

The image shows five petri dishes containing agar with antibiotic susceptibility testing results. Each dish has several circular zones of inhibition. The labels on the dishes include: 'MEN 10', 'CIP 5', 'LEV 5', 'CIP 5', 'MEN 10', 'IMM', 'AK 30', 'DOR 10', 'SCF 105', 'CIP 5', and 'LEV 5'. The zones of inhibition vary in size and clarity, indicating different levels of antibiotic sensitivity for the organisms being tested.

Edinburgh *Infectious Diseases*

Leading infectious disease research and training

Annual Report 2016/17

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Executive summary

What is Edinburgh Infectious Diseases

We are the Network of researchers across the University of Edinburgh and associated organisations with an interest in infectious diseases.

The aims of Edinburgh Infectious Diseases

1. Represent the strengths of infectious disease science in Edinburgh through our symposia, workshops, outreach activity and internet profile;
2. Maintain a strategic overview of infectious disease research in Edinburgh, to maximise synergy between established activities and promote new avenues for investigation;
3. Foster infectious disease teaching and training at all levels within the University, including the development of new postgraduate initiatives.

Our major activities and achievements in 2016/17

- We have seen continued growth in size and spread of membership of *Edinburgh Infectious Diseases* to over 180 principal investigators.
- Our members were awarded over £34.5M for infectious disease research in FY 2015/16 and published over 470 research papers in 2016.
- *Edinburgh Infectious Diseases* has contributed to the development and coordination of major successful international funding applications.
- We launched our strategy for Antimicrobial Resistance Research in Edinburgh in March 2017.
- We continue to facilitate increased communication and collaboration between social scientists and basic and clinical researchers.
- We have supported the launch of the Wellcome Trust Four Year PhD Programme in Hosts, Pathogens and Global Health doctoral training programme.
- We have added value to the experience of undergraduate students in infectious diseases through support of the Society for Immunology and Infectious Diseases and organisation of seminars for the Infectious Diseases Honours class.
- We are connected to our members through compilation and circulation of a weekly newsletter of relevant seminars and news, and organisation of effective research networking events, which have contributed to building the vibrant community of researchers in Edinburgh working on infectious diseases.

Director's Statement

The membership of *Edinburgh Infectious Diseases* continues to increase in size with a total of 850 scientists and clinicians including 180 group leaders. In the last year, we have continued to serve the community through our network activities, symposia, strategic workshops etc. We have also established key strategic priority areas for particular focus by *Edinburgh Infectious Diseases*. A key goal was the development of a strategy for antimicrobial resistance research (AMR) in Edinburgh built around 4 key AMR-related research themes led by theme leaders who are international leaders within their fields. The theme leaders will co-ordinate activities within and between themes underpinned by One Health and Social Science cross-thematic approaches. The AMR strategy was launched recently at a symposium held the Playfair library with over 200 registered attendants from Edinburgh along with guests from some of the major national funding bodies. Recent funding successes by *Edinburgh Infectious Diseases* members in AMR research are encouraging and we must now build on the new structures to establish Edinburgh as a leading centre of excellence for AMR research.

In other priority areas, our activities to promote interactions between basic and social scientists will culminate on 24 April in a one-day symposium 'Global Challenges in Infectious Disease: Showcasing social science research in Edinburgh'. We anticipate that these activities will lead to stronger research links between our basic and social scientists and funded collaborative projects. With regard to Global Challenges, we have recently surveyed the *Edinburgh Infectious Diseases* membership to identify current partnerships with low and middle income countries and we continue to promote Global Challenge Research fund (GCRF) bids by *Edinburgh Infectious Diseases* members, such as the recent successful TIBA NIHR grant application. Moving forward, in the light of the new Industrial Strategy Challenge Fund we will pro-actively support the development of partnerships with industry in readiness for ICSF funding calls.

An important remit for *Edinburgh Infectious Diseases* is supporting teaching and training and we have acted as a vehicle towards improving coordination and collaboration between existing undergraduate teaching programmes of relevance to infectious diseases in Edinburgh. With regard to post-graduate training and capacity building, we wish to build on existing research and infrastructure strengths in Edinburgh to train the next generation of scientists by establishing new doctoral training programmes. Current concepts under discussion include 'One Health models of Infectious Diseases' and Physical sciences and AMR'.

Finally, we have just launched our new website which along with our outreach activities, aims to extend the reach of *Edinburgh Infectious Diseases*, engaging the outside world and reporting our key activities, initiatives and the successes of our membership.

