

## Unit-level environment template (REF5b)

<b>Institution: Imperial College London</b>
<b>Unit of Assessment: 5, Biological Sciences</b>
<b>1. Unit context and structure, research and impact strategy</b>

**Overview**

The **Department of Life Sciences (DoLS)** at Imperial College London is one of the largest groupings of biological scientists within a single department in Europe, with 79 FTE academic staff, 12 independent research fellows, 168 research staff, 189 PhD students, 300 Masters students, and 980 undergraduate students. This scale allows us to have strength and depth across the full spectrum of biological sciences: molecules, cells, organisms, and ecosystems. DoLS is located on two campuses, South Kensington in London and Silwood Park in Berkshire, with the latter hosting our activities in ecology and evolution. DoLS sits within the Faculty of Natural Sciences (FoNS), which was created in 2005 to integrate research in mathematics and the physical and biological sciences. Our health-related research benefits from close links with the Faculty of Medicine, which facilitates the path to real-world application and impact. Our research is supported by a wide variety of research councils, charities and industrial bodies, with external funding of £178.5M awarded over the REF period. This submission comprises staff in DoLS, plus *Fisher* from the Faculty of Medicine, whose activities are closely aligned with UoA5. Contract level of submitted staff: Fellow (10.8%), Lecturer (9.7%), Senior Lecturer (20.4%), Reader (15.0%), Professor (44.1%). Contracts are open-ended except for Fellows.

**Research groupings and cross-cutting centres**

Within DoLS, staff are organised into **twelve fluid and intersecting research themes**: Anaesthesia, Sleep and Pain; Bacterial Pathogenesis; Cell and Developmental Biology; Ecosystems and the Environment; Evolutionary Biology; Glycobiology; Infection and Immunity; Integrative Systems Biology; Membrane Biology; Molecular Mechanisms of Disease; Molecular Plant and Microbial Systems; Synthetic Biology. The major research activities of these themes and notable achievements during the REF period are described below, followed by our higher-level research objectives over the next five years. To promote the cross-fertilisation of ideas, staff are encouraged to join more than one research theme; 53% of our academic staff and independent research fellows are formally associated with more than one theme. Interdisciplinary research is further promoted via **Imperial Centres of Excellence led or co-led by DoLS**: Centre for Integrative Systems Biology and Bioinformatics (Director: *Sternberg*), Centre for Synthetic Biology and Innovation (Co-Director: *Baldwin*), Centre for Structural Biology (Director: *Meier*), Centre for Neurotechnology (Co-Director: *Wisden*). The MRC Centre for Molecular Bacteriology and Infection promotes cross-faculty research in bacterial pathogenesis and antimicrobial resistance (8 affiliates from DoLS, 16 from the Faculty of Medicine), and the Grand Challenges in Ecosystems and the Environment initiative (Director: *Savolainen*) focuses on finding solutions to key environmental challenges by acting as an interface between science, practitioners and policy makers.

**Research position relative to REF2014**

In 2013 the Department removed the earlier divisional and sectional structure, creating a unified administrative framework and a flexible organisation based on research themes. In view of the success of this reorganisation, we have been continuing to build our research capacity across the research themes established in 2013. Guided by the strategic five-year plan laid out in REF2014, and responding to new national and international priorities, we have grown research activity in the genetic modification of insects (gene drives) to control malaria and other vector-borne diseases, in

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synthetic and systems biology, in antimicrobial resistance, and in the structural biology of pathogens and host-pathogen interactions. At our Silwood campus, we have diversified coverage of the ecological and evolutionary disciplines beyond our traditional strengths in theory and computation, with marked expansion in the aquatic (marine and freshwater) realms, climate change research, and applied ecology. To implement this programme of strategic alignment and consolidation, we appointed a new Chair in Structural Biology (*Meier*, succeeding So Iwata) and 19 junior academics, as well as 21 research fellows in strategic priority areas. Over the REF period, 23 academics were promoted to Senior Lecturer, 10 were promoted to Reader, and 18 were promoted to Professor. Over the same period, 24 staff have left (3 retirements, 21 moves).

### Aims and notable achievements of the research themes

The **Anaesthesia, Sleep and Pain** group aims to understand the physiological roles of sleep in mammals and invertebrates, and how it contributes to healthy ageing. Using advanced molecular genetics and behavioural analysis, *Franks* and *Wisden* (Wellcome Investigator Award (IA) renewed in 2020) discovered new brain circuits regulating sleep and wakefulness. Before focusing on physiological sleep, *Franks* worked on the mechanisms of anaesthesia; his discovery that xenon potently inhibits NMDA receptors and is neuroprotective underpins one of our impact case studies. *Wisden*, in his role as programme lead at the UK Dementia Research Institute at Imperial, is exploring the protective role of sleep against dementia. These investigations are complemented by *Brickley* who studies cognitive decline in ageing mice. *Gilestro* developed the Ethoscope platform for high-throughput behavioural studies of fruit flies, leading to the unexpected discovery that chronic sleep restriction in flies is not lethal. The versatile Ethoscope has already been adopted by other DoLS researchers who use the fruit fly as a model organism in neurobiology (*Southall*) and immunity (*Dionne*). *Okuse* has been studying the mechanisms of neuropathic pain, with funding from Japanese companies (ONO Pharmaceuticals, Orion Pharma).

The **Bacterial Pathogenesis** group, affiliated with the cross-faculty **MRC Centre for Molecular Bacteriology and Infection** (renewed for another five years in 2017), aims to define the molecular mechanisms underlying bacterial disease, virulence and antibiotic resistance. *Frankel* and *Clements* study the pathogenic mechanisms of enterohaemorrhagic *Escherichia coli*. Using a mouse model system, and leveraging the multiomics expertise of *Larrouy-Maumus*, *Frankel* (Wellcome IA) discovered how enteric bacteria manipulate host gut metabolism to evade innate immune responses (basis of current MRC Programme Grant). This line of research has been strengthened by the recent recruitment of *McDonald*, a gut microbiome expert. *Filloux* studies the mechanisms of biofilm formation and the secretion systems of *Pseudomonas aeruginosa*. He discovered how the bacterial type III secretion system subverts host cell function by altering histone H3 modifications. *Williams* studies bacterial infections in the context of cystic fibrosis. Recent recruit *Costa* brings expertise in structural biology to the study of bacterial pili and secretion systems. Finally, *Beeby* has established himself as a world leader in cryo-electron tomography of bacterial flagellar motors, exploiting to the full his Satellite at the Francis Crick Institute.

The **Cell and Developmental Biology** group aims to define the mechanisms regulating tissue development, maintenance and regeneration in order to improve lifelong health. The world-leading research of *Lo Celso* is focused on the dynamic processes underlying healthy and malignant haematopoiesis, and the role of haematopoietic stem cells in severe infections (Wellcome IA). By using pioneering intravital microscopy, *Lo Celso* discovered that leukaemia cells remodel the bone marrow microenvironment to further their own expansion, a finding that is highly relevant for leukaemia therapy (basis of current CRUK Programme Foundation Award). Translation of this

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research will be facilitated by *Lo Celso's* recent appointment as Co-Director of the Centre for Haematology in the Faculty of Medicine. The haematopoietic stem cell niche is also the research focus of *Luis* (Sir Henry Dale Fellow). *Southall* (Wellcome IA) developed an innovative cell type-specific transcription profiling technique to study neuronal development in fruit flies. *Barkoulas* uses *Caenorhabditis elegans* as a model organism to study the mechanisms of developmental robustness (ERC Starting Grant) and host-pathogen interactions (Wellcome IA). *Lo Celso* is Head of the Facility for Imaging by Light Microscopy (FILM), a state-of-the-art facility serving hundreds of users from across Imperial.

The **Ecosystems and the Environment** group addresses the greatest challenge of our time: how to sustain a growing global human population and the ecosystems that support it. Research spans all levels of biological organisation, from genes to the entire biosphere, and multiple scales in time and space, from acute pesticide spills to global heating. *Ewers* leads the SAFE (Stability of Altered Forest Ecosystem) Project in Malaysian Borneo, one of the world's largest ecological experiments that investigates the consequences of rainforest fragmentation and possible mitigation strategies. In 2020, *Ewers* received £2.7M from the NOMIS Foundation to construct a "virtual rain forest". *Purvis* (joint appointment with the Natural History Museum) leads the PREDICTS (Projecting Responses of Ecological Diversity In Changing Terrestrial Systems) project, which uses global data to quantify the impact of human pressures on biodiversity. *Banks-Leite* established the minimum amount of area required to preserve biodiversity in the Brazilian Atlantic Forest, and the cost of preservation. Her findings have shaped government policy in Brazil and underpinned new laws on land use as a result (impact case study). *Lloyd* quantified the carbon lost from the Amazonian basin in drought years. New recruit *Waring* (joint appointment with the Grantham Institute) investigates how the ecology of plant and soil microbial communities influences the carbon cycle and its feedbacks on climate change. *Prentice* directs the Leverhulme Centre for Wildfires, Environment and Society established 2019 and leads REALM (Reinventing Ecosystems And Land-surface Models, £1.9M ERC Advanced Grant). *Woodward, Bell, Pawar, Ransome* and *Cavan* are studying the impact of climate change and chemical stressors on food webs and ecosystems. *Woodward* has led two large NERC consortia in these areas, with a combined grant value of £6.2M. *Gill* and *Graystock* investigate the effects of neonicotinoid pesticides on insect pollinators. *Cator* studies the behaviour of mosquitoes with a view to applying the insights to the control of mosquito-borne diseases. New recruit *Pearse* hit the ground running and leads a NERC COVID-19 project, modelling the spread of SARS-CoV-2 under different environmental conditions (with the Mathematics Department).

