

Institution: University of Edinburgh

Unit of Assessment: UoA05

1. Unit context and structure, research and impact strategy

1.1 Overview

The School of Biological Sciences (SBS) at the University of Edinburgh is one of the largest in the UK (138.6 FTE returned here, growing 26.3% from REF2014). Our research is integrated and thematic, covering a spectrum from molecules to organisms, genetics to populations, and data innovation to solution-driven science. We have provided leadership in many fields (e.g. genetics, molecular biology, evolutionary biology, parasitology, stem cell biology, epigenetics, systems and synthetic biology), and built an environment that has catalysed connections between fields. In this REF period we have strategically nurtured collaboration with industry and consolidated our links with human and animal health researchers across Edinburgh. Our size and breadth provide the foundation for our truly integrative **research vision**: *we support excellence in discovery science, while investing in solution-led research to address issues of health and wealth in society and the sustainable environment*. This ambition requires multi-dimensional approaches, and has had led to discoveries that harness the power of quantitative, modelling-based and predictive biology:

- Establishing the mechanisms of circadian rhythms in plants by modelling how the gene network of the circadian clock links across scales from genotype to phenotype, using transcriptional pathway data to predict whole-plant growth and phenotypes (**Millar, Halliday**, *Molecular Systems Biology*, 2015; *PNAS* 2014).
- Driving evolutionary biology to the forefront of the response to the Covid-19 pandemic by leading the coronavirus sequencing consortium (CoG-UK), a SAGE sub-committee funded by the UK Government and Wellcome (£20M) to provide phylogeographic analyses of SARS-CoV-2 transmission across the UK (**Rambaut**, *Lancet Microbe* 2020, <https://www.gov.uk/government/organisations/scientific-advisory-group-for-emergencies/about>)
- Bringing ageing research to studies of wild animals, with multi-generational data demonstrating that immunosenescence is a strong predictor of mortality, unexpectedly mirroring the age-associated decline in human immune function (**Pemberton, Nussey**, *Science*, 2019).
- Providing significant new hope for sufferers of Rett syndrome by identifying minimal gene constructs that can be transferred into mice where they substantially repair neurological abnormalities, reversing even established neurodevelopmental disease (**Bird**, *Nature*, 2017).

We have actioned our research vision via major interdisciplinary funding awards, substantially diversifying our income sources. During the REF period, we obtained funding awards totalling £196.3 million, an increase of ~25% over the previous REF period, including £2.7 million from industry. Funding highlights include:

- £13M from UKRI to establish the *UK Centre for Mammalian Synthetic Biology* led by **Rosser** and augmented by £4.8M from BBSRC to establish the *Edinburgh Genome Foundry*, the world's largest automated DNA assembly platform.
- £7M from NIHR for *TIBA (Tackling Infections in Africa)*; <http://tiba-partnership.org>, a unique Africa-led, multi-disciplinary programme. This includes developing a SARS-CoV-2

antibody test for Africa, led by **Woolhouse, Mutapi** and **Matthews**. TIBA has since attracted £2.5M in follow up funding from 10 agencies for capacity building, training and community engagement.

- £13.7M from Wellcome for two 4-year PhD programmes in 'Hosts, Pathogens and Global Health', and 'Integrative Cellular mechanisms'; each providing broad, interdisciplinary training, respectively combining research from infection, immunology and evolutionary biology (**Matthews, Woolhouse**) or cell biology, physics, chemistry and medicine (**Marston, Regan and Allshire**).
- £2M for industry engagement and commercialization activities including a strategic partnership with multinational FujiFilm Diosynth Biotechnologies UK to create a 'Centre of Excellence in Bioprocessing 2.0', the formation of spin out companies OGI Bio Ltd, **Pilizota**, Green Bioactives Ltd, **Loake**, and two further spin out companies from research on protein factor H (*Gemini Therapeutics* (now quoted on NASDAQ), *Invizius*. **Barlow**).
- \$35M from the US-based Simons Foundation for the *Simons Initiative for the Developing Brain* co-directed by **Bird**.
- £20M from India to build the *Gujarat Biotechnology University* in partnership with the Government of Gujarat. A conceptually similar program with Zhejiang University created the translational *Joint Research Centre in Engineering Biology* has seen 'in-country' investment of >£10M.
- £3.5M for a NERC Large Grant to advance wild animal ageing work by studying the relationship between the microbiome and healthspan (**Nussey, Pedersen, McNally, Free**).
- £25.3M in external capital funding from RPIF, the Darwin Trust, the Wolfson foundation and others, to construct a state-of-art facility for world-leading interdisciplinary research, the £125M 'new biology' project. Due to open in early 2023 the construction has been delayed by COVID-19 until 2025).

We have embedded our research vision through strategic collaborations, research centres and interdisciplinary programmes. Following our success in establishing the Centre for Regenerative Medicine with MRC Centre status (2008), we have deepened our collaboration with Medicine through TIBA and the Initiative for the Developing Brain. The UK Centre for Mammalian Synthetic Biology has strengthened our collaboration with Engineering and Medicine, and our Centre for Synthetic and Systems Biology provides a key interface between Biology, Physics, Engineering, Informatics and Medicine. We have grown two Wellcome-funded Research Centres - the *Wellcome Centre for Cell Biology* (£6.2M renewal in 2020), a world-leading centre of excellence for cell biology research, and the *Centre for Immunity, Infection and Evolution* to advance interdisciplinary infection biology. These have each successfully won new Wellcome PhD programmes expanding our interdisciplinary ambition in both areas. Additionally, we have enhanced our translational potential by securing £600K in BBSRC IAA funding, £257k in EPSRC IAA funding, and £800K through a Wellcome Institutional Translational Partnership Award (ITPA), recently renewed to 2024 (£2.4m), with which we have progressed 33 impact projects. Our researchers are further supported by access to ~60 PhD studentships per year, largely via new, interdisciplinary Doctoral Training Programmes (DTPs), including two Wellcome and four UKRI programmes (BBSRC, NERC, EPSRC, and MRC). **The diversity of our DTPs illustrates the breadth and interdisciplinarity of our research, while the award of substantial new programmes from both Wellcome and UKRI recognize the positive research culture we have created - a key assessment metric for both agencies. Our research excellence has been recognised by a 2021 QS World University Ranking of 20.**

1.2 Research Strategy

We are structured around **three scientific themes** that operate without boundaries. Deliberately, within each, we have assembled networks to drive fundamental research and deliver solutions to the global challenges in health and the environment. Consequently, we have identified **three global challenges** that have driven forward our strategic effort in this REF period, marking a transition from the approach we adopted in REF2014 and **leading us towards a vision of Building a New Biology**.

This strategy of integrating our science to address global challenges has brought together biology, physics, maths, chemistry, engineering and data science research. Our scientific themes increasingly aim to address these challenges through innovative bio-based solutions for industry, society and our planet, working in synergy with applied practitioners in medicine, veterinary sciences and industry, as needed. This precision engineering of biological systems and the data skills to interrogate them, sums to our Building a New Biology project; a new way of doing biology research with new tools to drive impact. Physically, this ambition will be embodied in our £125M New Biology Building where we will co-locate researchers from across the breadth of our activities in 2025.

Highlights by Scientific Theme

- **Evolution, Infection and Immunity**
- **Cell and Structural Biology**
- **Systems and Synthetic Biology**

Evolution, Infection and Immunity (EII): 62 category-A staff; 104 current PhD students

EII combines a strong foundation of evolutionary biology, woven into the study of infection and ageing. Capitalizing on this long-standing strength, ECRs funded through the *Centre for Immunity, Infection and Evolution* (2007-2017) developed collaborative projects working between immunology, infectious disease and evolutionary biology labs. This model, also central to the 'Hosts, Pathogens and Global Health' Wellcome PhD programme, has proved exceptionally productive, with the outputs from both established and junior groups highlighting the diversity, innovation and quality of science within this theme. Highlights include:

- Tracking and modelling the real-time dynamics of Ebola, Zika, avian influenza and Coronavirus outbreaks (**Rambaut**, e.g. *Nature* 2014, *Virus Evolution*, 2018, *Nature Microbiology* 2020)
- Elucidating the molecular basis of quorum sensing mechanisms in trypanosomes that control transmission to the insect vector and their impact in coinfections (**Matthews**, *Cell*, 2019; *Nature Micro* 2017).
- Showing how extracellular vesicles from a helminth parasite suppress macrophage activation and constitute an effective vaccine for protective immunity (**Buck**, *Cell Reports*, 2017, *Nature Comms*, 2014)
- Revealing novel mechanisms that are key to tissue repair and wound healing (**Allen**, *Science*, 2014, **Zaiss**, *Science*, 2017)
- Shedding light upon why females live longer than males: **Regan** (*eLife* 2016) used genetic sex reversal of a specific gut region to uncover a substantial sex difference in the pathology of the aging gut in *Drosophila*

- Discovering a key mechanism that influences recognition of self-antigens in autoimmune settings (**Zamoyska**, *Nature Immunology*, 2014).
- Finding that the transcription factor FOXN1 specifies development of the thymic epithelial cell lineage, which crucially regulates T cell development and T cell repertoire selection (**Blackburn**, *Nature*, 2017).
- Revealing the vast evolutionary diversification and potential for zoonotic transfer of *Plasmodium vivax* parasites from apes to humans (**Sharp**, *PNAS*, 2018)

Cell and Structural Biology (CSB): 63 category-A staff; 149 current PhD students

Led by the renewed *Wellcome Centre for Cell Biology*, CSB has made major advances in chromosome and RNA biology, and the epigenetic control of gene expression. It is now apparent that epigenetic mechanisms span much of the tree of life, from yeast to mammals. Highlights include:

- Revealing how centromeric DNA and hetero-chromatin mediate transgenerational inheritance of epigenetically regulated traits (**Allshire**, *Science*, 2015).
- Discovering that over-expression of the kinetochore protein CENP-A results in genome instability in aggressive tumours (**Earnshaw**, *Nature Comms*, 2016).
- Leading the burgeoning field of mass spectrometry cross-linking for proteomics (**Rappsilber**, *Structure*, 2020), allowing the architecture of the Mycoplasma expressome to be characterised below 1nm resolution (**Rappsilber**, *Science*, 2020).
- Revealing that the 3D structure of the peri-centromere is critical for proper chromosome segregation during cell division (**Marston**, *Nature*, 2020)
- Developing and applying key techniques (CRAC, CLASH and TRAPP) for the analysis of RNA-protein and RNA-RNA interactions (**Tollervey**, *Molecular Systems Biology*, 2019), including for the analysis of SARS-CoV-2 (**Tollervey**, *Wellcome Open Research*, 2020).
- Demonstrating that piRNA-directed DNA methylation silences young active transposable elements, is key to genomic integrity and specifies immortality of the male germline (**O'Carroll**, *Nature*, 2017).