Overall, we look ahead to the next year with enthusiasm, aiming to build on recent successes, while continuing to identify new opportunities to promote excellent science and infectious disease training in Edinburgh.

A handwritten signature in black ink, appearing to read 'Ross Fitzgerald', written over a light blue horizontal line.

Professor Ross Fitzgerald, Chair of Molecular Bacteriology, The Roslin Institute

Director of *Edinburgh Infectious Diseases*

April 2017

Organisation and membership of *Edinburgh Infectious Diseases*

Edinburgh Infectious Diseases is coordinated by Director (Professor Ross Fitzgerald) and Executive Manager (Dr. Hilary Snaith), and supported by an administrative assistant (Jennifer Hurst). The Network has regular input from an Executive Committee, which meets once a month.

Table 1: Current members of the *Edinburgh Infectious Diseases* executive committee

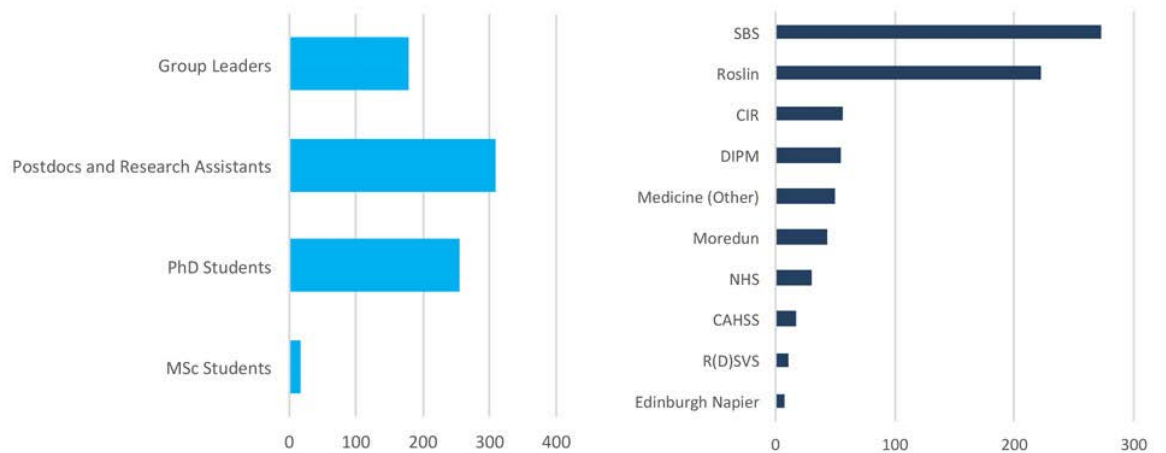
Member	Affiliation
Dr. Till Bachmann	Division of Infection and Pathway Medicine, Royal Infirmary of Edinburgh, Little France
Dr. Amy Buck	Institute of Immunology & Infection Research, Ashworth Laboratories, King's Buildings
Prof Harry Campbell	Usher Institute of Population Health Sciences and Informatics, Teviot Place
Prof David Dockrell	Centre for Inflammation Research, Queen's Medical Research Institute, Little France
Dr. Bernadette Dutia	The Roslin Institute, Easter Bush
Prof Gary Entrican	The Moredun Research Institute
Prof Ross Fitzgerald	The Roslin Institute, Easter Bush
Prof Clifford Leen	Department of Infectious Diseases, Western General Hospital
Prof Keith Matthews	Institute of Immunology & Infection Research, Ashworth Laboratories, King's Buildings
Prof Harish Nair	Usher Institute of Population Health Sciences and Informatics, Teviot Place
Prof Jürgen Schwarze	Centre for Inflammation Research, Queen's Medical Research Institute, Little France
Dr. Hilary Snaith	<i>Edinburgh Infectious Diseases</i> , Ashworth Laboratories, King's Buildings
Prof Mark Stevens	The Roslin Institute, Easter Bush
Dr. Alice Street	School of Social and Political Science, George Square
Dr. Kate Templeton	Royal Infirmary of Edinburgh, Little France
Prof Sue Welburn	Division of Infection and Pathway Medicine, Royal Infirmary of Edinburgh, Little France

Over the past year membership of *Edinburgh Infectious Diseases* has grown to over 180 academics, drawn from the University of Edinburgh, Heriot Watt and Edinburgh Napier Universities, NHS Lothian and associated Institutes, including the Moredun Research Institute and Scotland's Rural College. A full listing of our members is on our website: <http://www.eid.ed.ac.uk/members>.