The **Evolutionary Biology** group aims to understand fundamental principles of evolution, adaptation and speciation in order to address global challenges, such as the loss of biodiversity due to human expansion and the evolution of antimicrobial resistance. *Rosindell* is using computational approaches to understand phylogenetic diversity, with particular emphasis on conservation biology. He is the creator and CEO of OneZoom, an interactive educational tool visualising the tree of life (impact case study). *Tobias* studies the evolution of biodiversity and how it is impacted by man-made environmental change. He is the Imperial representative on a £6.3M GCRF project, SENTINEL (Social and Environmental Trade-offs in African Agriculture). *Brazeau* uses early vertebrate fossils to reconstruct the evolution of skull, jaws and paired appendages, *Abzhanov* (joint appointment with the Natural History Museum) studies the evolution of reptiles and birds, and *Schroeder* focuses on the behaviour and evolution of the latter. *Savolainen* and *Leroi* discovered an important role of viviparity (embryo development inside the parent) in the diversification of fish. *Fumagalli* is developing new computational methods to discover the genetic basis of adaptive traits (e.g. in polar mammals) using population genetics. *Bidartondo* (based at Kew) studies the ecology and evolution

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of mycorrhizas. *Vogler* (joint appointment with the Natural History Museum) has developed metagenomic shotgun sequencing of entire complex communities in bulk for the analysis of species richness and phylogeny. Environmental DNA technology (impact case study) is used by *Savolainen*, *Vogler*, *Woodward*, *Bell* and *Ransome* to monitor endangered and invasive species, as well as entire species communities, in environmental samples. *Savolainen* currently leads a NERC COVID-19 project to monitor sewage samples for the early detection of SARS-CoV-2 outbreaks and potential wildlife reservoirs (several academic and government partners).

Evolution, ecology and the environment are at the heart of the **Grand Challenges in Ecosystems and the Environment** (GCEE, soon to become the Georgina Mace Centre for the Living Planet) initiative led by *Savolainen*. Since its launch in October 2013, GCEE has served as a hub for addressing global environmental challenges in a truly transdisciplinary fashion, bringing together researchers from across Imperial: DoLS, Centre for Environmental Policy, School of Public Health, Civil and Environmental Engineering, Grantham Institute for Climate Change and the Environment.

The **Glycobiology** group aims to understand the essential functions of carbohydrates in biological systems, with an emphasis on human physiology and disease in order to improve lifelong health. *Dell*, *Haslam* and *Morris* are world leaders in mass spectrometry-based structural glycomics and glycoproteomics. They collaborate widely on the roles of glycans in human reproduction (£4M March of Dimes European Preterm Birth Research Centre at Imperial) and in infection and immunity (£4.1M GCRF establishment of biopharmaceutical and animal vaccine production capacity in Thailand and neighbouring South East Asian countries, led by the University of Kent). Also in partnership with Kent, they received BBSRC COVID-19 funding to characterise SARS-CoV-2 protein antigens for diagnostic purposes. *Drickamer* and *Taylor* focus on carbohydrate binding proteins in the immune system, combining detailed structure-function studies with discovery tool development, e.g. mammalian lectin arrays for screening host-microbe interactions (collaboration with the Royal Veterinary College). *Hohenester* uses structural biology to study glycans of the extracellular matrix; his structure of a minimal laminin-dystroglycan complex is the culmination of 20 years of Wellcome-funded research into cell-matrix adhesion complexes.

The **Infection and Immunity** group aims to define mechanisms of host immunity and host-pathogen interactions in order to reduce the burden of infectious diseases. A major activity in this theme is research on malaria, described in a separate paragraph below. The remainder of the group focus on the human adaptive immune system, innate immunity, and eukaryotic pathogens. *Ono* developed a novel tool for analysing temporal dynamics of T cell differentiation and activation *in vivo*, and is using this to define T cell reactivity to SARS-CoV-2 proteins with a view to second-generation vaccine development. *Brady* carried out foundational research on transcription factors involved in natural killer cell development, which has led to a spin-out company for NK cell immunotherapy (NK:IO, £1M start-up funding). *Dionne* (Wellcome IA) uses fruit flies to study the systemic effects of bacterial infection, in particular the connection between immunity and metabolic regulation. *Rudenko* (Wellcome Senior Research Fellow) and *Tiengwe* (Sir Henry Dale Fellow) study African trypanosomes, focusing on the mechanisms underlying immune evasion and iron homeostasis, respectively. *Child* is a Sir Henry Dale Fellow developing novel chemical biology tools to study redox signalling in the intracellular pathogens, *Toxoplasma* and *Plasmodium*. *Selkirk and Gounaris* investigate how nematode parasites manipulate the host immune system to their advantage. *Dallman* is studying mechanisms of inflammation using a zebrafish model system (£550k from Boehringer Ingelheim). *Fisher* (Faculty of Medicine) is studying emerging fungal diseases, in



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*particular chytridiomycosis, which is causing dramatic population declines of amphibians (impact case study).*

Malaria research has gone from strength to strength, establishing DoLS as a world-leading centre in both basic and applied fields. DoLS investigators have led and been part of several very large international consortia (total funding of over £70M awarded to DoLS over the REF period, with the majority from US sources: Bill and Melinda Gates Foundation, Open Philanthropy, Foundation for the National Institutes of Health). *Burt* and *Crisanti* lead Target Malaria (renewed in 2020 for another five years); *Christophides* (Wellcome IA) and *Windbichler* lead Transmission Zero (renewed in 2020 for another three years). Both consortia are developing genetically modified *Anopheles* mosquitoes (gene drives) to control malaria transmission. Ground-breaking foundational research (e.g. Nature Biotechnology 2016, over 800 citations) is combined with a truly international outlook, with collaborations established in disease-endemic countries in Africa, Asia, and South America. Collaborations include a strong component of capacity building (e.g. containerised CL3 laboratory in Tanzania) and knowledge transfer. The other strand of malaria research concerns the parasite, *Plasmodium*. *Baum* is investigating the complex cell biology of this unicellular parasite, especially its mechanism of host cell invasion, with a strong translational focus on drug and vaccine development (with GlaxoSmithKline, Wellcome Healthcare Innovator Award).

The **Integrative Systems Biology and Bioinformatics** group develops and applies mathematical, statistical and computational approaches to answer fundamental questions in biology. The research is characterised by the fertile interplay between theoreticians and experimentalists, conducted under the umbrella of the **Centre for Integrative Systems Biology and Bioinformatics** (Director: *Sternberg*). *Sternberg* has developed and disseminated the freely available PHYRE protein structure prediction server, which is used by over 100,000 distinct users each year, including approximately 500 registered commercial users (impact case study). The collaboration of *Endres* with Brian Stramer (King's College London) has led to a new view of cell migration based on intracellular actin flows. *Isalan* and *Stumpf* explored computationally the ways in which Turing patterns (e.g. leopard spots) are generated, defining the design rules of the underlying networks. Our capabilities in systems biology have been strengthened considerably by two recent appointments: *Babtie* (a former BBSRC Future Leader Fellow) is developing methods to quantify the impact of uncertainty in mathematical models of biological systems, and *Perez-Carrasco* is using stochastic dynamical system theory and Bayesian inference to understand how dynamics and precision during embryogenesis are controlled by underlying gene regulatory mechanisms.

The **Membrane Biology** group, a major constituent of the cross-faculty **Centre for Structural Biology** (Director: *Meier*), elucidates the structure and function of integral membrane proteins in order to understand human and microbial biology. The group makes extensive use of the Diamond Light Source (X-ray crystallography) and eBIC (cryo-electron microscopy), with *Beis* strategically located at the Research Complex at Harwell. Group members also participate in LonCEM, an Imperial-led consortium sharing a Wellcome-funded (£3M) Krios cryo-electron microscope at the Francis Crick Institute. *Meier* (Wellcome IA) determined structures of dimeric ATP synthases that explain the origin of membrane curvature in mitochondrial cristae. *Rouse*, a new UKRI Future Leaders Fellow, employs advanced computational methods to study cardiolipin signalling in mitochondria. *Bubeck* defined the mechanism of pore formation by the complement membrane attack complex and now focuses on the regulation of this important immune effector (current ERC Consolidator Grant). *Byrne* determined the crystal structure of a eukaryotic purine symporter and defined the roles of membrane lipids for structure and function. *Matthews* and *Beis* determined structures of bacterial transporters, defining mechanisms of biofilm formation and intermicrobial

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warfare. In 2020, *Meier* led a successful application for a Glacios microscope to modernise the long-established electron microscopy facility at South Kensington (£1M Wellcome funding, £600k Imperial contribution).

The **Molecular Mechanisms of Disease** group, another major constituent of the Centre for Structural Biology, is using structural and biochemical techniques in order to understand the molecular mechanisms of neurodegenerative diseases and cancer. *De Simone* has pioneered solid-state and solution NMR methods to show how  $\alpha$ -synuclein perturbs biological membranes and causes neurotoxicity in Parkinson's disease. *Ali* was awarded a £1.9M CRUK Senior Cancer Research Fellowship to investigate the mechanism of the unfolded protein response and the role of ER stress in cancer; his rigorous biochemical dissection of UPR sensors is unique in the field. *Curry* investigates the replication strategies of RNA viruses, focusing on translation initiation in norovirus. *Guerra* used preclinical disease models to define the role of natural killer cell receptors in hepatocellular carcinoma. *Mann* developed a new method for screening cysteine-reactive small molecules and discovered covalent fragments that target the clinically important cell cycle regulator Cdk2 (collaboration with the Department of Chemistry, spin-out company Onefour Discovery). He is currently applying this technology to develop inhibitors of the major protease of SARS-CoV-2.