Systems and Synthetic Biology (SSB): 33 category-A staff; 64 current PhD students

SSB springs from SynthSys, the Centre for Synthetic and Systems Biology (<https://www.ed.ac.uk/biology/synthsys>). SynthSys provided the leadership that established the UK Centre for Mammalian Synthetic Biology in 2015 and the Edinburgh Genome Foundry (EGF) in 2016. The EGF has revolutionised high-throughput assays that can involve simultaneous assembly of many hundreds of simple DNA constructs within a few days. This is supported by our expanding capabilities in cell phenotyping, with the development of a sister facility, EdinOmics. SSB has an overt aim to combine fundamental science with translational impact in microbiology, industrial biotechnology, crop science/agritech/food security, medical biotechnology and cell biology. Highlights include:

- Completing the synthesis of the first yeast chromosome, even before the EGF was established (**Cai**, *Science* 2017, Year).
- Constructing synthetic Human Artificial Chromosomes that undergo rearrangements (chromothripsis) that have implications in cancer development (**Cai**, **Earnshaw**, *Science*, 2017, 2018).

- Developing a low-cost, easy-to-use biosensor to address an unmet global health challenge: arsenic contamination of water that affects 140 million people (**Wang and French**, *Nature Chemical Biology*, 2019)
- Modifying the CO₂-capturing enzyme Rubisco to allow its aggregation in higher plants into a unique liquid-like compartment called the pyrenoid to improve photosynthesis (**McCormick**, *Nature Comms*, 2020)
- Optimising the expression and secretion of biologic drugs in mammalian cells as part of a strategic partnership with FujiFilm DioSynth Biotechnologies
- Demonstrating that the self-organisation of embryonic stem cells depends upon geometrical constraints (**Lowell**, *Development*, 2018).
- Discovering that prokaryotic Argonaute proteins provide a third mechanism (in addition to restriction-modification and CRISPR) to control invader DNA in bacteria (**Leach**, *Nature*, 2020).

Highlights by Global Challenge

- **The Biology of Our Changing World**
- **The Biology of Health and Disease**
- **Engineering Biology for Health and Wealth**

The Biology of Our Changing World addresses directly the effects of environmental change on life, integrating evolutionary genetics, ecology, epidemiology and pathogen biology, but also encompassing aspects of global health studies and areas such as AMR, emerging infectious diseases and pandemic monitoring. Our successes in reshaping Rubisco (**McCormick**, *New Phytologist* 2017, *PNAS* 2019) and modelling the circadian clock (**Millar**, *Molecular Systems Biology*, 2015; *PNAS* 2014) move us forward in underpinning food security; understanding the evolution of SARS-CoV-2 (**Rambaut**, *Lancet Microbe* 2020, *Science* 2021) has permitted a deeper understanding of the current COVID-19 pandemic spread; our new understanding of plant and animal reproductive flexibility in response to warmer springs promises help in mitigating the effects of global warming (**Phillimore**, *Global Change Biology* 2015, *Nature Climate Change*, 2018).

The Biology of Health and Disease works across scales (genes to systems) and draws in cell and molecular analysis of immune cells and pathogens in addition to fundamental studies on cellular function. This encompasses infection and cell biology, immunology, stem cells, development and aging studies. Our successes in addressing fundamental aspects of wound healing (**Allen**, *Science*, 2014, **Zaiss**, *Science*, 2017) and immunology (**Zamoyska**, *Nature Immunology*, 2014) complement our understanding of the development of the immune system (**Blackburn**, *Nature Immunology*, 2016). At two ends of a spectrum, the ability to reverse the symptoms of Rett syndrome (**Bird**, *Nature*, 2017) and delivery of health care in Africa through TIBA (**Mutapi**, *TIBA*, <http://tiba-partnership.org>) stem from our understanding of fundamental science.

Engineering Biology for Health and Wealth, develops cutting-edge technologies for basic research and biotechnology solutions. This challenge builds on our platform technologies (e.g. the Genome Foundry) and our industrial collaborations (e.g. the strategic partnership with FujiFilm DioSynth Biotechnologies). Our successes in bioengineering cyanobacteria (Cyanogate: **Wang and French**, *Plant physiology*, 2019) and expression constructs for the expression and secretion of biologic drugs in mammalian cells (**Rosser**, *Nucleic Acids Research*, 2014, 2019) attest to our approach to this challenge.

1.3. Impact Strategy

Over the REF period, we have explicitly linked our scientific research themes to global challenges in health, environment and development, elevating the profile of impact in in our academic discourse. Our strategy for impact has been:

- To carry out world-class fundamental research that drives innovation.
- To promote research outcomes that directly address societal and economic needs, through addressing global challenges, providing enabling funding (e.g. Impact Accelerator Awards), and making strategic appointments of staff (e.g. **Rosser**, our Director of Industrial Engagement; **Burgess**, our Impact Champion; **Wallace** who has won a UKRI Future Leaders Fellowship in 2020).
- To identify, nurture and develop opportunities for impact wherever they arise. This has been achieved by close work between our Director of Industrial Engagement, Impact Champion, Business Development Executives, Public Engagement team and Edinburgh Innovations (the University's commercialisation service).

Winners of EPSRC (5 awards) and BBSRC (17 awards) Impact Acceleration funding include: **Horsfall** to work with GSK on optimisation of penicillin-producing strains (£86K); **Pilizota** to work with IBioIC to spin out OGI Bio Ltd. (£65K); **Rosser** to develop a strategic partnership with FujiFilm Diosynth Biotechnologies UK (£96K). The Wellcome Institutional Translational Partnership Award (ITPA) has awarded 11 grants for translational activities, with an average of £20K per project, including a project on repositioning lead trypanocidal drugs for clinical and veterinary use, led by **Walkinshaw**, and the development of UV light cleavable quantitative proteomics tags, by **Ly**.

Public Engagement

Our core public engagement (PE) programme (<https://www.ed.ac.uk/biology/public>) is coordinated by dedicated PE staff and co-funded by SBS and the Darwin Trust of Edinburgh. In addition, the Wellcome Centre for Cell Biology and the Centre for Regenerative Medicine deliver their own PE programmes. Currently, our PE Team coordinates over 10 long-term projects.

We have sought to engage young and adult audiences, and built projects targeting under-served local communities. This includes participation in the Edinburgh Council Discover Programme, which provides meals and engaging activities for deprived children during the summer holiday, and our long-term work with deprived communities close to campus, e.g. award-winning work done in the Craigmillar area by the PE Team at Centre for Regenerative Medicine. Our PE and Communications are enhanced by projects such as BioPOD (the official SBS podcast, produced by PhD students), and the Press Gang (a group of staff and student volunteers who promote current research in collaboration with University Press Office). In all our activities, we strive to engage with socio-economically deprived communities, and to raise Science Capital within such communities local to our campuses. We have fully embedded PE in the structure of SBS, and key to this is involvement of researchers and PG students in all PE activities. This enables them to gain vital skills and experience, directly engage people with their research, meet funder requirements, and obtain support in creating their own PE projects.

Policy

We have created links with policymakers, and our research and expertise directly influences decision makers. **Mutapi** (Zimbabwe, Schistosomiasis and Africa/COVID generally through WHO and African Academy of Science), **Leigh-Brown** (UK/US, HIV) and **Rambaut** (UK SAGE, coronavirus) have significant influence in the area of health policy; **Rosser** and **Millar** have direct input to Scottish and UK industrial policy: **Rosser** as member of the Scottish Scientific Advisory Council, and **Millar** as Chief Scientific Advisor on Environment, Natural Resources and Agriculture

for the Scottish Government. **Oyarzun** is a World Economic Forum Global Future Council Fellow. **Pemberton, Ennos** and **Stone** have influence in the area of the environment and ecological policy, via Scottish National Heritage, the Woodland Trust, and Edinburgh City Council respectively.

Health

Our strong collaborative interactions with Edinburgh Medicine and the Roslin Institute, especially in the areas of stem cell biology, immunology, infectious disease epidemiology and global health, provides a clear route to impact in health and clinical medicine of humans and animals. A prime example of this is the embedding of our stem cell biologists in the Centre for Regenerative Medicine, where their impact is maximized by close juxtaposition with clinical scientists maximising the opportunities for collaboration. Examples include **Kunath** (Parkinsons disease treatment), **Blackburn** (Eurostemcell resource), **Telfer** (change to UK fertility guidelines and practice). **Mutapi's** leadership of Tackling Infection to Benefit Africa (TIBA) brings together researchers from across biological sciences and veterinary science to deliver real benefits to Africa.

Economy

A dedicated team of Business Development Executives liaise directly with researchers in SBS and identify opportunities that can then be developed via specialized marketing, contracts or spinout teams. Edinburgh Innovations (EI) has also engaged an 'entrepreneur in residence' to provide real world advice on spinouts and commercialization. SBS has set up an Industrial Engagement Group led by **Rosser** to build strategic relationships with industrial partners. The group has led the development of industrial engagement workshops for staff and students, and set up an industry advisory board, with stakeholders encompassing the diverse expertise in SBS research, from instrumentation to agri-tech.

The University of Edinburgh is a founding member of Scotland's Industrial Biotechnology Innovation Centre (IBioIC), with SBS staff on the scientific advisory board (**Burgess**) and EI staff on the commercial advisory board (**Kerr**). IBioIC, provides partnership access to over 400 companies, from micro SMEs to multinationals, as well as funding to leverage academic industrial partnerships. Since 2014, IBioIC has funded 31 projects involving Edinburgh academics, with a total value of £2.4M. This has leveraged £3.2M of industrial cash and in-kind matched funding.

1.4. Open and ethical research

Our research culture has rapidly become more data-intensive and Open within this assessment interval. Open Access publication in the School is advocated and supported by a full-time School staff member, with compliance at 94%. Many groups now use preprint servers, such as BioRxiv, as part of the strategy to accelerate Open dissemination, and post-publication review is also growing, in particular, through Wellcome Open Research.

As part of our ongoing implementation of DORA (see also People section), the School is supporting, sharing, measuring and recognising a broader range of research outputs. Our researchers invest heavily in data generation, and the School seeks to return the best value from increasing re-analysis and re-use. Research Data Management (RDM) is key to this process. The University's aspirational RDM policy of 2011 set the tone and is now being updated to reflect FAIR (Findable-Accessible-Interoperable-Reusable) principles. However, the diversity of our research products has required a nuanced, domain-specific approach, with School and University support, researcher-led training, and advocacy from senior academics. The University of Edinburgh Research Data Service Steering Group is chaired by **Millar** from the School.

Our research groups use sustainable, University infrastructure for Data Management, as well as customised, internal resources. All active research groups store their working data on the University secure Filestore, and several use the central Git repository for software projects that can be Open. ~25% of groups are disseminating data via the University's Open, Trusted Repository, which is discoverable through DataCite and Google, though disciplinary resources are preferred, such as PRIDE, MetaboLights and the European Nucleotide Archive (ENA). Datasets can be located through links stored in the University CRIS (PURE). Our Research Centres and School facilities advise on the most appropriate Open resources to use, and offer domain-specific training, including for all new staff and student inductions. Several staff lead 'Carpentries' training in good data and software practices, supported by the University's advanced computing centre EPCC and by the UK Software Sustainability Institute.

