cell imaging (SciRep2018).
- To reproduce the results of JBC2016, **Salgado** and **Vollmer** needed to create a new, different and reproducible assay. Consequently, they were able to experimentally confirm catalytic and zinc binding sites proposed in the original paper (MolMicro2018).
- **Hudson** assessed the techniques used to determine levels of mitochondrial heteroplasmy using next generation sequencing. This study concluded that many approaches did not take into account nuclear mitochondrial sequences, potentially resulting in misleading data (Mitochondrion2019).

4.4 Responsiveness to national and international priorities and initiatives

4.4.1 Antibiotic Resistance

UoA5 publications frequently address the urgent problem of antibiotic resistance. Moreover, UoA5 scientists are actively engaged in the search for new antibiotics (*4.5.2*). This is further evidenced by grant awards to **Vollmer**: MRC JPI AMR 1st Joint Call: Transnational call InnovaResistance: Innovative approaches to address antibacterial resistance (£317,881, 2015); Antimicrobial Resistance cross-council initiative, Collaborative Grant with Sheffield, Oxford and Southampton (£502,364, 2015); and **Zenkin** RCUK collaborative research grant 'The Physics of Antimicrobial Resistance' with Sheffield, Oxford, and Edinburgh (£640K, 2018).

4.4.2 COVID-19 response

Despite the challenges for laboratory-based researchers during the COVID-19 pandemic and associated lockdowns, several UoA5 staff were able to participate in local or national responses:

- **Trost** received a UKRI award (£302K) to develop mass spectrometry-based assays for COVID-19 screening (P1 moonshot lab for COVID-19).
- Reviewing and modifying experimental methods/SOPs and operations within FMS Infectious Diseases Facility to permit SARS-CoV-2 research (**Khan**).
- NU NHS Trust COVID-19 Support group (**Trost**, **Higgins**).
- Academic liaison to the Innovation Lab of Newcastle's COVID-19 lighthouse laboratory (**Trost**).
- Member of UKRI-COVID-19 pool of experts (**Trost).**)
- GetPPE-NCL academic lead/ project co-ordinator. Dynamo North East UK "Not for Profit/Public Sector Project of the Year 2020" (**Holden**).

4.5 Promoting future commercial and clinical impact

4.5.1 Supporting future impact

MRC Confidence in Concept funding is available through FMS to pump prime projects with potential future impact. **Murray** recently secured funding (£78k) through this scheme, with UoA1 colleagues **Hubbard**, **Simpson** and **Hardcastle**, to create high-throughput platforms for identifying bacterial replication inhibitors with the potential to act as novel anti-bacterial compounds. **Higgins** received £66k funding to develop a novel assay to identify kinases upregulated in cancerous tissues, potentially aiding cancer diagnostics (based on ***UoA5 output:*** *NatCommun2020*; ***Patent*****:** 'Kinase Inhibitor Profiling to Identify Kinases' (KiPIK)). In addition,

funding is available through the Newcastle **Wellcome Translational Partnership: Quinn** and **Hubbard** (UoA1) have secured £10k to test whether currently available p38 kinase inhibitors target the homologous Hog1 SAPK in pathogenic fungi and so can be used as anti-fungal treatments.

4.5.2 Examples of future impact

New Antibiotics: **Demuris** (**Errington**) is a drug discovery company exploiting a unique collection of Actinomycete bacteria, which can manipulate the behaviour of surrounding organisms, including bacteria, fungi, plants and animals. Demuris recently partnered with the WCMR to identify and develop novel therapies to treat mitochondrial disease. In addition, **Zenkin** was awarded an MRC Industrial Collaborative Award (£613k, 2019) jointly with Demuris to investigate a novel mode of RNA polymerase inhibition.

New therapies for patients suffering with mitochondrial disease. The WCMR (**Lightowlers)** also has screening projects with Novartis and Nestlé to assess large compound libraries for effects on mitochondrial function. The group are actively working with The Scripps Research Institute to perform structure-activity relationship studies on a lead compound.

Novel Biomaterials: Polymers of *Yersinia pestis* protein Caf1 can be specifically engineered to contain motifs that stimulate the adherence, growth and proliferation of eukaryotic cells. Commercial and medical applications of this technology include wound healing and culturing stem cells. The process of developing this technology towards commercial application is funded by a £2.4million BBSRC/Innovate UK Catalyst Award. In addition to the lead PI, **Lakey**, this interdisciplinary team includes **Perkins** (UoA5), **Reynolds** (UoA1), **Fulton** (UoA8) and **German** (UoA3). ***Relevant UoA5 output:*** *Chem2020*; ***Patent*****:** 'Recombinant polypeptide'.