The **Molecular Plant and Microbial Systems** group studies the molecular and cellular biology of plants and microorganisms in order to provide solutions to challenges in bioenergy and food security. *Rutherford* discovered that cyanobacterial chlorophyll *f* performs photochemistry at far-red wavelength, overturning the prevailing view that it is a light-harvesting pigment. He will be a major user of the new Pulse EPR Facility at the White City campus (£2.3M EPSRC funding). *Nixon* established that chlorophyll *f* is synthesised by a variant of photosystem II. His current efforts are directed at transferring long-wavelength photosynthesis into other species, including crop plants. Previous bioreactor innovations by *Nixon* launched two spin-out companies that produce plant extracts for the nutritional and cosmetic industry (impact case study). Biochemical and genetic approaches are complemented by a deep understanding of the evolution of photosynthesis (*Cardona*, new UKRI Future Leaders Fellow), cutting-edge ultrafast spectroscopy and serial femtosecond X-ray crystallography (*van Thor*), and structure determination of protein complexes involved in photosynthesis (*Murray*). A second distinct strand of this research group focuses on commercially important plant pathogens: *Blumeria graminis*, which causes barley powdery mildew (*Spanu* and *Cota*), and *Phytophthora infestans*, which causes potato blight (*Bozkurt*). *Turnbull*, *Sena* and *Song* study mechanisms of plant development.

The **Synthetic Biology** group is a major constituent of the **Centre for Synthetic Biology**, which was recently awarded a Centre for Doctoral Training in BioDesign Engineering (Director: *Baldwin*; £7M EPSRC funding; 70 researchers across Imperial, University of Manchester and UCL). Research is based on engineering all aspects of biology in order to make new bioproducts and develop new tools and therapies. *Baldwin* is applying machine learning and automated DNA assembly to biological systems engineering. *Weinzierl* is developing high-throughput methods for probing RNA polymerase function. *Isalan* built a directed evolution robot to engineer the smallest artificial dual genetic switch described to date: a 63-amino acid peptide. *Buck* and *Schumacher* are engineering nitrogen fixing bacteria to sustainably support crop plant growth (£4.6M BBSRC sLoLa grant). They developed an innovative proteomic method for this project, which they rapidly repurposed for the quantitation of SARS-CoV-2 proteins (BBSRC COVID-19 grant). *Jones* uses metabolic engineering to produce biofuels and high-value chemicals in bacteria (AromatEco spin-out). New recruit José Jimenez (joined after the REF census date) is adding expertise in resource allocation in bacterial

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populations, with applications in the bio-plastic economy. As a foundational technology, synthetic biology is also integral to other research priorities in DoLS, such as gene drive development (*Windbichler, Meccariello*) and photosynthesis research (*Murray*).

### Mechanisms for developing and sustaining excellence in research

We aspire to conduct research at the highest international level and maximise the societal and economic impact of our research. To realise this ambition, we place great value on fostering an inclusive and vibrant research culture, unconstrained by traditional discipline boundaries. In this we are helped by the unique breadth of research interests within a single coherent department, ranging from molecules to cells to organisms to ecosystems. The DoLS Management Committee determines strategic priorities for academic appointments and the use of resources; it also sets the policies and operational procedures to implement our research vision. Recruitment of staff and research infrastructure are detailed in Sections 2 and 3, respectively. The Research Committee advises on research opportunities, helps develop our research infrastructure, and supports academic staff and research fellows in writing the most compelling funding bids. This is achieved through mentoring of early career researchers, workshops on grantsmanship for all staff, and internal review of grant proposals. A variety of internal or internally managed funding schemes exist to support new initiatives, such as the Faculty of Natural Sciences (FoNS) Strategic Fund which provides kick-start funding (up to £15k) for new collaborations and engagement with small and medium-sized enterprises and the Impact Acceleration Accounts of the Research Councils. FoNS recently established four strategic [FoNS research themes](#), mapping existing research excellence within the faculty onto UKRI priorities. Two of the themes are championed by DoLS academics, who receive financial support to organise thematic workshops and develop large funding proposals in their respective areas: Accelerating Biosciences (*Baldwin*) and Environment & Sustainability (*Woodward*).

The bi-weekly departmental seminar hosts national and international invited speakers, as well as internal speakers including PhD students and postdocs. Additional seminar series are organised by the Silwood Park community, the Imperial Centres led or co-led by DoLS (Structural Biology, Integrative Systems Biology and Bioinformatics, Neurotechnology, Synthetic Biology and Innovation), the MRC Centre for Molecular Bacteriology and Infection, the UK Dementia Research Institute, the Imperial Networks of Excellence in Malaria, Physics of Life, and Glycobiology, and the Agri Futures Lab. The annual DoLS Away Day allows staff to exchange ideas in an informal setting and brainstorm ideas for industry engagement and collaborative funding proposals. A monthly newsletter is used to celebrate success and inform on new initiatives in the department.

### Research strategy over the next five years

Our strategy is to sharpen the focus on a small number of priority areas, without losing the breadth of research topics that makes us unique. We intend to achieve this aim by: (i) becoming even better at exploiting synergies between our research themes; (ii) aligning the work done in the themes to the priority areas, wherever possible; (iii) strengthening our links with other departments at Imperial that can bring complementary skills to the priority areas. Over the next five years, we will focus on:

- Infectious diseases
- Synthetic biology solutions to real-world problems
- Innovative technologies in cell biology, immunology and neurobiology
- Applied ecology and agritech

**Infectious diseases:** In 2020, Imperial College formally approved the establishment of an **Institute of Infection**. The purpose of this new cross-faculty Institute is to foster and drive multidisciplinary

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research in infections and infectious diseases across Imperial. The establishment of the Institute will be overseen by Charles Bangham (Faculty of Medicine) and *Baum* (DoLS). The physical hub of the Institute will be on the South Kensington campus, in a building jointly occupied by Medicine and DoLS, and already equipped for high-containment (CL3) activities. The Institute of Infection will be a tremendous opportunity for many DoLS researchers to pursue even more ambitious goals and establish new collaborations with clinician scientists, chemists, mathematicians, and engineers. DoLS staff that will be affiliated with the Institute include microbiologists (*Bell, Clements, Dionne, Filloux, Frankel, Laurouy-Maumus, McDonald, Ransome, Williams*) and parasitologists (*Baum, Child, Christophides, Crisanti, Gounaris, Rudenko, Selkirk, Tiengwe*), as well as structural biologists studying pathogens, host-pathogen interactions, and immune responses to pathogens (*Beeby, Beis, Bubeck, Byrne, Costa, Cota, Matthews*). As the Institute of Infection takes concrete shape, we expect that others in DoLS will gravitate towards it, e.g. *Dell* and *Haslam*, who already collaborate with Imperial virologists on the essential role of glycans in host-pathogen interactions. SARS-CoV-2 will dominate the research landscape for years to come, and our expanding activities in this area will find a natural home in the Institute of Infection (e.g. quantitative proteomics and T cell reactivity of SARS-CoV-2 proteins, currently under UKRI-funded investigation by *Buck* and *Ono*, respectively).

Malaria research has become one of the most high-profile activities in DoLS. The aim of this research area is to develop potentially transformative interventions to control and eliminate malaria transmission in the most affected countries. In order to achieve this aim, we will continue to draw on the full expertise available in DoLS and the future Institute of Infection. We will carry out foundational work on malaria cell biology to develop the next generation of drugs, diagnostics, and vaccines (*Baum* and collaborators in the Departments of Chemistry and Bioengineering); develop novel genetic strategies both to suppress mosquito populations and to render them unable to transmit malaria (*Crisanti, Christophides, Windbichler*); develop the population modelling framework to guide product development and to predict field impact from lab observations (*Burt, Cator*); develop detailed risk assessments, engage with a wide diversity of stakeholders, and work with partners in Africa to build the capacity to assess and adopt new technologies (Target Malaria).

**Synthetic biology:** Synthetic Biology is the underpinning discipline for advances in the UK bioeconomy, in areas ranging from healthcare to biomaterials to sustainable energy. The Imperial Centre for Synthetic Biology, founded in 2018 and currently co-directed by *Baldwin* and Guy-Bart Stan (Department of Bioengineering), has served as the hub for our activities in this arena: gene circuit and network design (*Baldwin, Buck, Isalan*), microbial metabolic engineering (*Jones*), engineering cyanobacterial photosynthesis (*Murray, Nixon*), synthetic gene therapy of neurodegenerative diseases (*Isalan*), and genome engineering for synthetic sex ratio distorters and gene drives to control invasive species and agricultural pests (*Meccariello, Windbichler*). Our ambition over the next five years is to grow this research area and move further along the path from technology development to real-world applications. One of the areas identified for growth are sustainable solutions for the production of chemicals, fuel and food – already the focus of *Jones, Buck, Murray, Nixon* and *Windbichler*, and further strengthened by the recruitment of José Jimenez (joined after the REF census date), who brings expertise in developing a circular bio-plastic economy. The emphasis on sustainable energy and food systems will naturally lead to a convergence of our activities in synthetic biology, plant biology and ecology. Thus, this strategic priority unites two FoNS research themes: Accelerating Biosciences and Environment & Sustainability.

**Innovative technologies:** Most advances in the life sciences can be traced back to new or improved technologies, such as tools for gene editing, 3D cell culture, imaging, novel instrumentation and



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methods of data analysis. In keeping with the Imperial ethos, discovery research in DoLS embraces technology development in all its forms. *Franks* and *Wisden* combine cutting-edge mouse genetics with custom-built electroencephalogram recording devices; with Imperial engineers, they are developing a real-time closed-loop system for REM sleep deprivation in mice. *Brickley* collaborates with engineers in the Imperial Centre for Neurotechnology on multiphoton imaging of neuronal networks. *Gilestro* has built a low-cost open-source platform for behavioural studies of fruit flies that uses machine learning for pose estimation. *Lo Celso* has pioneered the intravital microscopy of bone marrow, using customised and prototype microscopes. *Bozkurt*, in collaboration with Imperial bioengineers, has developed a biosensor that allows the multiplexed monitoring of plant cell death. *Ono* and *Southall* have developed novel genetic methods to study cell development in the nervous and immune system. *Baum*, *Brady*, *Byrne*, *Cota*, *Hohenester* and *Mann* are collaborating with Imperial chemists to develop novel research tools and inhibitors with therapeutic potential. Over the next five years, we aim to intensify our interactions with Imperial scientists and engineers, in order to harness the full potential of our research in the core disciplines of cell biology, immunology, and neurobiology, and will use our leadership of relevant FoNS research themes, Imperial Centres of Excellence, and CDTs to realise this ambition.