As of April 2017 *Edinburgh Infectious Diseases* has over 850 members, with 180 group leaders, over 300 postdocs and research assistants, and over 250 PhD students (see graph below left). The Roslin Institute and the School of Biological Studies continue to have the highest numbers of infectious disease researchers, but there are significant concentrations located at the Little France site, both in the Queen's Medical Research Institute and in the Chancellor's Building (see graph below right). We are also pleased to be engaging with more members of the College of Arts, Humanities and Social Sciences as part of our aim to foster interdisciplinary approaches to addressing questions in infectious disease research.

We were delighted in October of 2016 when Professor David Dockrell moved to the University of Edinburgh from Sheffield to take up the new Chair of Infection Medicine. He brings with him a vibrant research group that is based in the MRC Centre for Inflammation Research at Little France, and is focused on understanding the innate immune system and how it can be harnessed to control

infection. David has already taken an active role in the *Edinburgh Infectious Diseases* community and is a new member of our Executive Committee.



Left: Total numbers of group leaders, postdocs and research assistants, and students working in infectious diseases across Edinburgh; right: distribution of infectious diseases researchers.

Another significant change has been the appointment of Professor Eleanor Riley as David Hume's successor as Director of the Roslin Institute. Eleanor has a long-standing interest in anti-malarial immunity, and will arrive at the Institute later in September 2017.

Other new appointments include Professor Debby Bogaert who has recently joined the MRC Centre for Inflammation Research from the University Medical Center in Utrecht. Debby is now building her research group to study the physiology and pathophysiology of respiratory infections and inflammation from an ecological perspective. Dr. Gavin Paterson has joined the Roslin Institute as a senior lecturer in Applied Diagnostics with a research programme including sequence-based diagnostic and genomic epidemiology of bacterial pathogens. The expansion of the Edinburgh-China teaching programme with Zhejiang University, has also allowed the recruitment of Dr. Richard Sloan from Barts and London Hospital to join the Division of Infection and Pathway Medicine. Richard's research focuses on the antiviral factors that inhibit HIV and other retroviruses. Over the next year it is anticipated that there will also be new appointments in the School of Biological Studies to further strengthen infectious disease research.

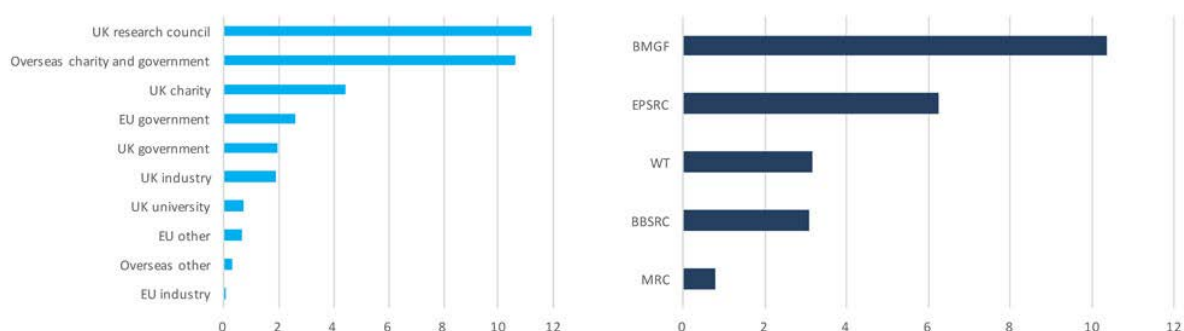
Funding for our research

Members of *Edinburgh Infectious Diseases* have continued to be successful in attracting considerable external research funding over the past 18 months. Analysis of the Key Performance Indicator statistics produced by Edinburgh Research and Innovation demonstrates the success of our members in winning competitive research funding from a wide variety of sources.

From the data available for the 2015-2016 financial year, *Edinburgh Infectious Diseases* members were awarded £34.5M, in the context of total University of Edinburgh funding of £268M for FY 2015-2016.