Senolytic compounds: **von-Zglinicki** has pioneered the use of senolytic drugs that clear unhealthy senescent cells for therapeutic purposes. The group recently completed a Knowledge Transfer Partnership with Nuchido to identify and develop senolytic compounds with anti-ageing effects. ***Relevant UoA5 outputs***: *NatCommun2017; CellMetab2019.*

Novel foods: **Aelius Biotech** is a contract research company whose 'Integrated Model Gut System' can be used to test drug delivery and absorption, functional foods and study pre- and pro-biotics. This model allowed **Pearson** to discover that specific alginates inhibit pancreatic lipase and could be used to control weight by reducing absorption of dietary fat. A weight loss trial, funded through Northern Accelerator, is currently ongoing. ***UoA5 output:*** *FoodChemistry2014; Patent: 'Model Gut System'.*

Commercialisation of novel glycoenzymes: **Bolam** and colleagues discovered novel glycoenzymes used by the gut microbiota to degrade and metabolise glycans, on an IB Catalyst 'Glycoenzymes for Bioindustries' project (with collaborators in Norwich, Manchester, Cardiff and Ludger, a bioscience company specialising in medical applications of glycobiology). Four glycoenzymes are currently licenced to Ludger for commercial evaluation and Bolam is providing expertise in enzyme characteristics and production to Ludger and their manufacturing partner, Prozomix (***Relevant UoA5 output***: *NatMicrobiol2019).*

4.6 Prizes, honours, prestigious lectures and guest positions

The high standing of many UoA5 researchers in the scientific community is evidenced by numerous honours and awards:

- **Gilbert** (2016), **Palmer** (2018), **Embley** (2019) were elected as Fellows of the Royal Society.
- **Palmer** (2015), **Errington** (2015), **Embley** (2016), **Vollmer** (2018) were elected as Fellows of the European Academy of Microbiology.
- **Vollmer** (2014), **Palmer** (2015), **Lewis** (2017) were elected as Fellows of the American Academy of Microbiology.
- **Errington**: BBSRC 20th Anniversary Medal and Prize for Excellence in Bioscience (2014); UK Biomedical Society Novartis Medal and Prize (2014); Leeuwenhoek Lecture Medal & Prize of the Royal Society (2014); UK Academy of Medical Sciences Jean Shanks Lecture (2015); Federation of European Microbiological Societies Lwoff Medal & Prize (2017); CBM, Madrid 12th Memorial Lecture "David Vazquez" (2017); l'Institut de Biologie Physico-Chimique, Edmond de Rothschild Lecture (2018).
- **Palmer**: EMBO, Elected member (2017); Gordon Research Conference, EMBO Keynote lecture (2019); Lorne Protein Conference, EMBO Keynote Lecture (2020).
- **Von-Zglinicki**: British Society for Research on Ageing, Lord Cohen Medal (2017); St Georges, University of London, Thomas Young Prize (2018)
- **Zenkin**: Society for General Microbiology, Fleming Prize Lecture (2014); Leverhulme Trust, Philip Leverhulme Prize (2014).
- **Waldron**: International Copper Meeting, Arturo Leone Young Investigator Award (2018).
- **Quinn**: British Mycological Society: President Elect (2020).
- **Harwood**: Microbiology Society, Honorary Membership (2016).
- Visiting Professorships: University of Cagliari, **Vollmer** (2015); Chemistry Department, University of Oxford, **Errington** (2018); Nanjing Agricultural University, **Waldron** (2019); Henan People's Hospital, **Palmer** (2019); Nanjing University, **Korolchuk** (2020).

4.7 Public Engagement

UoA5 scientists helped organise Soapbox Science Newcastle (**Salgado** 2015-2017) and presented at this event (**Lowe** 2015, **Quinn** 2017). They have also presented at 'Pint of Science' (**Quinn** 2018), 'Palace of Science' (**Salgado** 2020, online) and 'Women in STEM' (**Salgado** 2020). **Salgado** was also a member of the Executive Committee of "Science is Vital" (2011-2015), participated in outreach activities organised by Diamond Light Source (2010-present) and was a featured scientist in the "Illuminating Atoms" exhibition for the International Year of Crystallography (2014). **Aldridge**, **Perkins**, **Salgado**, **Waldron** all coordinated the ICaMB blog and other social media (2012-2019). **Madgwick** participated (2019) in 'The Cell Detectives', organised by our scientific facilities this allows members of the public to interact with research tools to see the inner working of the cell.

We frequently engage with local schools and provide opportunities for work experience placements. Between 2015 and 2019, ICaMB hosted 57 school students on work experience placements. In addition, from 2015 to 2018, **Perkins** hosted visits from pupils at St John's Catholic School and Sixth Form College, Bishop Auckland. In 2018, **Perkins** spoke about his

research at Durham Sixth Form College in a 'Careers in Cancer Research' event organised by the charity Worldwide Cancer Research.

UoA5 scientists engage with local artists and museums. From 2015 **CBCB** scientists have collaborated with local artist Derek Hill to create the event 'Art in Science'. **Hirt** has participated in events at the Great North Museum: "Planet 2.0" (2018) and "Worldwide Webs" (2019). **Yuzenkova** used work from her group in an art exhibition at the Hancock Museum (2020). **Quinn** presented 'Killer Fungus' at the Royal Society Summer Exhibition (2016).

These activities are supported by *VOICE*, (Valuing Our Intellectual Capital and Experience), our public engagement network and associated online digital platform. Established in 2007, VOICE has grown significantly with national and international reach and now sustains a network of thousands of engaged "research-active citizens", supporting thousands of research projects. This is complemented by our 'Training Matters' programme that has delivered 60+ sessions, providing 400+ researchers with a range of engagement skills such as effective science communication and supporting them to develop robust public engagement plans. FMS scientists have used this training at Wellcome ISSF-funded 'Research Matters' events (50+ events engaging over 2500 attendees).