**Applied ecology:** Silwood Park is globally renowned as one of the birthplaces of modern ecology and aspires to maintain its reputation as the premier site for ecological experiments in the UK. Silwood Park's 100 ha of natural parkland and freshwater habitats are used extensively as a testing ground for long-term, large-scale ecological experiments. Current landmark experiments include an extensive array of over 200 experimental ponds, a 30 years-running terrestrial experiment comprising over 1000 treated plots, and the long-term monitoring of birds, trees, and other wildlife. The campus acts as a hub for ecological field experiments in the London area, with academic staff affiliated with the Royal Botanic Gardens, Kew (*Bidartondo*) and the Natural History Museum (*Abzhanov*, *Purvis*, *Vogler*), and close links to related institutes across London (British Ecological Society, Zoological Society of London). A key asset of Silwood is the proximity of the field site to world-class laboratories (see Section 3 for infrastructure investment over the REF period). The long-term vision is a campus oriented towards pure and applied ecology, where ecological research is conducted seamlessly at multiple scales, from miniature ecosystems in the laboratory up to whole-landscape manipulations that can span multiple years or even decades.

The unifying research objective at Silwood is to understand how ecosystems respond to perturbations: global warming (*Prentice*), pesticides (*Gill*) and other chemical pollutants (*Woodward*), deforestation (*Banks-Leite*, *Ewers*), and agricultural intensification (*Waring*). Silwood academics tackle this objective using a wide array of approaches: field and laboratory experiments on campus (*Bell*, *Ransome*, *Schroeder*, *Waring*, *Woodward*), experimental forest fragmentation in Southeast Asia (*Ewers*), exploiting natural experiments in Brazil (*Banks-Leite*) and Iceland (*Woodward*), and developing novel models of how ecosystems respond to perturbations (*Pawar*, *Pearse*, *Rosindell*). Future areas we have identified for capacity-building include developing “nature-based solutions” to help meet zero pollution targets, reduce carbon emissions and to build more resilient and sustainable food systems. Activities on sustainable palm agricultures are already underway in Africa (*Savolainen*), in collaboration with the Centre for Environmental Policy and funded by GCRF. These ambitions are perfectly aligned with the FoNS research theme, Environment & Sustainability.

## Impact strategy

In line with the very wide range of research interests in DoLS, our impact strategy values diversity: we believe that a blend of curiosity-driven research, technology development, and applied research is the most fertile ground for generating impact. Our impact case studies reflect this philosophy: one

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case is rooted firmly in discovery science (*Franks*), others began as technological innovations emanating from research into fundamental biological questions (*Nixon, Savolainen*), whereas the majority of cases incorporated impact explicitly from inception (*Banks-Leite, Fisher, Rosindell, Sternberg*). Impact activities are recognised in DoLS' annual Pay Relativity exercise. The COVID-19 pandemic triggered a large pool of latent impact in DoLS, driven by a desire to respond usefully to a grave global challenge. Moving with agility, staff repurposed existing UKRI grants (*Ono*) or technologies (BBSRC COVID-19 grant to *Buck*) and formed alliances to deploy skills in new ways: *Pearse* and *Savolainen* were awarded NERC COVID-19 grants, in part for the development of sewage sampling to detect infections in our halls of residence; *Crisanti*, while on secondment to the University of Padova, initiated and led the testing of asymptomatic people in Veneto province. We aim to keep this spirit alive for the future. Indeed, impact is the thread running through our research strategy for the next five years and beyond. In promoting translation and generating impact, DoLS benefits from having an experienced Enterprise Champion (*Baldwin*) and strong ties with Imperial's Industry Partnerships and Commercialisation (IPC) office. Recent engagement with IPC helped launch the NK:IO start-up of *Brady* and Matthew Fuchter (Department of Chemistry), the Onefour Discovery start-up of *Mann* with Alan Armstrong (Department of Chemistry), and assisted Marine Valton (a PhD student of *Jones*) in winning a Royal Society of Edinburgh Enterprise Fellowship to develop sustainable fertilisers (BIO-F spin-out).

<b>2. People</b>
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**Staffing strategy and staff development**

Our aim is to employ the best scientists and provide them with the support they need to develop research programmes of the highest international quality. Academic staff are recruited only when it is felt that their research complements existing activities and that they will develop to their full potential in DoLS. Strategic decisions on recruitment are made by the Management Committee in consultation with the Research Committee. Succession planning is an important element of our annual departmental planning round, and is informed by demographics, anticipated retirements, research strategy and teaching requirements. Our recent rounds of academic recruitment have resulted in a number of junior appointments in strategic areas: theoretical systems biology (*Babtie* and *Perez-Carrasco*, replacing *Stumpf*), synthetic biology (José Jimenez, joined after the REF census date), antimicrobial resistance and the gut microbiome (*McDonald*), biodiversity and conservation (*Pearse*), biogeochemistry and soil ecology (*Waring*, joint appointment with the Grantham Institute for Climate Change), and marine biodiversity (*Ransome*, a former postdoc in DoLS).

DoLS hosted 21 research fellows during the REF period, including UKRI Future Leaders Fellows, NERC Independent Research Fellows, Royal Society University Research Fellows, Sir Henry Dale Fellows, a Wellcome Senior Research Fellow, and a CRUK Senior Cancer Research Fellow (see Section 4 for a full list with names). Fellow applications are selected for departmental support using a robust internal process (see EDI section below). A key consideration is whether fellows will thrive in the department, with alignment to established research strengths being as important as scientific excellence of the candidate. Research fellows are almost exclusively research-focused and are given the same support as permanent academic staff to successfully establish their research groups (space, administrative support, access to PhD and Masters project students). They can undertake limited teaching duties in order to prepare them for the next step in their career, with support from the Directors of Undergraduate and Postgraduate Studies.

## Unit-level environment template (REF5b)

### Development and support for early career researchers

**New academic staff:** New lecturers are appointed for a three-year probationary period and are assigned an academic mentor, a senior member of staff who provides guidance on preparation of research grant applications, management of research projects, and good teaching practice. The academic mentor meets regularly with the new lecturer and prepares a report for their line manager and the HoD at each review stage. Progress is assessed formally at a mid-probation review (fifth term of service) and a final review in the penultimate term. Review panels consist of the HoD, the line manager, the academic mentor, and additional academic staff from a relevant research area. New lecturers are assigned no substantive administrative duties and a reduced teaching load during their first three years of appointment to enable them to secure funding and establish a strong research programme. The teaching load is not prescribed but is generally in the range of eight lectures plus associated tutorials in the first year, incrementing annually. New lecturers must complete a Learning and Teaching Programme, including a course on research student supervision, normally within the first two years of appointment. The Research Committee organises internal grant review and mock interviews for applicants for ERC Starting Grants and Wellcome Investigator Awards, and the successful applications of Lecturers (*Barkoulas, Southall*) for these prestigious grants attests to the effectiveness of this support.

**Research fellows:** Research fellows are also assigned an academic mentor, who is usually their fellowship sponsor and therefore familiar with their research programme. Imperial's sector-leading Postdoc and Fellows Development Centre (PFDC) provides courses and support tailored to the specific requirements of research fellows. We place particular emphasis on supporting the progression of fellows, either to more senior fellowships or to academic appointments. *Ali* progressed from a CRUK Career Development Fellowship to a CRUK Senior Cancer Research Fellowship in 2016, and now holds a proleptic academic appointment in DoLS. *Song* is Royal Society University Research Fellow and also holds a proleptic academic appointment. *Babtie* is a former BBSRC Discovery Fellow, *Bell* is a former Royal Society University Research Fellow, and *Rosindell* is a former NERC Independent Research Fellow. Other former fellows have taken up academic positions in different departments at Imperial (Harry Low) and elsewhere (Eoin O'Gorman, University of Essex), demonstrating the success of our approach in both selecting and supporting our research fellows.

**Postdoctoral researchers:** DoLS had 131 postdocs (5% approved for working part-time) on the REF census date. Postdoc contracts specify ten days of skills training per year. Contract length is aligned with grant funding. Only in exceptional cases, requiring HoD approval, are shorter term contracts permitted. Tailored training, including support for a wide range of career pathways, is provided by the PFDC. The DoLS Postdoc Champion (*Endres*) liaises with the PFDC to ensure that their activities are informed by the views of our postdocs. During the REF period, the PFDC provided 135 one-to-one coaching sessions for early career researchers (62% women) and 31 mock interviews (50% female candidates). A total of 157 DoLS members attended PFDC courses, including residential courses lasting several days. DoLS has its own PostDoc Committee (PDC), which receives financial and administrative support from the department to organise careers and networking events, and to invite external speakers. The PDC organises an annual Proof of Concept competition, which allows postdocs to apply for modest departmental funding to pursue their own research ideas, using their supervisors' laboratory space/equipment. All postdocs are invited to staff meetings, and there is a standing agenda item for postdoctoral affairs. In 2020 alone, five of our postdocs (4 women, 1 man) progressed to independence within DoLS: *Meccariello* and *Cavan* to

## Unit-level environment template (REF5b)

four-year Imperial College Research Fellowships; *Rouse* and *Cardona* to UKRI Future Leaders Fellowships; and *Ransome* was appointed as a Lecturer.