These awards include a large grant of £10M from the Bill and Melinda Gates Foundation to fund the Center for Tropical Livestock Genetics and Health at the Roslin Institute. Other highlights included over £5M awarded to Mark Bradley and his team by the Engineering and Physical Sciences Research Council for molecular sensing and imaging, ~£1M awards by the European Commission and the Wellcome Trust to Rosalind Allen and Ross Fitzgerald respectively, to continue their work addressing antimicrobial resistance. Ivan Morrison and Tim Connelley received over £600K from the BBSRC to develop vaccines against bovine TB, and Finn Grey was awarded £510K by the MRC to continue his work on human Cytomegalovirus. Direct industry funding of £1.8M was also obtained, and further support was leveraged via RCUK LINK and IPA funding schemes (figures not currently available).

The graphs below quantify the funding sources including major UK and international charities, the UK and EU government research councils, and from industry collaborations.



Left: Total funding awarded to *Edinburgh Infectious Diseases* members in FY 2015-16; right: total funding from selected funders (BMGF – Bill and Melinda Gates Foundation; EPSRC – Engineering and Physical Sciences Research Council; WT – Wellcome Trust; BBSRC – Biotechnology and Biological Sciences Research Council; MRC – Medical Research Council.)

The first half of FY 2016-2017 has also seen considerable funding awards made for infectious disease research, with £17.5M awarded in total. Antimicrobial resistance research has over £3.5M with awards to David Dockrell and Meriem El Karoui from the MRC and the Wellcome Trust. Details of all the awards over £500K in FY 2015 - 2016, and in the first half of FY 2016 - 2017 are given in tables 2a and 2b below.

Table 2a: Awards >£500,000 made in FY 2015 to 2016				
PI Name	PI Dept.	Sponsor Name	Project Title	Award Total (£)
David Hume	Roslin Institute	Bill and Melinda Gates Foundation	Center for Tropical Livestock Genetics and Health	10,000,000
Mark Bradley	Chemistry	EPSRC	Multiplexed 'Touch and Tell' Optical Molecular Sensing and Imaging	5,077,841
Rosalind Allen	Physics and Astronomy	European Commission	EVOSTRUC: The physics of antibiotic resistance evolution	1,304,989
Steven H Spoel	Institute of Molecular Plant Sciences	European Commission	IMMUNE-EXPRESS: Proteasome-Mediated Gene Expression in Plant Immunity	1,111,080

Ross Fitzgerald	Roslin Institute	Wellcome Trust	Understanding bacterial host adaptation to combat infectious diseases	981,065
Bruce Whitelaw	Roslin Institute	BBSRC	Genome editing for quantitative traits in livestock	889,293
Christopher Haslett	Centre for Inflammation Research	EPSRC	Multiplexed "touch and tell" optical molecular sensing and Imaging	823,260
Dave Burt	Roslin Institute	BBSRC	Unravelling the networks that regulate seasonal rhythmicity in the epigenome	743,257
Tim S Walsh	Division of Health Sciences	Selex Ltd	SELEX Pilot: LASER Assisted Staphylococcal ERadication prior to orthopaedic implantation surgery	716,511
Ivan Morrison	R(D)SVS	BBSRC	NKp46+CD3+ T-Cells As A Novel Target For Vaccines Against Bovine TB	£605,367
Finn Grey	Roslin Institute	MRC	Systematic identification of host proteins involved in Human Cytomegalovirus replication, assembly and egress	510,054

Table 2b: Awards >£500,000 made in first half FY 2016 to 2017

PI Name	PI Dept.	Sponsor Name	Project Title	Award Total (£)
David Dockrell	Centre for Inflammation Research	MRC	Optimising Innate Host Defence to Combat Antimicrobial Resistance	2,631,980
Harish Nair	Centre for Global Health Research	European Commission	Respiratory Syncytial Virus Consortium in Europe	1,770,250
Sarah Reece	School of Biological Sciences	Wellcome Trust	Parasite offence or host defence? The roles of biological rhythms in malaria infection	1,527,986
Meriem El Karoui	School of Biological Sciences	Wellcome Trust	DNA repair and genetic stability: elucidating the effects of cell physiology in Escherichia coli	955,487
Jayne Hope	The Roslin Institute	BBSRC	VACCINE: Defining signature responses at the innate-adaptive interface to inform the design of vaccines inducing cellular immunity	870,609
Jürgen Haas	Division of Infection & Pathway Medicine	MRC	Control of type III interferon expression and Herpes simplex virus type 1 replication by miR-200	690,239
Emily Gwyer Findlay	Centre for Inflammation Research	Royal Society	Cathelicidin is Critical for Pathogenic T cell Development in Multiple Sclerosis	662,275
Harish Nair	Centre for Global Health Research	Sanofi Pasteur MSD Limited	Nasopharyngeal pneumococcal carriage study in South Asian infants	647,015
Debby Bogaert	Centre for Inflammation Research	Chief Scientist Office	Early-life effects on host-microbiome interactions	533,000

Facilitating collaborative funding applications

The environment for infectious disease research in Edinburgh is enhanced by the network of connected researchers generated by *Edinburgh Infectious Diseases*. Over the past year this has facilitated applications for several large multisite funding programmes.