For bioinformatics and image data, the Wellcome Centre for Cell Biology has two technologists to support data management. The team in the SynthSys Centre now support the School and groups in Medicine, using a £300k contribution from the shared Wellcome ISSF. This "Bio_RDM" team led by **Millar** comprises two research software engineers and a curator. Bio_RDM trains and helps grant applicants with Data Management Plans, curates biomedical data to a high standard and provides services such as an Electronic Lab Notebook based on the University wiki, and a shared OMERO server for Open microscopy images. Electronic notebook use has been embedded in the training for our new Wellcome PhD programmes supporting adoption by the next generation. For advanced users, the team adapts open-source data systems that automate data analysis and management. The team also links to the UKRI Reproducibility Network locally, supporting bottom-up advocacy. At the University level, **Millar** chairs the Research Data Steering Group and the Responsible Research Metrics working group. Several staff are external advocates: for example, **Allshire** is engaged in the development of Open Research policy in the Wellcome Trust, as is **Millar** in Scottish Government, BBSRC and the international FAIRDOM project, and **Rambaut** is a leader in the global sharing of viral sequences (see Wellcome-funded ARTIC network).

All research carried out in SBS now undergoes ethical scrutiny and approval (including undergraduate projects). This is via an on-line approval system that is light-touch for most of our work, but escalates to full review for relevant research projects. An Ethical Review Group led by **Schirmer** carries out these reviews. This group also acts as a point of contact to address issues around research integrity (**Rowe**) and leads on discussion with students on ethical and societal responsibilities in research. All of our (1styr) PhD students attend a compulsory 'Ethics Day' training that is very well received and generates much heated discussion. A network of Postdoc Advisors supports our postdoc community providing the first port of call for discussion of research integrity issues, in addition to career and mentorship advice.

1.5. Future strategy and vision

Our ambition of integrating our science to address global challenges is encapsulated in the **Building a New Biology** project to bring most of our science together in one new building.

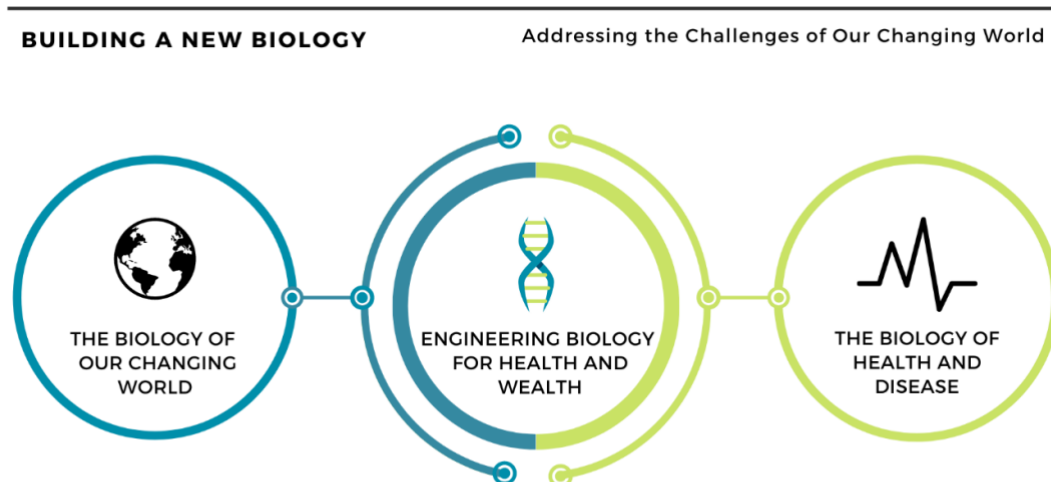


Figure 1 - Visualization of the School's evolving themes and their integration

Our ambition of **Building a New Biology** has driven plans to consolidate our interactions within a new building. £105M of university and £25.3M external investment from UKRPIF, the Darwin Trust, the Wolfson Foundation and others are going into new estate to support this flagship development. This project was due for completion in late 2022 (opening early 2023), but because of COVID is delayed until 2025. The University of Edinburgh's vision, to create one of the world's finest research clusters for the Biological Sciences, is an ambitious plan to grow our research capacity, quality and outputs in directions that support intellectual discovery and generate health, social and economic benefits. This iconic building will co-locate our researchers and technologies within an integrated research complex to create an interactive physical environment that reflects these ambitions.



Figure 2: Building a New Biology, architect images

The foundation of this estates programme is the complete re-development of our Darwin Building to create a physical and metaphorical heart for Biological Sciences: a gateway to Biology in Edinburgh, a focal point for outreach activities, and a magnet for attracting partners to enable our translational work. It will house 3 floors (3,000m²) of shared-access, advanced technology facilities (Edinburgh Genomics, the Edinburgh Genome Foundry, Proteomics/Metabolomics, Protein Production and Biophysical Characterization, Flow Cytometry, Micro-fluidics, Advanced Imaging and Cryo-EM). These facilities, and access to the expertise of our academics, will attract industrial collaborators into a research hotel within the building, and this space will also act as an early-stage incubator for early-stage proof-of-principle work leading to spin-out opportunities arising in the School. Moving up the Darwin Tower, we will have 6 floors (6,000m²) of state-of-the-art, open-plan research laboratories designed for ultimate flexibility that will be occupied based on thematic co-locations, or 'research neighbourhoods'. Specifically, we intend to expand our research in:

- antimicrobial resistance and global health
- environmental change
- sustainable biotech solutions for the circular economy

The new building will house 350 researchers - a 50% increase on previous occupancy. At the front of the Darwin Tower, a section called 'the Hive' gives physical meaning to the 'Gateway to Biology' providing multi-functional space that acts as a cross-road for researchers in all our connected buildings and beyond, offering dedicated engagement space for our community (i.e. scientists from other disciplines on King's Buildings and the general public), and meeting rooms for industrial contacts. Catering, social and social learning space will be key to making this an attractive destination and meeting place.

2. People

2.1 Staffing and recruitment strategy

Our people strategy has been to combine new appointments to areas of strategic research opportunity with career development, retention and advancement for excellent 'home-grown' researchers. This has led to a 27% expansion in our academic staff numbers (142 staff submitted to REF2021 compared to 112 to REF2014).

In this REF period, we have recruited 6 early career researchers (ECRs) to the University's tenure-track Chancellor's Fellowships (CFs) (**Laohakunakorn, Macias-Ribela, McNally, Soufi, Spence, and Vale**) and 17 ECRs to lectureships (**Agrawal, Baranovic, Barker, Blin, Buonomo, Burgess, Cachat, Cowan, Darmon, Oyarzun, Philip, Regan J, Richardson A, Vohra, Wallace S, Wilson and Wood**). 6 of these (**Macias-Ribela, Soufi, Spence, Wallace S, Wilson and Wood**) have gone on to win externally funded Fellowships (Wellcome, MRC, Royal Society, UKRI-FLF). We have also sponsored a further 18 independently funded (e.g. Research Council) Fellows (**Alexander, Arulanandam, Cheerambathur, Cook, Granneman, Hartfield, Heun, Ly, Martin, Ross, Sibley, Johnston, Lowell, Makovets, Twyford, Voigt, Wallace E, Welburn and van Ooijen**).

As our staffing strategy includes encouraging the sponsorship and recruitment of independently funded research fellows, we operate a comprehensive Fellowship Review and Retention policy. All externally funded career development (first fellowship) fellows undergo an advisory development review after 3 years and are supported through advice and mentorship to make a successful Senior Fellowship application. Part of this review is to indicate various paths that might be open to each individual researcher and one of these is transfer to a University-funded position

after the cessation of fellowship funding. For those who have shown excellence in achievement in their first fellowship, and a strong fit to our strategic priorities, we make a commitment to transfer to an open-ended academic post. We have made this commitment to 7 ECRs in the current REF period. The majority of our ECR fellows have gone on to gain Senior Fellowships (9 in this REF period). The achievement of a Senior Fellowship guarantees future retention.

To balance the intake of early-career staff, we have made 8 senior appointments over the period to provide leadership of strategic research areas. **Burgess** has been appointed as a Senior Lecturer in Biological Mass Spectrometry and **Stracquadanio** as a Senior Lecturer in Synthetic Biology. **Kaufman**, **O'Carroll**, **Regan L**, **Riley**, and **Silvertown** have been appointed to professorships in Immunology, Stem Cell Biology, Interdisciplinary Science, Immunology and Infectious Disease, and Technology Enhanced Science Education, respectively.

The University Chancellor's Fellow scheme, started in 2013 and continued in this REF period, has been a game-changer in scale and quality of ECR recruitment, but also with regard to the support and encouragement that has enabled these ECRs to succeed. These 'tenure-track' positions have been nurtured through mentorship and advisory reviews and CFs have been given every opportunity to succeed. We have underwritten contracts to allow them to apply for grant and fellowship funding right up until the end of their initial 5-year appointment period. In the two years prior to the REF2021 period we made a major investment in 12 ECR appointments to CFs to drive forward our ambitious thematic research strategy. This went hand-in-hand with the appointment of 9 lecturers and recruitment of 18 externally funded fellows. All of these ECR staff have been supported and encouraged to succeed during this current REF period. Several have moved into leadership positions in our School (e.g. **Pilizota**, Director of Research, and **El Karoui**, Director of Equality & Diversity, and then Director of SynthSys), and have already been promoted to personal chairs (**Spoel**, **El Karoui**, **Pilizota**, **Horsfall**, and **Lowell**).

The quality of our appointments is attested by the number of externally funded Research Fellowship awards at all levels in the period (24 compared to 18 in the previous REF period). In addition to those externally-funded fellowships listed above more senior awards have been made or renewed within the School during the REF period, including: 3 Wellcome Principal Research Fellows (**Allshire**, **Earnshaw** and **Tollervey**); 1 Royal Society Professor (**Beggs**); 1 RAEng Professorship (**Rosser**); 14 Senior/Advanced/Leadership Fellows with funding from MRC, EPSRC, WT, NERC, CRUK and EU; 42 'Career development' and other standard-level fellowships (WT, MRC, NERC, BBSRC, EPSRC, RS, EU and other charities); and 14 training/mentored fellowships (WT, EU, RS and other charities). The quality of our people is also reflected in other external measures of recognition and esteem including a knighthood to **Bird**, 6 elected to membership of EMBO (**Bird**, **Chambers**, **Kaufman**, **Marston**, **O'Donal**, **Pemberton**), 3 elected to FMedSci (**Matthews**, **Allshire**, **Riley**), 3 elected FRS in the period (**Keightley**, **Matthews** and **Pemberton**) bringing the total FRS employed in the School during the period to 9.