### Development and support for established academic staff

All members of academic staff submit an annual Progress Review and Development Plan, which is developed in consultation with their line manager (typically a senior academic working in the same or in a closely related research area) who provides advice on publications, grant applications, teaching, gaining external recognition, and promotions. Peer review is offered for all grant applications by established academic staff prior to submission. The HoD has annual one-to-one meetings with academic staff and independent fellows to review their Academic Performance Profiles. This includes discussion of teaching, research and administrative workload metrics that are captured in the Profiles. Other topics covered include safety leadership, PhD mentoring, and how their postdocs are supported and encouraged to take their Concordat training entitlement. The primary aim of these meetings is to provide support and guidance for meeting departmental expectations for citizenship and achievement.

**Promotions:** All non-Professorial members of academic staff are requested to submit their CVs for discussion at one of the two DoLS promotions committee meetings held annually. Committees are chaired by the HoD, with one committee overseeing recommendations for promotion to Senior Lecturer, Reader or Senior Research Fellow, and a second committee overseeing recommendations for promotion to Professor or Principal Research Fellow. Line managers provide short reports on the progress of individual members and a recommendation whether the department should support promotion. Two committee members orally present the case for each member of staff, based on their assessment of the CV and line manager's report. The case is then discussed by the committee, before a decision on departmental support is made. Even if a member of staff does not seek promotion in a given year, one-to-one feedback is provided on how their case could be strengthened in future. We have found this to be an extremely robust process, with all applications from DoLS being successful in the last three promotion rounds. During the REF period, 23 were promoted to Senior Lecturer (7 women, 16 men), 10 to Reader (1 woman, 9 men), 18 to Professor (3 women, 15 men), and two men were promoted to Senior Research Fellow.

We regularly support staff in applications for Royal Society Wolfson Research Merit Awards. There have been two recipients of these during the REF period. We select staff, encourage them to apply, and review their applications. We also encourage staff to apply for more senior fellowships and support candidates with internal peer review of their applications and with mock interviews. Sabbatical leave is encouraged and awarded up to a maximum of three terms after six years of service, contingent upon a coherent plan for research and staff development. During the REF period, eight staff have taken sabbatical leave. The department also encourages and supports unpaid secondments for academic and personal refreshment. During 2020, *Crisanti's* secondment to the University of Padova enabled the rapid pivoting of his infection research from malaria to SARS-CoV-2. *De Simone's* current secondment to the University of Naples is allowing his young family to reconnect with their grandparents.

### Development and support for technical staff

There are 32 Research Technicians in DoLS, 5 working part-time at their request. All are represented at high-level committees by the departmental Technical Operations Manager, Allison Hunter (until recently Higher Education and Technician Educational Development regional network manager). As a founding signatory of the Technician Commitment, Imperial is offering bespoke training and



## Unit-level environment template (REF5b)

development courses for technicians, ranging from safety to leadership and supervision (51 courses taken by DoLS technicians since 2017). All DoLS technicians are invited to attend termly technician meetings, which have both internal and external speakers (e.g. Science Council) and provide updates on regional and national events. Matters raised by technicians that merit departmental attention are escalated to the Management Committee via Hunter. There is a standing agenda item for technician affairs at the Departmental Staff meeting. Eight technicians have received HoD Citizenship Awards in the past 3 years, and the recipients were celebrated with biographical profiles in the DoLS Newsletter. DoLS supports the career progression of technicians by promoting professional registration (5 technicians registered) and attendance at external workshops. As a direct consequence of these initiatives, 3 research technicians were recently appointed to a laboratory technical manager role. Finally, research technicians are encouraged to contribute to The Science Museum's Technicians Gallery, which hopes to inspire young people to consider a future career path as a technician.

### Research students

**Recruitment and selection:** To attract the best-qualified candidates, we advertise on the Imperial College website and on FindAPhD.com. In the last five years, DoLS received an average of 335 applications per year (~32% from overseas) and admitted 313 PhD students over the REF period. All candidates must have at least a good 2:1 BSc degree and normally also a Masters degree; candidates with substantial research experience (one year or more) may be accepted without a Masters. Shortlisting is carried out by prospective supervisors and members of the departmental Postgraduate Education Committee. Interviewing is carried out by at least two members of academic staff, who make recommendations to the Director of Postgraduate Studies in writing. Our MRes programmes are also a route for PhD entry, with 27% of students entering PhD studies in 2019 on 1+3 year doctoral training programmes. DoLS currently holds a BBSRC Doctoral Training Partnership (DTP) (2015-2023, £10M including linked iCASE awards), a NERC Centre for Doctoral Training (CDT) on Quantitative and Modelling Skills in Ecology and Evolution (2017-2023, £2.2M), and an EPSRC CDT in BioDesign Engineering (2019-2027, £7M). In addition, we were funded by the Wellcome Trust for four-year PhD programmes in Theoretical Systems Biology and Bioinformatics (2017-2023, £2.4M) and Molecular and Cellular Basis of Infection (jointly with the Faculty of Medicine, 2014-2018, £4.1M). Additional studentships are provided by the Institutional MRC, NERC and EPSRC DTPs, the FoNS Schrödinger Scholarship Scheme, joint funding from Imperial and the Chinese Scholarship Council, and the Imperial President's Scholarship scheme. Research Councils provided support for 169 awards as follows: BBSRC (81) NERC (52), MRC (27), and EPSRC (9). Other studentships were provided by the Wellcome Trust (11), other UK charities (28), other UK scholarships (4), overseas government scholarships (29), overseas non-government studentships (3), Imperial College studentships (23), departmental bursaries (24). 22 PhD students were self-funded. Finally, DoLS received 13 CASE awards supported by various BBSRC modes with industrial partners including Bayer, Boehringer Ingelheim, Eli Lilly, GlaxoSmithKline, Illumina Cambridge, and Syngenta.

**Training, support and development:** DoLS provides PhD students with training in the following areas: (i) discipline-specific research methods, to equip students to undertake their research projects efficiently; (ii) use of information technology to search for, process, and present information; (iii) written, graphical and oral communication of their research to different interest groups. Being embedded in a department that is research-active across the full spectrum of life sciences, our PhD students are exposed to a wide range of research areas. They attend biweekly departmental seminars, as well as the annual Open Days organised by the Imperial Centres. Most of our PhD

## Unit-level environment template (REF5b)

students have two supervisors and all our students have a Progress Review Panel (PRP) comprising two academic staff other than the supervisors. The PRP provides academic and pastoral support, and is responsible for ensuring that students progress successfully. Formal oversight by the PRP consists of an Early Stage Assessment at 7-9 months after registration and a Late Stage Assessment at 18-24 months. At departmental level, pastoral support is provided by two Postgraduate Tutors, who also act as Disabilities Liaison Officers, working closely with the Director of Postgraduate Studies; at least one of these posts is always occupied by a woman. Cohort activities are overseen by our Cohort Building Leader (*Bozkurt*). Additional support comes from the College Tutors, the Health Centre, the Student Counselling Service, and the Student Union Welfare Office. Postgraduate student representatives are members of all relevant departmental committees. DoLS organises social events throughout the year to facilitate networking and cohort building. We also organise and fund Research Days for all second and third year PhD students, at which they present their research to their peers and academic staff using posters (second year) and oral presentations (third year). DoLS presents awards for best posters and presentations, and additional awards for excellence in science communication. The top-ranked students are selected for presentations at the annual FoNS Research Showcase event. Students access other forms of professional skills training primarily through our award-winning Graduate School and Careers Service. Over the REF period, our PhD students took part in 1,234 training sessions organised by the Graduate School. DoLS scored above the Russell Group benchmarking for PhD student wellbeing in the most recent Postgraduate Research Experience Survey.

## Equality and diversity

Imperial's Equality, Diversity and Inclusion (EDI) strategy for staff and students is led by DoLS member *Curry*, who in 2017 was seconded (70%) to the new role of Assistant Provost for EDI. DoLS has an established EDI Committee with representatives from every part of the department. EDI is a standing agenda item at DoLS staff meetings and at management committee meetings. We hold an Athena SWAN Bronze Award, which was renewed in 2019. We chose not to apply for a Silver Award because we needed more time to address the gender imbalance of our academic staff. We recruited 4 female staff in 2020 (see below) and will be applying for a Silver Award next time. To support equality in recruitment and at work, DoLS mandates participation in the College's recruitment training programme and ensures a high uptake of unconscious bias and bullying and harassment training. Despite these efforts, instances of unacceptable behaviour do occur and are dealt with seriously. Staff are encouraged to speak up anonymously via the FoNS ["Have Your Say"](#) hotline or via the DoLS Online Suggestion Box (link advertised in the monthly DoLS newsletter to all staff). On average, 1-2 staff each year have been required to attend training courses or undertake mentoring/coaching following a formal investigation. From 2017, DoLS has taken active steps to increase the diversity of departmental seminar speakers: since then, 39% of speakers have been women; and 4% have been Asian, 6% Chinese, and 2% Black.