Respiratory Syncytial Virus Consortium in Europe



In January 2017 the Innovative Medicines' Initiative awarded £24M to the Respiratory Syncytial Virus (RSV) Consortium in Europe (RESCEU) project, of which £1.77M has come to the University of Edinburgh. The project is led by Harish Nair in the Usher Institute for Population Health Sciences and Informatics, and

involves several colleagues from the University of Edinburgh, alongside European partners. The RESCEU team will gather data to draw up best practice guidelines to improve the way RSV-associated disease is monitored across Europe and to inform future vaccination programmes.

Tackling Infection to Benefit Africa

Earlier on this year, Mark Woolhouse and Francisca Mutapi, alongside colleagues from across *Edinburgh Infectious Diseases* and collaborators in nine African countries, prepared a consortium application for the call from the National Institute for Health Research for Global Health Research Units. At the time of writing we have just heard that the Programme has been awarded £7.4M to create a new multidisciplinary centre for Tackling Infections to Benefit Africa (the TIBA Centre; tiba means to cure an infection in Swahili).



TIBA is a partnership between the University of Edinburgh and leading African scientists in Botswana, Ghana, Kenya, Rwanda, South Africa, Sudan, Tanzania, Uganda and Zimbabwe. Uniquely, TIBA will work on all aspects of infectious diseases management – from basic research to uptake by local communities – in a single, unified framework. This meets an often articulated but rarely addressed need, to view infectious disease management not in isolation but in the context of local health systems and wide societal issues. TIBA will also contribute to the strategic goal of improving the health research ecosystem in Africa, providing a rare opportunity for different countries to work together in a common framework.

Identifying links to connect researchers

A key aspect to developing research proposals that are eligible for funding by the RCUK Grand Challenges Research Fund, is identifying the appropriate partners in low and middle income countries with whom to work. *Edinburgh Infectious Diseases* has contributed to building capacity in this area by compiling a data base of our members' collaborators in the developing world, which will be made available on our website. This has already been a valuable resource for the TIBA Centre application

(above), and we intend to continue augmenting the information available.

Publication highlights

In 2016 *Edinburgh Infectious Diseases* members published over 470 papers (see Appendix 1). Selected highlights are three papers published in the *Lancet*, two in the *Lancet Infectious Diseases*, five in *Nature*, nine in *Nature Communications*, five in *PLoS Pathogens*, five in *PLoS Neglected Tropical Diseases*, three in *PLoS Biology*, three in *Science*, two in *eLife* and one in *Cell*. Details of some of the papers are below:

- Alderton, S., Macleod, E.T., Anderson, N.E., Schaten, K., Kuleszo, J., Simuunza, M., Welburn, S.C., and Atkinson, P.M. (2016). A Multi-Host Agent-Based Model for a Zoonotic, Vector-Borne Disease. A Case Study on Trypanosomiasis in Eastern Province, Zambia. *PLoS Negl Trop Dis* 10, e0005252.
- Alibhai, J., Blanco, R.A., Barria, M.A., Piccardo, P., Caughey, B., Perry, V.H., Freeman, T.C., and Manson, J.C. (2016). Distribution of Misfolded Prion Protein Seeding Activity Alone Does Not Predict Regions of Neurodegeneration. *PLoS Biol* 14, e1002579.



- Clement, M., Marsden, M., Stacey, M.A., Abdul-Karim, J., Gimeno Brias, S., Costa Bento, D., Scurr, M.J., Ghazal, P., Weaver, C.T., Carlesso, G., et al. (2016). Cytomegalovirus-Specific IL-10-Producing CD4+ T Cells Are Governed by Type-I IFN-Induced IL-27 and Promote Virus Persistence. *PLoS Pathog* 12, e1006050.