2.2 Staff development, training and support

New academic appointments are allocated a 'start-up package' to support the establishment of their research activity at Edinburgh. The scale of the package depends on the level of appointment and the need for specialist equipment. However, for new lecturers the package usually includes a PhD studentship (or technician/RA) and a lab consumables budget (~ £30k). New staff have reduced teaching and administration loads in their first two years to facilitate the establishment of successful research programmes.

Staff development is key in SBS for all career stages. We utilise all of the training programmes run by the University's highly-valued Institute for Academic Development (IAD). IAD has a very broad remit in developing staff (and PhD students) in both research and teaching. We nominate all of our new ECRs and new fellows for the IAD 'New Research Leader' programmes that focus on the transition from postdoc into lab management for the first time (over 40 new PIs have completed the training since 2014). Ten early- to mid-career staff have completed the Postgraduate Certificate in Academic Practice (PgCAP). For senior staff (grade 9 and 10), there is an opportunity to develop the skills to lead large and collaborative projects in a Strategic Leadership in Research Programme, culminating in an 'Ideas Summit'. Senior PIs showing interest in, or aptitude for, academic leadership roles are encouraged to attend leadership development provided by UoE HR Department (more than 20 staff have completed the 'Senior Leadership' course to date). We also support staff to take up external opportunities such as the EMBO group leader course and Wellcome Leadership Programmes. In addition, SBS has developed, in association with an external Leadership coach, training sessions for people entering the first stages of their leadership path or those aspiring to this role. This is a hybrid model that combines one-to-one sessions (x2) and group work (x5) and has been universally popular with feedback from all 12 staff being, "I wish I'd done this earlier in my career". Five female academic staff have attended the highly-regarded the Advance HE Aurora programme in the last 5 years. The School also offers additional opportunities for staff at all levels through focused personal coaching programmes; since 2017 we have run 'career coaching' for staff in postdoc or junior PI roles (40 staff so far). Initiated in association with Equate Scotland, and focused on female staff, we have since widened the programme to include other grades and genders, while increasing our funding to grow cohort size 3-fold.

Additional coaching support is available for returning parents or others who have taken career breaks. All new PIs are allocated a more experienced member of academic staff as a one-to-one mentor for the first few years or for the length of their fellowship. While this is a formal arrangement, new ECRs and Fellows normally develop additional, more informal, mentoring relationships with senior academics in their field. In recent years, we have focussed on extending what has been a long-standing social and professional development network ('BioDocSoc') for postdoctoral research staff and PhD students. In 2018, we recruited 2 early-mid-career staff to act as 'Postdoc Champions' and they in turn recruited a team of 'Postdoc' Advisors' who are available on an ad hoc basis to any postdoc for career advice and any other support and guidance that may be sought. These advisors, who are volunteers from amongst the School's established PIs, can provide individual advice and can direct postdoctoral staff to a range of other helpful resources or support them to resolve problems in the workplace. This arose from the work of our 'Postdoc Champions' who undertook an in-depth discussion with the postdoc community as to what would most benefit them. Another initiative to arise from this has been a more structured programme of training and development for teaching experience available to our postdoc staff, including a small number of paid part-time secondments tenable for up to 3 years, to allow postdocs to undertake CPD (e.g. Edinburgh Teaching Award towards a Fellowship of the Higher Education Academy) and gain mentored teaching experience to benefit their future academic careers. In developing these schemes as School policy, and championing them with both PIs and postdocs, the School has pre-empted and indeed gone further than much of the Concordat to Support the Career Development of Researchers.

Opportunities for sabbatical leave to pursue research ideas are open to all academic staff and there is financial support for female staff to take sabbaticals specifically in relation to activities that will bolster their promotion to professorial Grade 10. Staff members at all levels have annual

performance and development reviews with their line manager, which help identify achievements and plan for future success, or agree beneficial development opportunities such as the training described above.

We operate a completely transparent Workload Allocation Model (WAM; all staff can see their colleagues' workload numbers), that allows balance in teaching, research, administration, knowledge exchange and wider academic contributions. The WAM also ensures that funded research projects are deliverable: The model reduces the expectation for contributions other than research as the research group increases in size. The WAM includes recognition for time spent in contributions to the wider scientific community such as journal editorships and membership of grant-awarding panels. It also recognises leadership of major research collaborations and for impact and engagement activity.

Promotion for academic staff between grades 7-10 conforms to the DORA principles in that it is not based on publication metrics, but on a combination of measures. Indeed, **Millar** chairs the University's Research Metrics Group which oversees the roll out of this. In this UoA we have for many years combined achievement (publication quality, funding awards and research student training) with contribution (teaching and leadership), together with knowledge exchange to reach decisions on promotion cases. Each year all academic staff are considered for promotion or contribution reward linked to performance, achievement, and contributions to the School and discipline. Each staff member is reviewed by two line managers and the Head of School. The recommendation for promotion or reward does not require application or nomination and the annual assessment of trajectory allows line managers to feedback and mentor staff towards progression in future years. All aspects of an individual's role as a university academic come in to play, but research, impact and knowledge exchange are key components.

We recognise the activity of all staff groups (and students) for their achievements in the area of research and impact with School Annual Awards for individuals and teams. The awards are not competitive (no 'winners') and the nominations are from other staff, including their peers. This also recognises the contribution of the support staff in our facilities (including media prep, wash-up and workshop) in making the environment the best it can be for our researchers. The University also recognises and rewards achievement in research and impact across all its activities, in the shape of the Chancellor's Awards. In the past few years SBS staff have won this University-wide prize for Research (**Rambaut**), for Rising Research Star (**Horsfall**) and for Impact (**Mutapi**).

2.3 Research students

The School of Biological Sciences gains much of its diversity and energy by recruiting excellent Post-Graduate students from across the globe. Our portfolio of studentship funding offers a wide choice to prospective students and we recruit ~60 PhD students per year. To do this we have won the support of a variety of funding sources including the BBSRC, NERC, EPSRC, MRC, Wellcome and the Darwin Trust. In addition, the University/SBS provides matched funding to the level of 13 studentships per annum.

We are the lead Institution for EASTBIO, the third largest BBSRC Doctoral Training Partnership (DTP). This £17M postgraduate research training partnership, awarded funding in 2019, brings together departments across the University of Edinburgh with partners in Aberdeen, Dundee, St Andrews, Stirling and SRUC, IBiolC, James Hutton Institute, Moredun Research Institute and Cool Farms Ltd.; the collaboration is an excellent way for us to share practice, develop our training offering and benefit from research expertise and facilities across the partnership. EASTBIO

awards ~27 studentships per year at the University of Edinburgh, of which ~12 are awarded in UoA5. We have expanded access to this training partnership to international students funded through the University's Global Research Scholarship and Principal's Career Development Scholarship.

On average 8 studentships per year are funded through our MRC, NERC Doctoral Training Partnerships and a UKRI Centre for Doctoral Training (CDT). The MRC Precision Medicine DTP (£8.8M) partners Edinburgh and Glasgow in biomedicine generally, and SBS contributes greatly in systems and synthetic biology and computational biology training. The NERC funded E4 DTP (£7.5M) is a partnership between Biological Sciences and Geosciences (in Edinburgh) and focuses on ecological analyses that help understand environmental change. The UKRI-funded CDT focuses on 'Biomedical Artificial Intelligence' approaches to biomedical data from molecular level (drug discovery) to genomic/populations levels.

The Wellcome 4yr PhD programme 'Integrated Cell Mechanisms' takes a data-driven and interdisciplinary skills-led approach to study cell biology/physiology. Our other Wellcome 4yr PhD programme, 'Hosts, Pathogens and Global Health', has recently renewed its funding for another 5 years (£5.5M) to build on its activity at the interfaces between infection biology, evolutionary biology and public health, with an emphasis on tropical diseases, with the opportunity for student experience in partner countries (mainly in Africa). A University-funded student of low and middle income country (LMIC) origin is supported on this programme each year, including full consumable and training costs. We contribute to the 'One Health' Wellcome Programme run out of Edinburgh Infectious Diseases (EID) and the Roslin Institute. Edinburgh was highly successful in this funding competition being the only University awarded 4 programmes in 2019, with this School hosting 2 programmes. This reflects recognition of our strongly supportive research culture and training excellence.

Funding from the Darwin Trust (20 students each year), is not focused on a particular area of science, but for overseas students, mainly of LMIC origin. On average we also host 6 PhD studentships per year that are co-funded by industry through IBioIC, CASE or individual research grants.

All of our funded PhDs are for 3.5-years or for 4-year, and all students are offered the same (or similar) training opportunities provided in-house or by our partner Institutions. Further training opportunities, including access to a unique tool for identifying training needs, are available to all students through IAD, which offers over 50 practical courses for students on PhD, taught MSc or Masters by Research programs. We have also developed and harmonised supervision procedures across the UoA where each PhD student chooses a second (academic) supervisor, and is assigned a pastoral supervisor and a committee chair. This thesis committee of four meets formally with the student once per year, with the proceedings logged through an online system. This regular tracking of student progress keeps students on target for submission within four years (over the last three cohorts our submission rate was 81% within four years, the remaining 19% includes those who have taken interruptions of study for ill health/maternity/internships).

We manage 8 vibrant MSc programmes (in Biochemistry, Biotechnology, Bioinformatics, Systems and Synthetic Biology, Drug Discovery and Translational Biology, Synthetic Biology and Biotechnology, Quantitative Genetics, and Biodiversity and Taxonomy of Plants, the last in association with the Royal Botanic Garden at Edinburgh) and recruit roughly 150 Masters students each year.

We implement robust recruitment procedures centred in all cases on student quality as opposed to supervisor need. Our PGT/PGR student body is diverse (53% F: 47% M and 33% international

student/visa holders), while we are piloting policies (flagging applications and customising recruitment materials) to ensure that students with disabilities and from disadvantaged backgrounds are attracted to apply and are selected for our EASTBIO programme. We have a strong focus on student mental health and wellbeing and have developed a bespoke workshop for students on resilience. A fortnightly drop-in session for PGR students who have problems they want to discuss is being piloted through EASTBIO. We see this work as building on a strong foundation of careful recruitment (all students are interviewed by a gender-balanced panel) and embedded pastoral and academic monitoring. During this REF period our PGR programmes have been run by a very successful Graduate School, that is embedded within College-level PGR structures. With the increase in interdisciplinary programmes and training, the University has recently set up a Doctoral College to disseminate and harmonise best practice across the University.

2.4 Equality and diversity

Equality, diversity and inclusion lie at the heart of all our strategies to provide a working environment that is welcoming and encouraging. Dignity and respect are core principles and good citizenship is rewarded through annual School and College awards and formally via the promotion or contribution reward processes. Established in 2009 the School Equality and Diversity Committee oversees our policy and practice regarding gender, race and disability. Our work to promote gender equality was recognised by an Athena SWAN Silver Award to the School, first in 2013 and renewed in 2016 (extended to 2022). Over this REF period, the School has become a beacon of good practice and is working towards an application for Athena SWAN Gold.