**EDI with respect to staff recruitment:** Academic staff recruitment is closely monitored for adherence with the department's EDI policy. The wording of all advertisements is checked and edited by the EDI Committee to ensure that it is as inclusive as possible, and we actively encourage applications from under-represented groups. 14 academic staff (3 women, 11 men) were appointed prior to the strict implementation of this policy in 2018. Our most recent recruitment campaign for junior academics (Lecturer/Senior Lecturer) in 2019-2020 attracted 389 applicants, comprising 135 women (35%), 247 men and 9 individuals who preferred not to provide a gender. 65% of applicants were White, 10% Asian, 5% Chinese, 4% Mixed, 2% Black, and 14% preferred not to provide their ethnicity. The shortlisting panels for each individual post were composed of experts in the respective

**Unit-level environment template (REF5b)**

research area, with at least one female member of staff on each panel. Parity across the panels was ensured by the Chair of the Academic Appointments Committee (*Byrne*) who assessed all applications. Final shortlists were compiled by the chairs of the individual shortlisting panels, *Byrne* and the HoD, and included 16 women (37%) and 27 men. Of these, 2 declared a disability and, where requested, modifications were made to the interview process to accommodate any special requirements. The interview panels were gender-balanced and parity was ensured by the HoD, *Byrne* and a College Consul being present at all interviews. Following interview, we appointed a total of 7 new academic staff (all White), comprising 4 women (57%) and 3 men (including José Jimenez who joined after the REF census date). During the REF period, we supported a total of 66 independent fellowship applications (32 women and 34 men). Of these, 21 (10 women and 11 men) were successful and took up their fellowships in DoLS. One of the fellows is Asian British, one is Black African, and one is Chinese, with the remainder being White. Two of our BAME fellows hold proleptic lectureships, but we recognise that much more needs to be done to increase diversity among all staff groups. To this end, we have recently established a high-level Culture Committee tasked with finding solutions to this vitally important issue.

**EDI with respect to REF2021:** Each member of staff was asked to submit five outputs, and the final selection was made by a panel consisting of the HoD (*Dell*), a Deputy HoD (*Woodward*), the Director of Research (*Hohenester*), and a former HoD (*Selkirk*). Close attention was paid to achieving a representative set of outputs in terms of staff seniority (49% of our outputs are by Professors who make up 41% of submitted staff) and gender (19% of our outputs are by women who make up 22% of submitted staff). Impact case studies are led by staff at all levels of seniority (22% Senior Lecturer, 11% Reader, 67% Professor) and 22% are women. The data for Section 4 (contribution to the research base, economy and society) were gathered in a structured questionnaire sent out to all staff. The 100% return rate of the questionnaire ensured inclusion of all activities considered important by our staff.

**Maternity/paternity/adoption support:** The Elsie Widdowson Fellowship Award is a highly successful College scheme, designed to allow academics returning from maternity, shared parental, or adoption leave to concentrate fully on research. The award provides funding for 50% of salary costs for one year and is used to relieve the returning academic of any teaching or administrative duties. Ten awards were made in DoLS during the REF period (7 women for 12 months, 1 woman for 8 months, 2 men for 4 months).

**EDI with respect to research students:** Applicants are requested to provide demographic details when they apply for a studentship. Overall, Imperial College has approximately equal numbers of male and female PhD students and this is broadly reflected in the distribution of our last three BBSRC DTP cohorts (25 women and 33 men). We endeavour to accommodate requests for flexible working by PhD students where, for example, it is necessary to leave the lab at certain times of the day or early on a particular day for religious observance. Imperial College has on-site prayer rooms to facilitate these observances. We support flexible working hours for students, where possible allowing late start or early finish times. Regarding maternity, paternity, shared parental, adoption and illness leave, DoLS follows national guidelines and the student is on interruption of studies while on leave. Full support and advice are available to such students, and the studentship is extended accordingly, so that their progression is not affected. A total of 38 PhD students (20 women and 18 men) took interruption of studies during the REF period: 6 for maternity and shared parental leave, 25 for health and personal reasons, and 7 for other reasons. In order to encourage applications for research degrees from a wider pool of graduates, DoLS established a Research Experience Placement

## Unit-level environment template (REF5b)

scheme (six-week paid internships) for students from non-Russell group universities in the London area. The scheme received great interest when it was launched in January 2020, but the COVID-19 pandemic prevented us from accepting any interns this year. In addition, DoLS is also funding three widening participation studentships. To help candidates prepare for both the application and interview process for these studentships, the department ran a virtual Q&A session, which was recorded and the recording made available to attendees and candidates who could not make the date. Out of a total of 85 applications, we selected 3 BAME students from disadvantaged backgrounds (2 women and 1 man), all of whom started their PhD research in 2020. In another effort to fuel the pipeline, DoLS has negotiated two generous Masters scholarships from DeepMind to support BAME UK students in Bioinformatics or Systems Biology.

### 3. Income, infrastructure and facilities

#### Research income

Over the REF period, DoLS was awarded a **total of £178.5M in funding**: £55.0M from UK Research Councils, £36.4M from UK charities, £63.0M from non-UK charities (mostly Target Malaria), £14.6M from the EU Commission, £1.8M from industry partners (Boehringer Ingelheim, Oxford Nanopore Technology, Falkathing, Janssen), and £7.7M from other sources. Highlights in the major categories are given below.

**UK Research Councils:** *Buck* (Principal Investigator, PI) with *Jones* and *Stumpf* were awarded a BBSRC Strategic Longer and Larger Grant to engineer bacterial nitrogen metabolism (£4.6M). *Woodward* led a £3.7M NERC Large Grant investigating the effects of global warming on sentinel systems (£1.8M to DoLS) and currently leads a £2.5M NERC Emerging Risks of Chemicals in the Environment programme (£1.4M to DoLS). *Frankel* was awarded a MRC Programme Grant (£1.9M) to investigate host responses to bacterial infection. *Wisden* is a PI of the MRC-led UK Dementia Research Institute (£1.3M to DoLS). DoLS led successful applications for a BBSRC Doctoral Training Partnership (£10M) and two Centres for Doctoral Training (EPSRC, £7M; NERC, £2.2M).

**UK charities:** A total of nine DoLS staff (*Barkoulas*, *Dionne*, *Frankel*, *Isalan*, *Lo Celso*, *Meier*, *Southall*, *Wisden* and *Franks* – jointly) were awarded Wellcome Investigator Awards, totalling £11.8M. *Rudenko* was awarded a Wellcome Senior Research Fellowship (£1.7M). *Ali* was awarded a Cancer Research UK Senior Research Fellowship (£1.9M). *Prentice* is Director of the Leverhulme Centre for Wildfires, Environment and Society (established in 2019, £5.6M to DoLS).

**Non-UK charities:** *Burt* has been PI of several very large Target Malaria consortia grants: Phase I, 2016-2020: \$37.5M; Phase II, 2020-2025, \$79M; Open Philanthropy support for Target Malaria, 2017-2022, \$17.5M. *Baum*, *Christophides*, *Crisanti* and *Windbichler* are PIs of projects worth \$13.4M funded by the Bill and Melinda Gates Foundation. Taken together, these activities have generated £63M of direct income to DoLS, with the remainder of the awards supporting substantial subprojects worldwide.

**EU Commission:** Three DoLS staff were awarded major European Research Council grants: Advanced Grant to *Prentice* (£2.3M), Consolidator Grant to *Bubeck* (£1.8M), Starting Grant to *Barkoulas* (£1.3M).

#### Space and infrastructure

DoLS occupies 12,451 m<sup>2</sup> of building space on the South Kensington campus and 3,850 m<sup>2</sup> at Silwood Park, with 71% of total space allocated to research. **Over the REF period, DoLS invested**



## Unit-level environment template (REF5b)

**£4.6M in refurbishing laboratories and building specialised facilities (£4.1M HEFCE contribution).** This included insectaries and plant growth rooms at South Kensington, as well as a large number of experimental ponds ([mesocosms](#)), an aviary, 10 new controlled environment rooms, and the Royal Society Wolfson Ecological Genomics Laboratory at Silwood Park. We ensure that all new and refurbished laboratories and facilities comply with Disability Discrimination Act access requirements. **Planned developments include a new insectary for Target Malaria (£3.3M, 351 m<sup>2</sup>) and a Growdome facility at Silwood Park (£2.2M).** Central Biomedical Services (CBS) is the animal housing unit used by DoLS researchers on the South Kensington campus. CBS has 80 rooms totalling 1,250 m<sup>2</sup> and has recently been refurbished at a cost of £9M to provide state-of-the-art facilities for animal husbandry, manipulation, surgery and training.

**Core facilities:** To remain at the forefront of international competition, we have continued to invest heavily in the core research facilities that support our multidisciplinary research portfolio. DoLS has a dedicated Infrastructure and Facilities Committee that advises on needs and opportunities. Over the REF period, **DoLS invested £9.9M in core facilities.** Major new equipment includes a Bruker Avance II 800 MHz NMR spectrometer (£2.1M), a ThermoFisher Glacios cryo-electron microscope (£1.6M), six light microscopes including a high-end automated live cell imaging system (£1.5M total), and five flow cytometry instruments (£1.3M total). We support these facilities with dedicated staff (9 full-time posts, 7 of which are HEFCE-funded) and rigorous management systems to ensure financial sustainability. The facilities are funded at a TRAC Full Economic Cost (FEC) in excess of £2.9M per annum. The facilities are bookable on-line and are available to all staff and students in DoLS, as well as to other Imperial departments and to external users (see table below for user numbers; examples of significant external partnerships are in Section 4).

Research facilities	FEC per annum	Total assets	Investment since 2013 (HEFCE contribution)	Research	
				Groups	Users
<a href="#">X-ray crystallography</a>	£224k	£730k	£171k (£22k)	26	40
<a href="#">Mass spectrometry</a>	£237k	£1.3M	£372k	34	68
<a href="#">NMR spectroscopy</a>	£520k	£3.0M	£2.2M (£300k)	21	52
<a href="#">Electron microscopy</a>	£630k	£3.0M	£1.9M (£600k)	41	89
<a href="#">FILM (light microscopy)</a>	£675k	£3.0M	£1.5M (£390k)	161	516
<a href="#">In vivo imaging</a>	£154k	£452k		10	39
<a href="#">Flow cytometry</a>	£508k	£1.8M	£1.3M (£710k)	85	255
Pulse EPR spectroscopy		£2.3M	£2.3M	New facility	

Outside of the core facilities, DoLS invested £662k to supplement £2.8M of external grant funding for research equipment, and contributed £462k towards LonCEM, an Imperial-led consortium for cryo-electron microscopy (total cost £5.7M; 280 m<sup>2</sup> dedicated space for a Krios microscope at the Francis Crick Institute). In 2016, DoLS received a loan of a £355k QTOF mass spectrometer from Agilent as part of a collaborative programme to advance proprietary technology in functional metabolomics (*Larrouy-Maumus*); the instrument was eventually purchased at a cost of £60k.