- Donaldson, D.S., Sehgal, A., Rios, D., Williams, I.R., and Mabbott, N.A. (2016). Increased Abundance of M Cells in the Gut Epithelium Dramatically Enhances Oral Prion Disease Susceptibility. *PLoS Pathog* 12, e1006075.
- Duffin, R., O'Connor, R.A., Crittenden, S., Forster, T., Yu, C., Zheng, X., Smyth, D., Robb, C.T., Rossi, F., Skouras, C., et al. (2016). Prostaglandin E(2) constrains systemic inflammation through an innate lymphoid cell-IL-22 axis. *Science* 351, 1333-1338.
- Gaunt, E., Wise, H.M., Zhang, H., Lee, L.N., Atkinson, N.J., Nicol, M.Q., Highton, A.J., Klenerman, P., Beard, P.M., Dutia, B.M., et al. (2016). Elevation of CpG frequencies in influenza A genome attenuates pathogenicity but enhances host response to infection. *Elife* 5, e12735.
- Holmes, E.C., Dudas, G., Rambaut, A., and Andersen, K.G. (2016). The evolution of Ebola virus: Insights from the 2013-2016 epidemic. *Nature* 538, 193-200.
- Jackson-Jones, L.H., Duncan, S.M., Magalhaes, M.S., Campbell, S.M., Maizels, R.M., McSorley, H.J., Allen, J.E., and Benezech, C. (2016). Fat-associated lymphoid clusters control local IgM secretion during pleural infection and lung inflammation. *Nat Commun* 7, 12651.
- Laxminarayan, R., Sridhar, D., Blaser, M., Wang, M., and Woolhouse, M. (2016). Achieving global targets for antimicrobial resistance. *Science* 353, 874-875.
- Mena, I., Nelson, M.I., Quezada-Monroy, F., Dutta, J., Cortes-Fernandez, R., Lara-Puente, J.H., Castro-Peralta, F., Cunha, L.F., Trovao, N.S., Lozano-Dubernard, B., et al. (2016). Origins of the 2009 H1N1 influenza pandemic in swine in Mexico. *Elife* 28.
- Miesen, P., Ivens, A., Buck, A.H., and van Rij, R.P. (2016). Small RNA Profiling in Dengue Virus 2-Infected Aedes Mosquito Cells Reveals Viral piRNAs and Novel Host miRNAs. *PLoS Negl Trop Dis* 10, e0004452.
- Moore, R.A., Head, M.W., Ironside, J.W., Ritchie, D.L., Zanusso, G., Pyo Choi, Y., and Priola, S.A. (2016). The Distribution of Prion Protein Allotypes Differs Between Sporadic and Iatrogenic Creutzfeldt-Jakob Disease Patients. *PLoS Pathog* 12, e1005416.
- Quick, J., Loman, N.J., Duraffour, S., Simpson, J.T., Severi, E., Cowley, L., Bore, J.A., Koundouno, R., Dudas, G., Mikhail, A., et al. (2016). Real-time, portable genome sequencing for Ebola surveillance. *Nature* 530, 228-232.
- Robertson, K.A., Hsieh, W.Y., Forster, T., Blanc, M., Lu, H., Crick, P.J., Yutuc, E., Watterson, S., Martin, K., Griffiths, S.J., et al. (2016). An Interferon Regulated MicroRNA Provides Broad Cell-Intrinsic Antiviral Immunity through Multihit Host-Directed Targeting of the Sterol Pathway. *PLoS Biol* 14, e1002364.
- Sridhar, D. (2016). Making the SDGs useful: a Herculean task. *Lancet* 388, 1453-1454.
- Sundararaman, S.A., Plenderleith, L.J., Liu, W., Loy, D.E., Learn, G.H., Li, Y., Shaw, K.S., Ayoub, A., Peeters, M., Speede, S., et al. (2016). Genomes of cryptic chimpanzee Plasmodium species reveal key evolutionary events leading to human malaria. *Nat Commun* 7, 11078.
- Swain, P.S., Stevenson, K., Leary, A., Montano-Gutierrez, L.F., Clark, I.B., Vogel, J., and Pilizota, T. (2016). Inferring time derivatives including cell growth rates using Gaussian processes. *Nat Commun* 7, 13766.
- Syed, S.N., Ducrot, M.J., and Bachmann, T.T. (2016). Antimicrobial resistance diagnostics: time to call in the young? *The Lancet Infectious diseases* 16, 519-521.