Equality, Diversity and Inclusion (EDI) has been mainstreamed in all our decision-making fora. The 14 member School Executive Committee (our senior management group) includes seven women; two Heads of Institute (**Regan** and **Zamoyska**), Director of Research (**Pilizota**), Director of the Graduate School (**Blackburn**), Director of Industrial Engagement (**Rosser**), Director of Professional Services (**Payne**), and the Chair of the EDI Committee (**Collins**). To support the work of the EDI Committee we have funded two student internships for focused EDI projects, leading to improvements in web content and communications, and in 2019 we allocated strategic funding and appointed an EDI Officer. Since then the EDI officer has launched a new LGBTQ+Bio Society to coincide with Pride 2019 and has run 8 differently themed focus groups to hear the suggestions and concerns of staff. Towards the end of the COVID19 lockdown our EDI Officer ran a survey in the School to capture people's varied experiences of having to work at home often in difficult circumstances. The results of this are being used to inform our 'work from home' policy, post-COVID and also changes to our space utilization and support for staff working at home. We have also captured individual circumstances and the impact on people's career progress, which will be fed into future career progression decisions. In addition, informal 'Equali-Tea' and Pride get-togethers provide networks supporting mental well-being, and a Biology student-run welfare network spanning the whole campus, 'WellComm Kings', emerged from the School's initial support for this activity.

As an indication of the success of our recruitment, support and mentorship of excellent female academics, during the REF period we have seen an increase in our proportion of women at grade 10 Professor from below 25% to just over 33% (19 out of 57), with 4 mid-career women promoted in 2020 (**Collins**, **Horsfall**, **Lowell** and **Pilizota**). We predict this will continue to grow as currently 40% of grade 9 Principal Investigators are women and, over the past 5 years, >40% of newly recruited PIs were women. Leakage from this pipeline seems to be stemmed by our promotion

processes that are not based on self-nomination, conform to DORA principles, and take into account family circumstances. A sabbatical scheme specifically aimed at supporting women to reach their next promotion target (in particular grade 10) was introduced in 2019. Family-friendly policies include: a default expectation that flexible working requests will be supported (5 to date), access to departmental funding to support childcare or other dependent responsibilities so that staff can attend career development opportunities such as conferences, a shared parental leave policy incorporated in to workload adjustments, a nursery located on-campus, workload adjustments for post-maternity-leave returners to enable them to re-establish their research activity (e.g. by delaying taking back their previous teaching contribution), access to coaching for returning parents and provision of facilities in the School's buildings for nursing mothers. These family friendly policies have been utilised by at least 10 academic staff since their introduction.

From analysis of our recruitment procedures, the EDI Committee noted that we have appointed at roughly 50:50 F:M ratio, having shortlisted balanced groups for interview, however, the applicants for posts were not well balanced. To rectify this, we have modified our recruitment adverts to seek to attract a wider range of applicants, e.g. to emphasise aspects of working life important to diverse applicants and stress the opportunities for support, mentorship and training open to all, thus ensuring parity of access to career development and reward. All members of interview/selection panels have undertaken unconscious bias training and EDI training related to recruitment processes.

Our EDI activities have moved beyond the School: in 2017 **Halliday** organised an exhibition focused on equality in STEM, highlighting the gender gap and women's professional journeys – 'Potential Difference'. This was hosted at the Royal Society of Edinburgh and then toured Scotland. **Halliday** also co-directs a major E&D research project (eBase) looking at barriers to success for women in large research leadership/grant competitions, as part of the EPSRC-funded Inclusion Matters programme. **Halliday** is now the College Dean of EDI and is developing a matrix-type model of EDI initiatives that draws in expertise from each of 7 Science and Engineering Schools, spreading good practice and ensuring pooling of efforts. Strategically, now and into the future, our focus is on the racial and ethnic diversity of our staff to provide role models for our very diverse student body and help address the attainment gap for BAME students. In this regard, of the cohort of six academic staff recruited in the last 6 months we have appointed 3 BAME lecturers/CFs.

Lastly, we have considered Equality, Diversity, and Inclusion in this REF submission. All staff involved, completed a specific training course on EDI for REF. We have followed policies and processes set out in our institutional code of practice, and inclusion in the output portfolio is based solely on merit, as assessed by a panel of academics specific to each biological discipline. Where appropriate, special circumstances have been considered in determining an individual member of staff's contribution to the output portfolio.

3. Income, infrastructure and facilities

3.1 Income

The School maintains a strong portfolio of research funding and has broadened the range of funding types and sources that support our research since REF2014. Over the REF period we have attracted £196M in research grants and contract awards. Mean annual expenditure (income) over the REF period is £28M. Our research award portfolio thus ensures we have a healthy funding base for continued research expenditure beyond the REF period. 44 research grants awarded

during the period have been between £1M and £2M, and 18 grants over £2M in value. These include the £8M renewal of WTCCB (2016), and a £13M BBSRC/MRC/EPSRC strategic award to create the UK Centre for Mammalian Synthetic Biology (2014) and TIBA (£7M). £19M of funding comes from schemes targeted to translate fundamental discoveries into applications, including BBSRC Sparking Impact, MRC Developmental Pathway Funding Scheme, WT Seeding Drug Discovery and the Technology Strategy Board and most recently an EPSRC Prosperity Partnership award (£7.9M) with Fujifilm Diosynth Biotechnologies. Not included in the total award figures, we have secured a Wellcome Trust Institutional Strategic Support Fund (ISSF) of £2M per annum since 2011. Over the REF period the breakdown of our awards from our major funders are as follows: BBSRC, £35M; EPSRC, £2M; MRC, £24M; NERC, £10M (total UKRI=£70M); Wellcome, £75M; EU, £14M; Industry projects, £2.6M

3.2 Infrastructure

The identification and development of large-scale research opportunities such as strategic awards, centres and major collaborative initiatives, including collaboration with industry, is supported through three dedicated research managers. We have expanded this team 3-fold over the REF period to help our researchers work across traditional discipline boundaries and secure new funding sources for innovative research. All research managers are PhD-qualified biologists, meaning that they can contribute significantly to coordination and writing of proposals to support academic success. Three administrative staff provide advice on proposal preparation, costing and submission, and grant management. This team works closely with the four Business Development and Commercial Relations Executives (BDE/CREs), with expertise in commercialisation and knowledge transfer, who work within the School and between us and Edinburgh Innovations (EI, the commercialisation arm of the University). Our BDE/CRE team has three functions: to identify, protect and develop IP assets for commercial outcomes; to engage with industry to foster long-term research partnerships; and to work with University services to provide specialist expertise in licensing, consultancy and company formation. The BDE/CRE roles are partly funded by a Wellcome Trust iTP Award, which has enabled us to expand this team (3-fold) since the last REF. These staff are members of a wider support team managed by EI, which also coordinates events and offers training in commercialisation and entrepreneurship.

The School has a full-time Public Engagement Manager and a Science Communications Manager leading a team of 4 staff running science communication and public engagement. Grants from the Darwin Trust (£300K), STFC (£200K), Wellcome (£443K in funding since 2016) and EU (EUR 600K), have supported a range of activities that provide opportunities for researchers to engage with external audiences and so deliver impact from our research.

Research strategy development is a multi-layered process. We have always encouraged and supported bottom-up initiatives in a way that can lead to bids for external funding (the Centre for Immunity, Infection and Evolution and Edinburgh Infectious Diseases are good examples of this). The development of a Centre for Environmental Change is being supported by investment posts at Lecturer/Senior Lecturer level, the appointment to the Chair of Natural History (**Pemberton**), a recently-awarded Royal Society Professorship (**Kruuk**) and by the launch of a Masters programme in Environmental Change Biology. Sustaining these activities and ensuring that cross-disciplinary opportunities are not lost is the role of our Research Committee. Discussions that lead to major initiatives often arise informally from our strongly interactive research environment and are facilitated by the School Research Symposium and an annual awayday as well as more focused thematic workshops to develop ideas. SynthSys (Centre for Systems and Synthetic Biology; <http://www.synthsys.ed.ac.uk/our-centre>) co-ordinates research activity across several

different Schools and is a prime example of a part of our organisation that brings forward and realises strategic projects. Our Research Committee works to ensure that funding opportunities are flagged and progressed. We have created a webpage to consolidate information about current and forthcoming funding calls, including deadlines, which is updated weekly and communicated by e-mail newsletter. Our PIs are supported to submit applications by a highly-responsive and very well-regarded (pre-award) Research Administration team of 5 people. Currently, with changes to the funding landscape and funding levels in some quarters, we are actively managing the number and quality of applications coming forward from our PIs.

3.3 Facilities

The School recognises the value of multi-user equipment and staff expertise in supporting world-leading research. Research themes and centres are underpinned by 'small research facilities' (SRFs), which offer equipment and expertise via cost-recovery models. Facilities work with a dedicated finance team that helps to set costs, develop business cases and sets cost-recovery expectations. The majority of facilities have an expert manager as well as an academic scientific director, who respectively provide long-term support and a focus on novel approaches. The facilities are represented at a monthly SRF meeting, where all facilities managers meet to share best practice and discuss challenges.

Technology facilities are grouped into '**design and build**' and '**measure and analyse**' themes. The **Centre for Regenerative Medicine** (CRM), a joint venture between the Schools of Biology and Medicine, also maintains several world-class research support facilities.

FACILITIES	Design and Build	Measure and Analyse	Centre for Regenerative Medicine
School Themes			
Global Challenges			
	- Plant Growth Facility - Edinburgh Protein Purification Facility - Edinburgh Genome Foundry	- Edinburgh Genomics - Electron Microscopy - Edinburgh Phenotypic Assay Centre - Flow Cytometry - Light Microscopy - EdinOmics	- GMP Cell Therapy - Chemistry & Computational Biology of the Niche - Light Microscopy - High Content Screening
Systems and Synthetic Biology	✓	✓	✓
Cell and Structural Biology	✓	✓	✓
Evolution, Infection and Immunity	✓	✓	✓
Our Changing World	✓		
Health and Disease	✓	✓	✓
Engineering Biology	✓	✓	✓

Figure 3: Visualisation of the School's facilities and their integration with the evolving themes.

Design and build: constitutes the **Edinburgh Genome Foundry** (EGF), the **Plant Growth Facility** and the **Edinburgh Protein Purification Facility** (EPPF). The **EGF** is unique in the UK and is the largest automated DNA production line/assay facility in Europe; it attracted inward investment of £5M from BBSRC and partnerships with Autodesk, Thermo Fisher and BGI for the equipment and programming and ~£2M in UoE-funded building refurbishment. This will be a major attractor of national and international, academic and industrial collaboration. This is especially borne out by the recent acquisition of a BBSRC-funded Berkeley Lights Beacon instrument with a value of £2M, which will allow ultra-high throughput screening of engineered cells.