### Use of major research facilities in the UK and overseas

DoLS staff made extensive use of the **Diamond Light Source** (440 8-hour shifts over the REF period, 67 users). Experiments by the Imperial Block Allocation Group, which is led and managed by DoLS, resulted in 82 publications and 217 coordinate sets deposited in the Protein Data Bank. From 2018, DoLS staff also used a total of 219 6-hour shifts at Diamond's **Electron Bio-Imaging**

## Unit-level environment template (REF5b)

**Centre (eBIC)**, resulting in 4 publications. *van Thor* is one of the few UK researchers to have had continuous success at gaining access to **X-ray free electron lasers**: LCLS (Stanford, USA), SACLA (Spring8 Japan), PAL-XFEL (Korea) and Eu-XFEL (Germany). In total, he performed 9 complex experiments, each lasting 36-72 hours of beamtime.

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

#### Research collaborations, networks and partnerships

In keeping with the international outlook of Imperial and the emphasis on multidisciplinary research in DoLS is highly collaborative. Identifying opportunities for collaboration is an important part of the annual Progress Review and Development Plan, and our probation and promotions processes are designed not to disadvantage staff who choose to operate in collaborative teams rather than as a single PI. Of the submitted outputs with an Imperial affiliation, 49% are collaborations with other UK institutions, and 62% are collaborations with international institutions. Of the submitted staff, more than half (53) have held grants with external partners from 96 institutions in 22 countries, and 31.5% of all grants held in DoLS over the REF period have been collaborations with other departments at Imperial. Formal links with other institutions are actively encouraged: *Beeby*, *Bubeck* and *Lo Celso* have Satellite Groups at the Francis Crick Institute; *Beis* is located at the Research Complex at Harwell; *Bidartondo* is based at Kew; and *Abzhanov*, *Purvis* and *Vogler* have joint appointments with the Natural History Museum. In 2020, DoLS and STRUBI at the University of Oxford were selected as academic partners for a joint senior appointment in cryo-electron tomography at the Rosalind Franklin Institute (led by *Meier* for DoLS).

**Large research consortia:** DoLS academics provide leadership to a number of large international research consortia. Our flagship activities in malaria research (Target Malaria, Zero Transmission) are spearheaded by *Burt*, *Crisanti*, *Christophides*, *Baum* and *Windbichler*, who collectively have been PIs on grants worth £110M. About £45M of this total sum are subprojects involving international research partners, which have supported the building or renovation of three Containment Level 2 insectaries in West and East Africa, and training of ~100 African researchers on topics related to gene drive, vector control and biosafety. *Christophides* is a PI of VectorBase, a \$14.4M project funded by the US National Institute of Allergy and Infectious Diseases and the US National Institutes of Health. Our research in applied ecology has a similarly global scope, with Silwood academics providing leadership of two large international projects (SAFE, *Ewers*; PREDICTS, *Purvis*) and participating in GCRF projects (*Savolainen*, *Tobias*). *Woodward* has instigated and led two large NERC-funded projects with multiple UK partners (Queen Mary University of London, Essex, Leeds, Warwick, Bangor, Exeter). *Dell* and *Haslam*, as part of the GCRF consortium led by the University of Kent, are facilitating research capacity building for biopharmaceutical and animal vaccine production with Thai academic and industrial partners.

**Use of research infrastructure by external partners:** Research using the **mesocosm ponds** at Silwood involves global multinationals such as Unilever (BBSRC CASE studentships), as well as national regulatory and policy-making bodies (e.g. the Environment Agency, sponsored by the Department for Environment, Food & Rural Affairs). The mesocosms are also an integral part of wider international networks of "distributed experiments", including the €10M EU AQUACOSM project. Our **insectaries** have been heavily used by over 30 external collaborators over the period, e.g. for malaria vaccination studies (Jenner Institute, Kymab) and drug testing (University of Dundee, Monash University), as well as by the Target Malaria consortium (11 research centres in 7 countries).

## Unit-level environment template (REF5b)

The new **controlled environment rooms** at Silwood have enabled work on the effect of climate change on bees (Royal Veterinary College, Natural History Museum), mosquitoes (Pennsylvania State University, Stanford University), plants (Sainsbury Laboratory) and microbial systems (several UK universities). Our **plant growth facilities** have critically supported 12 external collaborations (e.g. Sainsbury Laboratory, James Hutton Institute, Nanjing University, Thompson Environment Consultants). Our **structural biology facilities** (X-ray crystallography, NMR spectroscopy, electron microscopy) have served over 100 external collaborations and users, both from academia (e.g. MIT, Harvard, Institut Pasteur) and industry (e.g. GlaxoSmithKline, Evotec, Apollo Therapeutics, Antikor). The **mass spectrometry facility** has an equally wide network of over 30 external partners, including the Animal & Plant Health Agency and Public Health England.

## Open science and research reproducibility

Open science practice has become firmly established in DoLS and promoted particularly by our junior staff. Preprint servers are embraced by staff at all levels, with over 200 manuscripts submitted to bioRxiv over the REF period (the majority since 2018). Aligning with the Concordat on Open Research Data, staff must, where possible, publish data, protocols and computer codes necessary to make their research reproducible. Software code is freely available through GitHub (*Baldwin, Brazeau, Ewers, Fumagalli, Gilestro, Pearse, Savolainen, Southall, van Thor, Windbichler*) and other platforms, e.g. the open source bioinformatics tools GlycoWorkbench and GlycanBuilder (*Haslam*) and CRISPR-TAPE (*Child*). Primary datasets have been deposited in Gene Expression Omnibus (*Ono*), ArrayExpress (*Isalan*), Dryad (*Bell, Burt, Graystock, Savolainen, Waring, Woodward*), Zenodo (*Ewers, Gilestro*) and Open Science Framework (*Banks-Leite*). Plasmids have been deposited in Addgene (*Isalan, Wisden*) and mouse lines at the Jackson Laboratory (*Wisden*). *Gilestro* published detailed building instructions for his Ethoscopes. *Pawar* manages the world's largest open metabolic traits database (Global Biotraits) and *Pearse* is a founding member of the Open Traits Network and of a coalition to release micro-climate datasets (SoilTemp). *Ewers* developed the SAFE Project with an open data policy, leading to the publication of 126 open access datasets to date, of which 76 are co-authored by DoLS staff ([zenodo.org/communities/safe/](https://zenodo.org/communities/safe/)) Together, these encompass >30 million data points and >5000 plant and animal taxa. In addition to data and code, we routinely archive physical samples wherever possible: for instance, our -80°C freezer suites house thousands of samples from across the world and all branches of the Tree of Life, which can be accessed if further validation of our published data is ever required. Field sites are also geospatially referenced so they can be resampled if needs be. DoLS staff have themselves replicated previous studies and published negative results, leading to major corrections of the scientific literature, e.g. [bdelloid rotifer evolution](#), [nitrogen fixation by \*Streptomyces thermoautotrophicus\*](#), and the [relative timings of flowering](#).

*Curry* has long advocated open science and related issues, such as research assessment reform. He used a platform in a national newspaper (The Guardian) to raise awareness about the value of preprints, both generally and in response to public health crises, and the importance of publishing negative results (2012-2018). He co-authored Research England's "The Metric Tide" report (2015), which critically examined the use of quantitative indicators in assessment. He has lectured widely on the issue, e.g. at meetings of Science Europe (2018), the American Association for the Advancement of Science (2019), and at the Howard Hughes Medical Institute, Washington, USA (2019). In 2016, in collaboration with academic publishers, he published a [preprint](#) (over 30,000 downloads) describing a methodology for generating the citation distributions from which journal impact factors (JIFs) are derived and calling on all journals to publish them as a way of mitigating misuse in research assessment. These distributions are now generated and made available annually to journals by Clarivate. In 2017, *Curry* was appointed chair of the DORA steering group. He created

## Unit-level environment template (REF5b)

an international advisory board and refashioned DORA as a campaigning organisation that is proactive about driving reform in research assessment and helping to develop the tools to do so ([Nature, 2018](#); [eLife, 2020](#)).

### Research integrity

As a signatory of the Concordat to Support Research Integrity, Imperial is committed to “maintaining the highest standards of rigour and integrity in all aspects of research” (see REF5a). The principles of the Universal Ethical Code for Scientists are adopted, ensuring research is conducted according to appropriate ethical, legal, and professional standards. The College’s Research Integrity Officer delivers research ethics and integrity awareness talks at DoLS staff meetings. Robust processes to deal with allegations of research misconduct are in place and DoLS actively promotes relevant training opportunities including research integrity and plagiarism. The latter is compulsory for all research students.

### Influencing and informing policy

*Windbichler* has been active in discussing and communicating the ethical and societal issues of gene drives. He has been a member of the BBSRC/UKRI working group on gene drives since 2018, and has lectured widely on the issue, e.g. as invited speaker at the UNESCO Chair on Bioethics, Vienna, Austria (2016), the Swiss Academy of Sciences (2017), and the German Ethics Council (2017). Other members of Target Malaria have provided written evidence (House of Lords) or verbal expertise (African Union, OECD). *Gill* made presentations in UK Parliament about the risk that pesticides pose to bees (2018) and about the use of molecular techniques to understand insect declines (2020). He also contributed to a Parliamentary Office for Science and Technology note on insect declines (2020). In 2020, *Rutherford* gave a talk on biofuels to a Royal Society policy meeting on the future of aviation, attended by representatives from BEIS and the aviation and fossil fuel industries; a policy document from the Royal Society for BEIS is in preparation.