A research strategy in Edinburgh to combat Antimicrobial Resistance

Antimicrobial resistance (AMR) is one of the most important challenges currently facing humankind. The government-commissioned O'Neill report (Review on Antimicrobial Resistance, 2014-2016) predicted a massive increase in deaths per year by 2050 as a direct result of the acquisition of resistance to antibiotics (from a baseline of 700,000 deaths per year currently). Furthermore, without effective policies to prevent the spread of AMR, it is estimated that the cost to the global economy would be 100 trillion USD. These potentially devastating predictions have led to the prioritisation of AMR research as a major focus for UK research funding by RCUK, and Wellcome Trust, and additional dedicated resources have been provided in the form of the Fleming fund, and Global Innovation fund, etc.



Edinburgh Infectious Diseases has recently assessed the strengths of AMR research in Edinburgh, highlighting potential areas for future focus, synergy and enhancement in the context of the current and ongoing national AMR research priority areas. It is clear that there will be considerable and sustained funding opportunities in the area of AMR research over the coming years and it is imperative that Edinburgh researchers are successful in competing for available funding and provide leadership in addressing this global challenge. In the new strategy we have identified four key AMR-related research areas with potential for excellence in Edinburgh; (i) Global and local epidemiology of AMR; (ii) Rapid diagnostics for more effective use of antibiotics; (iii) Biological, physical and evolutionary mechanisms underpinning AMR; and (iv) Alternatives to antimicrobials for controlling infections.

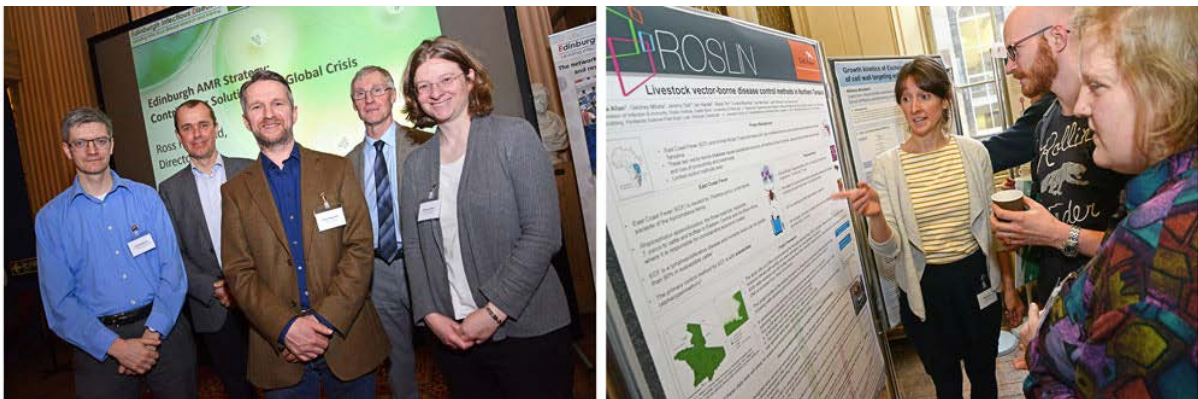
To lead advances across these themes Mark Woolhouse (Centre for Immunity, Infection and Evolution) will be the AMR Champion. Alongside three other theme leaders, Rosalind Allen (School of Physics and Astronomy), David Dockrell (Centre for Inflammation Research) and Till Bachmann (Division of Infection and Pathway Medicine), Mark will promote our AMR science, co-ordinate activities and spearhead funding applications. Future success will also depend on building capacity in excellent AMR research through support of early career scientists, and continued development of links with international (particularly in low, middle income countries) and industrial partners.

Launch of Antimicrobial Resistance Research Strategy

The new strategy was launched at the Edinburgh AMR Research Symposium on Wednesday 22 March 2017, to an audience of over 180. As AMR Champion, Mark Woolhouse set the stage for the day in his keynote lecture, explaining how AMR has arisen, what implications this has for human and animal

health and what is needed to ensure we are able to use antibiotics effectively into the future. The rest of day focused on the four research themes and highlighted some of the ways Edinburgh is already contributing solutions to counter AMR.

The day concluded with a very informative panel discussion with representatives from the Medical Research Council (Caroline Harris), The Engineering and Physical Sciences Research Council (Stephanie Newland), the Chief Medical Officer of Scotland (Alistair Leanord), Health Protection Scotland (Eleanor Anderson) and The University of Edinburgh Research Support Office (Catherine Burns). Their main take home messages were to think big and boldly, to be willing to take risks and to be multi- and inter-disciplinary. Good advice, which was well received by all in the audience, as *Edinburgh Infectious Diseases* looks to support and develop new funding initiatives in AMR.