Figure 4: The Edinburgh Genome Foundry: automated, robotic DNA production line, and Berkeley Lights Beacon cell sorting and selection instrument.

EPPF has developed a worldwide reputation as a centre of excellence for the production and characterisation of high value proteins, in both industry and academia. EPPF has worked with several biopharma companies, who chose the EPPF for reagent production and characterisation. More recently, EPPF developed a novel cross-species crystal-seeding methodology that resulted in crystal structures for ‘impossible to crystallise’ macrocyclic peptide ligands, one of which was solved at the highest resolution so-far reported for a protein:ligand structure: 0.77Å. For work on this innovative technique, in 2018, members of the EPPF team were awarded a prestigious UK prize from the British Crystallographic Society. The **Edinburgh Plant Growth Facility** comprises over 2200 m² of glasshouse space and six controlled environment rooms (over 500 m²).

Measure and analyse: constitutes **Edinburgh Genomics (EdGe)**, **EdinOmics**, the **Flow cytometry** core facility, the Wellcome **Centre Optical Instrumentation Laboratory (COIL)**, the **Electron Microscope (EM)** facility and **Research Data Management**.

Discovery sciences are provided by a combination of genomics and transcriptomics services. **EdGe** are equipped with an Illumina MiSeq and NovaSeq, an Oxford Nanopore PromethION and have just received delivery of a BBSRC-funded PacBio Sequel IIe, the first of its kind in Europe. The Sequel IIe will provide extremely long reads (up to 20kb) with an unprecedented high accuracy of 99.9%. **EdinOmics** provides metabolomics and proteomics via five mass spectrometers, including the only Agilent 6560 Ion Mobility Q-ToF and 7200 GC-QToF in Scotland. EdinOmics, an Agilent Partner Lab, is focused towards synthetic biology, and consequently is a partner lab of both EGF and EPPF, providing rapid strain and protein characterisation for these facilities. Both EdGe and EdinOmics provide extensive bioinformatic support and experimental design services to collaborators, to ensure maximal exploitation of complex ‘omics datasets.

Electron Microscopy and **Cryo Electron Microscopy** facilities have merged and recently obtained funding for a new direct electron detector module for the Jeol CryoEM, providing unprecedented sensitivity and resolution. The School is a founding partner in the Scottish Macromolecular Imaging Centre in Glasgow (<https://www.gla.ac.uk/researchinstitutes/iii/cvr/scmi/about/about/>), (SMIC) providing access to a state-of-the-art JEOL CRYO ARM 300kV microscope for both single particle analysis and cryo-electron tomography. **Flow cytometry** supports four instruments – three 20 parameter 4 laser models and a 3 laser 10 parameter instrument.

Light Microscopy is provided by COIL and the CRM Light Microscopy unit. Staff at COIL were recently co-authors on (Paldi et al. Nature 2020) and among the instrumentation is a unique Multifocus microscope. This experimental system is capable of obtaining images from 9 different focal planes without movement, providing unprecedented capabilities in super-resolution microscopy.

Edinburgh Phenotypic Assay Centre (EPAC), established in partnership with the School, provides high throughput screening capabilities for drug discovery. The facility houses an IncuCyte ZOOM coupled to a Heracell 240i incubator for phenotypic monitoring under normoxic and hypoxic conditions. It also houses an ImageXpress MicroXI platform for high-content imaging, fully equipped with plate handling robotics. The facility is also equipped with extensive compound libraries, comprising a 12,000 compound diversity set, as well as a 1280 compound library of existing drugs for repurposing.

CRM facilities consist of **GMP Cell Therapy**, the **Chemistry and Computational Biology of the Niche (CCBN)** facility, **Light Microscopy** and **High Content Screening**.

GMP Cell Therapy is a state-of-the art 1000m2 good manufacturing practise facility, designed in consultation with the Medicine and Healthcare Regulatory Authority (MHRA) to provide high quality manufacturing of cell therapies and stem cell products within UK and Europe. The facility is licensed by the Human Embryology Fertilisation Authority (HFEA), Human Tissue Authority (HTA) and MHRA. **CCBN** is a joint facility between the School of Engineering and CRM, using a PRIMO platform to manufacture custom cell substrates for the control and standardisation of in vitro microenvironments (2D/3D micropatterns, microfluidic devices). The **high content screening** facility is equipped with an Operetta high content microscope and a Vectra Polaris quantitative pathology imaging system, allowing high levels of cells morphology and physiology data to be collected in high throughput.

SBS is supported by large scale animal facilities, as well as centralised media prep and washup. The animal facility consists of a 1500m2 unit for rodents, fish, birds, insects and amphibians, supporting animal model research in development and disease, vector-borne infectious disease studies, and behavioural research.

The University has invested £7M in building Waddington II that houses plant growth rooms, growth chamber facilities, transgenic plant growth capability and adjacent new glasshouses. We have refurbished over the past 5 years the Ashworth Laboratories (£6M) and the Roger Land Building (£8M) as decant space from the old Darwin Building.

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

4.1 Public engagement

The School has 4 public engagement (PE) practitioners who deliver a wide range of high quality and exciting activities to thousands of people of all ages across Edinburgh City and surrounding regions. During REF2021 we integrated this team to develop and deliver a more coherent strategy for engagement and revised our activities to meet the demands of modern audiences and to target more 'hard to reach' demographics. Our vision has been to establish the School as a leader in the provision of creative and impactful PE activities for multiple audiences. We aim to stimulate meaningful discourse about our research and its impact on our world and to encourage *all* our staff and students to embrace PE as an integral component of their roles. To support the latter, we deliver training to encourage and build researcher confidence in the design and delivery of

exciting and impactful engagement activities. The School also appointed an Impact Champion (**Burgess**), to ensure that impact is high on our agenda.

Our PE staff are supported by grants from Wellcome (as part of the Centre for Cell Biology award) and the Darwin Trust, which generously funds us at a level of £100K per annum. As a result, we have developed a diverse portfolio of PE activities. Our Science Communications Manager is raising the profile of our research through press releases, feature articles, social media (followers @SBSatEd on Twitter up 50% - to over 1600 in 2019/20) and digital media (short science videos created for Twitter have gained 28,000 views in the last three years). Increased research coverage, social media promotion and other communications have helped to drive traffic to research stories on the School website. In the year 2019/20 the News and Events section received over 12,000 page views.

During the REF2021 period, we delivered the following:

- We engaged with over 13,000 school pupils thereby supporting the secondary school biology curriculum (e.g. PCR classes in the National Museum for Scotland, Pupils in Labs, Bioinformatics training). These projects are in high demand by schools that could not otherwise offer this practical work in class. For instance, the 'Pupils in Labs' programme hosting workshops and lab visits on campus. Over the past 4 years we have welcomed 513 students from 19 different schools into these laboratory workshops.
- Our '4273π Bioinformatics project' has visited 74 schools and reached 170 schools and over 1600 school children (through workshops, CPD events, masterclasses, online CPD events) across Scotland to deliver bioinformatics training; this programme led by **Barker** has been adopted and funded by the Science and Technology Facilities Council as a flagship initiative.
- We engaged over 270,000 members of the public with interactive activities delivered through science and related festivals and events (e.g. including the high-profile Edinburgh Science Festival, Midlothian Science Festival, Mind the Lab [events based in transport hubs], Tattoo my Science, Life through a Lens). These projects showcase our current research, enable people of all ages to meet our scientists, and provide crucial engagement opportunities for our staff and students.
- We collaborated with the National Museum and Scotland and the Universities of Glasgow and Dundee to develop a major exhibition focused on neglected tropical disease: "Parasites-Battle for Survival". This ran November 2019-March 2020 and was targeted to school-aged children, attracting >37000 visitors before premature closure due to COVID. The exhibition particularly highlighted the contribution of woman in science with special features on **Mutapi** and **Reece** from Edinburgh and with input from many researchers in our EII theme.
- We have engaged 580 people in community-based projects, which allow us to engage 'hard to reach' members of our local community (e.g. young adults) as well as those in socioeconomically deprived areas, working on building longer-lasting relationships for the future. For example, in the past two years we have supported Edinburgh Council's *Discover!* programme to reach children in more deprived communities during the summer school holidays.

Researcher-led public engagement activities are also encouraged and supported. These include the flagship EuroStemCell website for stem cell biology (**Blackburn**), the launch of an Edinburgh Café Synthétique (a version of Café Scientifique focused on the topic of synthetic biology), and BioPodCasts, a postdoc led activity to highlight School research topics via podcasts.

4.2 Policy

Staff have played active roles in the development of policy, nationally and globally. Some of the most influential are listed here:

Rosser is a member of the EU High Level Strategy Group on Industrial Technologies. The group gave strategic recommendations to the European Commission on which key enabling technologies to prioritise post Horizon 2020 in European research and innovation in order to strengthen Europe's innovation capacity and leadership in industrial technologies. **Rosser** continues to be an active member of the Scottish Science Advisory Panel (SSAC), providing advice to the Scottish Government on science funding.

Millar is a member of the BBSRC Council and 'New Ways of Working' panel, and is seconded to the Scottish Government as Chief Advisor for Rural Affairs and the Environment. He is also on the UKRI Research Infrastructure Roadmap working group on Biosciences, Food and Health, and Chair of the BBSRC sLoLa panel (Strategic Longer Larger Grants) 2019.

Mutapi is member of the Royal Society of Edinburgh Post-Covid Futures Commission and is also a member of the World Health Organisation, Diagnostic Technical Advisory Group (DTAG) for neglected tropical diseases (Schistosomiasis Sub-group) that develops guidelines to feed into the new global NTD roadmap 2021-2030. She also sits on the UK Foreign, Commonwealth and Development Office (FCDO) Accelerating Sustainable Control and Elimination of Neglected Tropical Diseases (ASCEND) Steering Committee and the Wellcome Trust Global Monitor External Advisory Board, which steers the world's largest study on how people around the world think and feel about science and major health challenges. **Mutapi** is also a major player in the African Academy of Sciences (AAS), where, as part of the steering committee she is influencing transformation of lives on the African continent through science. Example projects include Epidemic Preparedness and Grand Challenges Africa, a multi-million dollar funding body led by AAS and the New Partnership for Africa's Development fund (with Bill and Melinda Gates Foundation).

Rambaut heads a group of viral sequence evolution modellers monitoring the trajectory of the COVID19 epidemic in the UK and the effect of lockdown measures. Rambaut is a leading member of the CoG-UK coronavirus sequencing consortium that delivers rapid and large-scale viral-genome sequencing to local NHS centres and the UK government - their project reports are fed into the UK SAGE Committee. They have generated over 1000 SARS-CoV-2 genomes in Edinburgh (more than any individual country other than USA and Australia). The sequencing approach being used by most of the groups in the UK (and many globally) came directly from this lab.