### Engagement with diverse communities and publics

DoLS staff have had a regular presence at the annual Imperial Festival, the College’s flagship outreach event, which in 2019 became the Great Exhibition Road Festival in partnership with the Natural History Museum, the Science Museum, the V&A and other cultural institutions. DoLS staff at Silwood Park, as part of the GCEE initiative, have been organising the “Bugs, Birds and Beasts Day”, an annual science fair attended by over 400 people from local schools and communities. *Sternberg*, in collaboration with Goldsmiths, developed the BioBlox suite of computer games for schools based on protein docking. *Ransome* worked with 20 students from a local school on research projects to foster science engagement and critical thinking, for which they won the Royal Society best project award (Charter’s School STEM Partnership, 2016-2018). *Ono* co-produced a [dance performance](#) for 200 schoolchildren from London and Wales, in which professional dancers visualised how immune cells fight infections. *Baum* worked with London schoolchildren to test their families’ soup recipes for antimalarial properties; this project was widely covered in the UK press, as well as in the Hindustan Times (“Mum knows best”). *Gill* was advisor for a National Geographic grant to engage schools in monitoring insect pollinators ([xpollination.org](#)). *Banks-Leite* and *Pawar* worked with Twig Science for developing teaching materials for Primary and Secondary school level teaching materials in the US. *Banks-Leite* produced a NERC-commissioned video (NERC Impact Award) and an article for Planet Earth Magazine. *Leroi* presented the “Secret Science of Pop” on BBC4 in 2016. *Nixon* co-supervised the PhD work of Dr Marin Sawa at the intersection of design and science; Sawa exhibited her work at several national and international events ([algaeprinting.com/events-and-exhibitions](#)).



## Unit-level environment template (REF5b)

### Contributions to and recognition by the research base

**Journal editorship and refereeing:** Eleven DoLS staff have served as senior or executive editors of scientific journals, e.g. Journal of Applied Ecology (*Banks-Leite*), BMC Plant Biology (*Bozkurt*), FEMS Microbiology Reviews (*Filloux*), Biochimica Biophysica Acta – Proteins and Proteomics (*Matthews*), Systematic Biology (*Rosindell*) and Advances in Ecological Research (*Woodward*). An additional 26 DoLS staff have served on editorial boards, e.g. Journal of Biological Chemistry (*Filloux, Haslam, Nixon, Taylor*), Journal of Molecular Biology (*Sternberg*), Journal of Bacteriology (*Filloux*), Glycobiology (*Drickamer, Haslam, Taylor*), Matrix Biology (*Hohenester*), PLoS ONE (*Gilestro*), Molecular and Biochemical Parasitology (*Rudenko, Selkirk*), Proceedings of the Royal Society B (*Bidartondo*) and Functional Ecology (*Tobias*). All DoLS staff contribute to the research base anonymously by reviewing journal manuscripts and grant proposals.

**Participation on grants committees:** DoLS staff have served on many national and international grants committees, e.g. BBSRC Committee D (*Byrne* – Co-Chair 2015-2018); BBSRC pool members (*Baldwin, Dionne, Endres, Isalan*); MRC Neurosciences and Mental Health Board (*Wisden* – Deputy Chair 2016); MRC Infection and Immunity Board (*Filloux*); NERC Peer Review College (*Bell, Brazeau, Ewers, Gill, Pawar, Savolainen, Schroeder*); NERC Individual Research Fellowship Review Panel (*Rosindell*); Wellcome Multi-User Equipment Awards (*Hohenester* – Chair 2015); Wellcome Biomedical Resources Awards (*Dallman* – Chair 2014-2016); Wellcome Expert Review Group and Seed Awards (*Baum*); Wellcome Interview Committees (*Christophides, Rudenko, Southall*); CRUK Programme Awards Panel (*Lo Celso*); Royal Society (*Bell, Burt, Dell, Matthews, Savolainen*); ERC Starting Grants (*Curry*); Horizon 2020 (*Gilestro, Isalan, Schroeder*); Natural Sciences and Engineering Council of Canada Discovery Grants (*Bell* – Chair); Austrian Science Fund (*Curry* – Chair); Agence National de la Recherche, France (*Byrne, Filloux, Franks, Larrouy-Maumus*); INSERM (*Lo Celso*); German Research Foundation (*Lo Celso*); Research Foundation – Flanders, Belgium (*Filloux*); Foundation for Polish Science (*van Thor*).

**Membership of advisory boards and steering committees:** DoLS staff have served on a large number of boards, both nationally and internationally, e.g. BBSRC Council (*Dallman, Dell*); The Francis Crick Institute (*Dallman*); National Institute for Biological Standards and Control (*Dell*); National Physical Laboratory (*Dell*); Research Complex at Harwell (*Bubeck*); Astbury Centre for Structural Molecular Biology, Leeds (*Matthews*); ELIXIR UK (*Sternberg*); Max Planck Institute for Terrestrial Microbiology, Marburg, Germany (*Filloux*); Institut Cochin, Paris, France (*Filloux*); Tokyo Tech, Japan (*Dallman*); Argonne National Laboratory, USA (*van Thor*); Malaria Eradication Scientific Alliance (*Baum*); African Centre of Excellence in Biotechnology (*Burt* – President); Centre for Public Health Research, University of Shenzhen, China (*Christophides*); Centre for Global Public Health, Tsinghua University, China (*Christophides*); European Food Safety Authority GMO Working Group (*Crisanti*).

**Consultancies:** Imperial Consultants (ICON) is the College's dedicated team of experts that help outsource the expertise of its academics for the benefit of industry and society. DoLS recognises the immense value of these activities and supports staff by releasing them from other duties, as required. Assisted by ICON, DoLS staff acted as consultants (e.g. for Merck, Procter & Gamble, Dr. Reddy's Laboratories, SV Health Investors, NeuroproteXeon) and as expert witnesses in legal cases (*Byrne, Haslam*).

**Fellowships:** Twenty-one individuals were awarded competitive fellowships during the REF period and held them in DoLS; seven of them (listed with their full names, not italicised) left DoLS before

**Unit-level environment template (REF5b)**

the REF census date or took up teaching roles. *Babtie*, *Cardona* and *Rouse* received BBSRC or UKRI Future Leaders Fellowships; *Despoina Mavridou* received a MRC Career Development Award; *Rosindell*, *Eoin O’Gorman* and *Oliver Windram* received NERC Independent Research Fellowships; *Bell*, *Song* and *John Pinney* received Royal Society University Research Fellowships; *Rudenko* received a Wellcome Senior Research Fellowship in Basic Biomedical Science; *Child*, *Luis* and *Tiengwe* received Wellcome and Royal Society Sir Henry Dale Fellowships; *Ali* received a CRUK Senior Cancer Research Fellowship. *Cavan*, *Graystock*, *Meccariello*, *Julia Harris*, *Rebecca Kordas*, and *Kirsten McEwen* were awarded [Imperial College Research Fellowships](#), which offer four years of support to outstanding early career researchers.

**Prizes and honours:** DoLS hosts six Fellows of the Royal Society (*Buck*, *Dell*, *Franks*, *Morris*, *Prentice* – elected 2018, *Rutherford* – elected 2014); three Fellows of the Academy of Medical Sciences (*Dell*, *Franks*, *Wisden* – elected 2014); and two EMBO Members (*Rutherford*, *Savolainen* – elected 2014). *Abzhanov* and *Cardona* are Fellows of the Linnean Society of London; *Savolainen* is a Fellow of the Zoological Society of London; *Baldwin*, *Child* and *Matthews* are Fellows of the Royal Society of Chemistry; 13 DoLS members are Fellows of the Royal Society of Biology; *Buck* and *Filloux* are Members of the American Academy of Microbiology; *Filloux* is a Member of the European Academy of Microbiology. *Dallman* was appointed OBE for Services to the Biosciences (2016); *Morris* received the Royal Medal of the Royal Society (2014); *Ewers* received the Scientific Medal of the Zoological Society of London (2019); *Lo Celso* received the Foulkes Foundation Medal of the Academy of Medical Sciences (2017); *Savolainen* received the Coincy Award of the Botanical Society of France (2015). *Frankel* is a Visiting Professor at the Academy of Medical Sciences Hamied Foundation UK-India AMR; *Nixon* is a Visiting Professor at the School of Biological Sciences, Nanyang Technological University, Singapore; *Ransome* is a Honorary Research Associate and Scholar of the Smithsonian Institute, USA; *Bidartondo* is a Honorary Research Associate of the Royal Botanic Gardens, Kew; *Selkirk* is a Visiting Professor at the Institute of Infection Immunity and Inflammation, University of Glasgow.

**Invited conference presentations and named lectures:** During the REF period, staff gave plenary and keynote lectures at elite international meetings, including Gordon Research Conferences (*Beeby*, *Bell*, *Brickley*, *Filloux*, *Hohenester*, *Meier*, *Pawar*, *Prentice*), Keystone Conferences (*Lo Celso*), Cold Spring Harbor Meetings (*Ali*) and EMBO Workshops (*Ali*, *Windbichler*), with hundreds more at other national and international conferences. DoLS staff also gave a number of prestigious named lectures, e.g. *Isalan* gave the Harveian Lecture of the Harveian Society of London (2020), *Lo Celso* gave the Carl Zeiss Lecture of the German Society for Cell Biology (2018), *Rutherford* gave the Sir Hans Krebs Lecture at the University of Sheffield (2014), *Ewers* gave the Inaugural Ben Collen Memorial Lecture at UCL (2020), *Dell* gave the Karl Meyer Award Lecture of the Society for Glycobiology (2016), and *Christophides* gave the Patton Lecture at Cornell University, USA (2019).