Woolhouse sits on the SPI-M (SAGE subgroup) and the Scottish Covid-19 Advisory Group

Pemberton is active at a national and governmental level (Scotland) on deer culling policy and other issues such as conservation of mountain hares (with Nature Scotland).

4.3 Industry engagement

The School has significantly enhanced its approach to engagement with industry during REF2021. A dedicated business development team in Edinburgh Innovations (EI) supports our new commercial engagement as well as technology transfer. In 2018, we created an academic leadership role of Director of Industrial Engagement (**Rosser**); the Director is a member of the School Executive Committee and ensures that enterprise in all its forms is integrated into our School's forward planning. This instils the opportunities for technology translation and commercial collaboration across all our activities, from teaching, training and research.

A variety of new activities have encouraged and supported improved industry collaboration and commercialisation over the REF2021 period. Staff have attended EI delivered workshops which help raise awareness of industry challenges and encourage researchers to consider how their research might apply (e.g. AIM Day Future Manufacturing, AIM Day Bio-Solutions). Access to local translational funding (BBSRC/EPSRC Impact Acceleration Accounts and Wellcome iTPA) and more recently a BBSRC Flexible Talent and Mobility Award have helped seed a wide variety of productive new commercial links. The most recently awarded, £600K in BBSRC IAA funding and £800K through the Wellcome Trust Institutional Partnership Award (iTPA), have encouraged ECRs and PDRAs to apply as project leads and to date we have secured £287K and £241K of IAA and iTPA funds to progress 22 projects.

During REF2021, the School has developed more strategic partnerships with companies, forging a number of key partnerships with Fujifilm Diosynth Biotechnologies, UCB Pharma, GSK, ScotBio and Ingenza. This recognizes that larger businesses often have complex needs that cannot be addressed by a single research group. Thus, collaborations with UCB Pharma (Parkinson's diseases, Biologics - **Kunath, Rosser**); FujiFilm Diosynth Biotechnologies (bioproduction, analytics, devices - **Pilizota, Horsfall, Rosser**); GSK (antibiotics, biologics, metabolomics – **Horsfall, Rosser, Burgess**); ScotBio (natural products - **McCormick**); Ingenza (metabolic engineering, automation – **Horsfall, Rosser**, EGF) have been fruitful for both partners. For instance, our collaboration with FujiFilm Diosynth Biotechnologies has further evolved into strategic partnership to establish a Centre for Bioprocessing 2.0 with York and Manchester Universities with an initial investment of ~£2M. This FujiFilm Diosynth partnership has recently been expanded with a Prosperity Partnership award of £7.9M from EPSRC.

As founding partners of Scotland's Industrial Biotechnology Innovation Centre (IBioIC) we have worked closely to build impact and reach. SBS staff sit on the IBioIC advisory board and we benefit from IBioIC-funded competitions. As an example, we co-led an invited re-application for £22M for UKRI Strength in Places Fund, supported by over 70 companies, enterprise agencies and local authorities, to build a platform to accelerate the development of novel bioproducts using our world-class facilities and expertise. This will support the creation of a Research Hotel to host these as well as SBS spinouts and local start-ups.

We have also had success in generating spinout companies such as OGI Bio Ltd (novel bioreactors, **Pilizota**), Green Bioactives Ltd (natural products, **Loake**), Gemini Therapeutics Inc and Invizius Ltd (novel therapeutics, **Barlow**). This is indicative of new entrepreneurial energy within the School.

4.4 Academic partnerships

We recognise the opportunities inherent in collaboration, both to address gaps in our capability (e.g. in research or translational potential) and/or to create stronger, broader and more

comprehensive research programmes/capabilities. This commitment is exemplified through many pan-University, and regional, networks including:

- Centre for Regenerative Medicine – A co-location of basic and applied stem cell biologists physically located close to Edinburgh Royal Infirmary.
- Centre for Infection, Immunity and Evolution – A close association between biological and medical researchers seeded by Wellcome support.
- Centre for Synthetic and Systems Biology (SynthSys) – a pan-University network of research around synthetic and systems biology, agnostic of system or application.
- Edinburgh Infectious Diseases – an Edinburgh City wide network of over 860 scientists and clinicians working on infectious diseases.
- Edinburgh Plant Science – a multi-institution network of over 600 plant and soil scientists who provide wide ranging expertise and capability in food security, environmental sustainability and policy.

The School is also closely associated with CSEC (the Centre for Science at Extreme Conditions) and COSMIC (the Collaborative Optical Spectroscopy, Micromanipulation and Imaging Centre). The Centre for Translational and Chemical Biology, along with support for the joint venture (with Medicine) of the Edinburgh Phenotyping Centre contributes strongly to drug discovery projects across the university (**Walkinshaw, Auer, Schnauffer**).

We are a founder member of the Scottish Universities Life Science Alliance (SULSA) that transformed cell biology and especially systems biology research capacity in Scotland; it has gone on to drive capacity building in drug discovery and more recently, as SFC funding reduced, SULSA has championed the broadening of emphasis to focus support of ECRs in all life science areas

4.5 International Partnerships

Trans-national collaboration has always been a keystone of our science, with our research excellence attracting international collaboration at all scales, from the individual lab to Institutional co-ordination. For example, during this REF period we have nurtured lab-to-lab collaborations in 45 countries, from South Korea to Ethiopia and Chile to New Zealand. More broadly, early in this period we signed an agreement with the University of Nagoya in Japan for a Joint PhD exchange programme. We encourage similar exchange links outside of this, including the student and postdoc scheme run by SULSA (PECRE, Postdoc and Early Career Researcher Exchange). These collaborations have been strengthened by the award of 8 GCRF projects.

A major development in the last 3-4 years has been the investment in strategic partnerships that build infrastructure and staffing for research and training with key partners in China and India. In China we began discussions in 2017 with the College of Life Sciences in Zhejiang University (Hangzhou, Zhejiang Province). Zhejiang is ranked 3 in China and 54 in the QS global rankings. This project builds on a burgeoning partnership forged by the UoE Medical School with Zhejiang University on a new international campus in Haining (60km east of Hangzhou); the Joint Institute delivers undergraduate teaching (in English) and research in biomedical science. Extending this relationship, we have formed, via an MoU, the Joint Research Centre in Engineering Biology. This Centre is housed in a new building that is currently being kitted out for collaborative projects between 4 labs each from ZJU and UoE. The aim of the Centre is to carry out research that is overtly translational in the area of biotechnology (industrial and plant/agritech, initially). Funding for postdoctoral workers and PhD students is beginning to flow and the aim will be to provide opportunities for exchange of students and early career researchers to work both in Edinburgh and Haining. We have brought Edinburgh Innovations into the project and have increasingly

productive links with Juanhu Lake Translational Park close to the International Campus to engage Chinese (and UK) industry in the research projects.

In India, the Gujarat Biotechnology University (GBU) has been developed as a novel and imaginative partnership between the Dept. of Science and Technology, Government of Gujarat (GoG) and the University of Edinburgh, to embed Innovation and Entrepreneurship in all its activities. Funded, by GoG, (£20M for the Edinburgh component) this new state university is founded with an ambition to enhance the training of the student body (initially at Masters and PhD levels). The skills and mindset of the faculty and research collaborations with external industry partners will be key to making this a unique offering in Indian Higher Education. With innovation and entrepreneurship culture at its core, we aim to deliver at GBU a research project-based training with societal impact as a critical outcome of all projects. We fully expect to see the development of new REF impact cases from this project in the future.

TIBA (Tackling Infections to Benefit Africa; <http://tiba-partnership.org>) is a centre programme with a dispersed structure and the University of Edinburgh at its hub. Importantly, the work of TIBA is Africa-led. Funded by the UK National Institute for Health Research (£7M), the partners are in 9 African countries (Botswana, Ghana, Kenya, Rwanda, South Africa, Sudan, Tanzania, Uganda and Zimbabwe). Its aim is to harness expertise and technical capability and to empower African scientists in effecting rapid change in reducing the burden and threat of infectious diseases. This involves rapid impact, 'making a difference' projects, toolkit projects, technology transfer and training to influence development of health policy and to strengthen health systems. It includes preparedness for pandemics (Ebola and others) and response to health emergencies. Our commitment to this area is demonstrated by the appointment of 2 Chancellor's Fellows for Global Health (**Moule** and **Mwangi**). **Mutapi** leads the initiative across all 3 Colleges in the University.

4.6 Indicators of wider influence/contributions to the research base.

Governorships and senior office bearers:

Blackburn: Board of Directors, and Coordinator of Training and public engagement activities, European Consortium for Systematic Stem Cell Biology. **Loake:** BBSRC, Management Board; President, International Society of Plant Reactive Oxygen and Nitric Oxide Research. Co-Founder and Governing Board member, IBioIC; Founder, Green Bioactives Ltd. **Lowell:** Board of Directors for the Company of Biologists. **Smith:** Elected to the International Association of Medical Science Educators Board of Directors.

Royal Society Fellows:

Pemberton, Keightley, Matthews (+ pre-existing: **Allshire, Beggs, Bird, Earnshaw, Sharp, Tollervey**)

Royal Society of Edinburgh Fellows (in this REF period):

Blackburn, Blaxter, Chambers, Gray, Mutapi, O'Carroll, Matthews, Reece, Rowe

Royal Society of Edinburgh's Young Academy of Scotland:

Horsfall

EMBO membership:

Bird, Chambers, Charlesworth B, Charlesworth D, Kaufman, Marston, O'Carroll, Pemberton, Welburn (Young Investigator)

FMedSci:

Bird, Allshire, Matthews, Riley

International and national advisory board membership:

Allshire: Management Board for EpiCrossBorders. **Auer:** Scientific Advisory Board, Celcuity LLC; Drug Discovery Advisory Panel, Parkinson's UK. **Bird:** Gairdner Foundation Medical Advisory Board; International jury for the Start and Wittgenstein Prize of the Austrian Science Fund; Governing Body, Lister Institute for Preventive Medicine; Institute of Molecular Pathology, Vienna; Gurdon Institute, Cambridge [Chair]; Friedrich Miescher Institute, Basel [Chair]; Francis Crick Institute, London [Chair]; Adviser to National Autism Project. **Cavanagh:** European & Developing Countries Clinical Trials Partnership (EDCTP). **Chambers:** Strategy Advisory Panel Member, BBSRC Bioscience for Health; Chair, Regenerative Biology and Stem Cell Working Group, BBSRC. **Collins:** Global Ocean Acidification Observing Network North Atlantic Hub Executive; Co-convenor of Scientific Committee on Oceanic Research. **French:** Advisor to Synbio Africa. **Horsfall:** Advisory Board member- European Synthetic Biology Society (EUSynBioS). **Kidner:** ESR confidante for Plant.ID EU DTP. **Marston:** Scientific Advisory Board Member, Max Planck Institute for Molecular Genetics. **Millar:** UKRI: Infrastructure Advisory Committee. **Molnar:** International advisory board of the Agricultural Institute Martonvasar, Hungarian Academy of Sciences. **Mutapi:** Member, RSE Post-Covid Futures Commission 2020; UK Department for International Development (DFID) Science Advisory Group; World Health Organisation, Member, WHO Diagnostic Technical Advisory Group (DTAG) for neglected tropical diseases; UK Research and Innovation (UKRI) Global Challenges Research Fund Strategic Advisory Group; World Health Organisation Expert Advisory Group: Technical Working Group; African Academy of Sciences Steering Committee; WHO Africa Region Director's Independent Advisory Group. **Pemberton:** Scientific Advisory Board of MPI for Evolutionary Biology, Ploen; National Trust for Scotland Natural Heritage Advisory Group; RCUK Individual Merit Promotion Committee. **Rambaut:** Participant of UK Government Scientific Advisory Group for Emergencies (SAGE) committee for COVID-19; CoG-UK Coronavirus Genomics Consortium Steering Committee; Scientific Advisory Board, Global Initiative on Sharing All Influenza Data (GISAID); HIV Sequence Database Editorial Board, Los Alamos, USA. **Reece:** Strategic Advisory Boards, Max Planck Institute for Infection Biology. **Riley:** UKRI COVID-19 research task force; DHSC/NIHR/MRC rapid response review panel (COVID-19), MRC- Council; member- external advisory board, MRC Centre for Virus Research, University of Glasgow; member external advisory board, Helsinki Institute for Life Sciences, University of Helsinki; Member, MRC Zika Rapid Response Initiative Panel; Deputy Chair, MRC Infections and Immunity Board (IIB). **Rosser:** EU High Level Strategy Group on Industrial Technologies; International scientific advisory board of Stem Cell Australia; member of Scottish Science Advisory Council; Engineering Biology Leadership Council; Scottish Industrial Biotechnology Development Group; Scientific Advisory Board – Synthetic Biology Doctoral Training Centre (Oxford-Warwick-Bristol). **Schnauffer:** Agency for Science, Technology and Research in Singapore, SBRI Innovation Grants. **Spoel:** Chair of GARNet Advisory Board; GATSBY Plant Science Advisory Board.

Committee membership of professional bodies, charities and trusts:

Allshire: Chair of Wellcome Trust/ Royal Society Sir Henry Dale Fellowship; Wellcome Trust Open Research - Expert Advisory Group; Board of Trustees for the Darwin Trust of Edinburgh. **Barker:** NERC Advisory and Implementation Group. **Bird:** Foreign Associate, US National Academy of Sciences; Lister Institute for Preventive Medicine; CRUK, Trustee of the Rett Syndrome Research Trust, USA, Trustee of the Kirkhouse Trust, Scotland. **Earnshaw:** ASCB International Affairs Committee; Sir Henry Wellcome Postdoctoral Fellowship Interview committee. **French:** Chair of the Responsible Conduct Committee for iGEM. **Horsfall:** Elected Section Co-chair: EFB's Bioengineering and Bioprocessing section; Executive Board member: European Federation of Biotechnology; Member of the iGEM diversity and inclusion committee. **Leigh-Brown:** UK HIV Drug Resistance Database-Steering Committee; Executive Committee; Chair, Molecular Epidemiology Study Group. **Loake:** Member of strategic review committees for John Innes Institute, UK, Sophia Agrobiotech Institute, France, Helmholtz Zentrum Institute, Germany. **Matthews:** Sectional Committee member, Academy of Medical Sciences. **Millar:** BBSRC Council. **Mutapi:** UK Department for International Development (DFID) Accelerating Sustainable Control and Elimination of Neglected Tropical Diseases (ASCEND) Steering Committee; African Academy of Sciences Steering Committee; African Academy of Sciences Epidemic Preparedness Committee; Bill and Melinda Gates Foundation Grand Challenges Meeting; Grand Challenges Africa (GC Africa) Steering Committee member; Chair WHO committee on treatment of Schistosomiasis in preschool-age children and paediatric Praziquantel formulations. **Pemberton:** Expert panel of Scottish Natural Heritage's Scientific Advisory Committee. **Rambaut:** HIV Sequence Database Editorial Board, Los Alamos, USA; Lead PI for Wellcome Trust Collaborator Award (ARTIC Network); PI and Executive committee of Bill and Melinda Gates Foundation programme. **Reece:** Editor for Advances in Parasitology. **Riley:** Chair- Bioscience for Health (BfH) Strategy Advisory Panel; Chair- Scientific Evaluation Panel, Zoonoses and Emerging Livestock Systems (ZELS); Member- BBSRC Research Advisory Panel; Member- Doctoral Training Programmes midterm review panel; member- BBSRC Vector Borne Diseases Expert Working Group. **Rosser:** Steering Committee Global Biofoundries Alliance; Member of the EU High Level Strategy Group on Industrial Technologies; Member of the Scottish Science Advisory Council; Member of the Scottish Industrial Biotechnology Development Group. **Rowe:** Management Committee of The European Malaria Reagent Repository. **Schirmer:** European Laminopathies Network. **Smith:** Elected to the International Association of Medical Science Educators Board of Directors; Program Committee for the IAMSE Annual Conference in Leiden, Netherlands. **Wallace:** elected member of the Chemistry-Biology Interface Council of the Royal Society of Chemistry.

Membership of grant and fellowship awarding bodies:

Bayne: Basic Science Interview Committee, The Wellcome Trust. **Chambers:** EMBO LTF Panel; ERC StG panel; FWF panel member for the Austrian Science Fund. **Hartfield, Pedersen, Obbard:** NERC Peer Review College. **Horsfall:** BBSRC Research Committee D. **Hudson:** Research Council of Norway, Evolution & Ecology panel. **Kidner:** Norwegian Research Council Ecology and Evolution. **Kunath:** CRACK-IT NC3Rs grant panel; BioSKAPE grant panel. **Lohse:** Academy of Finland grant/fellowship evaluation panel for Evolution. **Matthews:** Wellcome Trust Science Interview panel; Carnegie Trust for the Universities of Scotland research assessor; **McCormick:** Member of the BBSRC NIBB PHYCONET Management Board. **Mutapi:** Deputy Chair, UKRI and UK Department of Health, National Institutes for Health Research (NIHR); Panel member- UK MRC Digital Innovation for Development in Africa (DIDA) GCRF Panel; Chair, UK

Department of Health, National Institutes for Health Research (NIHR) Global Health Research Funding Groups Panel; UK Department of Health, NIHR Research Professorships panel; Panel member EU Horizon 2020, Unit E3: Fighting Infectious Diseases and Advancing Public Health; Deputy Chair, UK Department of Health NIHR –GCRF Funding. **Obbard**: IRF Panel. **Pedersen**: Academy of Finland - Research Council for Biosciences and Environment (RCBE). **Reece**: ESF panel of experts. **Riley**: Member- Research and Knowledge Exchange Committee (RKEC). **Rosser**: Deputy Chair BBSRC Committee D; EPSRC Science, Engineering and Technology Board (SETB). **Rowe**: Member of the Royal Society of Edinburgh Fellowship panel; Member of the American Society of Tropical Medicine and Hygiene/Bill and Melinda Gates Foundation Travel Award Committee; Member of The Royal Society Newton International Fellowships Panel. **Schirmer**: Comisión Nacional de Investigación Científica y Tecnológica, Chile. **Smith**: Committee Member -International Association of Medical Science Educators (IAMSE) Educational Scholarship Committee; IAMSE Junior Faculty Travel Awards. **Spoel**: GATSBY Plant Science Advisory Board. **Swain**: International Human Frontier Science Program Committee. **Stone**: NERC Peer Review College. **Tollervey**: Edinburgh University ISSF committee. **Voigt**: Referee for research proposals for Wellcome, Worldwide Cancer Research, FRM (Fondation Recherche Medicale – France). **Zamoyska**: ERC starting grants LS6 “Immunity and Infection”. BBSRC Pool of Experts: **Burgess, Buonomo, De Sousa, Horsfall, Matthews, Pilizota, Welburn**. Wellcome Trust Expert Review Groups: **Lowell, Marston, Reece, Tollervey, Zamoyska**.

Honours, fellowships and other awards:

Alexander: Royal Society University Research Fellowship. **Allshire**: Elected Fellow of Academy of Medical Sciences **Bird**: The Brain Prize; Buchanan Medal, Royal Society, London; Fellow of the American Association for Cancer Research; Foreign Associate, US National Academy of Sciences; Charles Rodolphe Brupbacher Prize for Cancer Research, Zurich; Shaw Prize in Life Science and Medicine, Hong Kong; BBVA Frontiers of Knowledge Award, Madrid; Jacob's Ladder Norman Saunders International Research Prize, Toronto; Knighthood New Year's Honours list. **Briggs**: British Society for Parasitology – President's Medal. **Cook**: British Crystallographic Association's Early Career Researcher Award. **Chambers**: Hooke Medal, British Society for Cell Biology; Visiting Professor, University of Tsukuba. **Earnshaw**: Elected Inaugural Fellow, American Society for Cell Biology; Daiwa Adrian Prize for UK-Japan Scientific Collaboration. **Goryachev**: F1000Prime; Faculty Member of the Year, Microbiology. **Hartfield**: John Maynard Smith Prize (ESEB). **Keightley**: Centennial Award for outstanding GENETICS article. **Johnston**: The Genetics Society Balfour Lecture. **Leach**: Leverhulme Trust Emeritus Fellowship. **Marston**: Wellcome Collaborator Award. **McCormick**: Best Innovative Collaboration Award with ScotBio, Scotland's Life Sciences Awards. **Matthews**: Sanofi-Institute Pasteur international prize for tropical medicine, 2015; Royal Society Research Merit Award. **Mutapi**: Elected Fellow, Zimbabwe Academy of Sciences; Elected Fellow, African Academy of Sciences; Elected Fellow, Africa Science Leadership Program and Future Africa Fellow; Elected Fellow, African Science Institute; University of Edinburgh Chancellor's Award for Impact. The Impact Award, David Livingstone Medal, Royal College of Physicians and Surgeons of Glasgow. **Pemberton**: Darwin-Wallace medal of the Linnean Society. **Reece**: CA Wright Medal; British Society for Parasitology, Scientific Medal, Zoological Society London. **Riley**: Fred L. Soper Lecturer, American Society of Hygiene and Tropical Medicine, USA; Ronald Ross Medal, LSHTM. **Rosser**: Royal Academy of Engineering Chair in Emerging Technologies. **Rowe**: C.A. Wright Medal from the British Society for Parasitology. **Tollervey**: Biochemical Society Novartis Medal and Prize; Mendel Medal, Masaryk University, Brno, Czech Republic. **Wallace**: Chartered Chemist status of the Royal Society of Chemistry.

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