Left: The Edinburgh AMR leaders: left to right – David Dockrell, Till Bachmann, Ross Fitzgerald, Mark Woolhouse and Rosalind Allen; right: Poster session at the Edinburgh AMR Research Symposium. (Photos by Norrie Russell).

Funding highlights for Antimicrobial Resistance Research

There have been several significant finding successes for AMR research over the past year. Notably Ross Fitzgerald (Roslin Institute) was awarded £981K by the Wellcome Trust, Meriem El Karoui (School of Biological Sciences) was awarded £955K, also by the Wellcome Trust, and David Dockrell (Centre for Inflammation Research) and colleagues received £2.6M from the Medical Research Council. Furthermore, Till Bachmann (Division of Infection and Pathway Medicine) is the leader of a JPIAMR Horizon 2020 funded network which will bring further prominence to our own research in AMR. We have also established links with the new AMR Centre based in Manchester, with a view to contributing to their rapid diagnostics platforms.

Social science in basic and clinical infectious disease research



Another area we have sought to develop during the course of the past year are connections between researchers in clinical and basic science, and those active in infectious diseases research in the social sciences. During 2016 we ran three workshops with the Institute for

Advanced Studies in the Humanities “Common Ground”, which brought together colleagues to explore the interface between research interests. A major common thread in these discussions was antimicrobial resistance; firstly, identifying the barriers to development and implementation of rapid diagnostics, and the secondly understanding how the behaviours of vets and farmers can affect the acquisition and spread of resistance in animals and the environment.

We have been working with the Edinburgh Centre for Medical Anthropology to host a one-day symposium “Global Challenges in Infectious Diseases”, which will highlight social science researchers in Edinburgh, and provide a spring board for the development of new collaborative projects. The symposium will also feed into a discussion for postgraduate students from across the University with the keynote speaker, Professor Vinh Kim Nguyen from the Université de Montréal, to promote interdisciplinarity at all levels.



THE UNIVERSITY of EDINBURGH
EDINBURGH CENTRE FOR
MEDICAL ANTHROPOLOGY

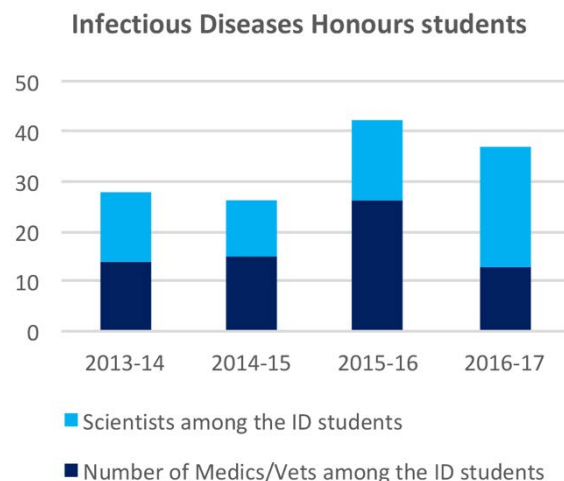
We have also fostered interactions between clinical and basic science researchers and colleagues at the Edinburgh College of Art and in the School of Health and Social Sciences. We held a productive meeting to discuss possible approaches to recent Research Council funding calls; these discussions are still at an early stage, but we are pleased to have been instrumental in supporting our members to reach out to new collaborators for the future.

Teaching and training

Undergraduate teaching in infectious diseases

The undergraduate honours programmes in Infectious Diseases and Immunology continue to attract talented students.

The Immunology programme has had 26 and 27 students for the past two years and is anticipating similar numbers for the 2017/18 programme. The Infectious Diseases programme has also had steady numbers of students. It is likely that now all medical students at the University of Edinburgh will be required to undertake an intercalated degree between years 2 and 3 of their training, leading to increased demand for all Biomedical Honours programmes, including Infectious Diseases. This represents an opportunity for the programme, to promote the importance of infectious diseases to future doctors, and awareness of the possible research training options for clinicians in infectious disease in Edinburgh.



The Infectious Diseases and Immunology Honours programmes are run by the Biomedical Teaching Organisation (BMTO) and the Biology Teaching Organisation (BTO), respectively. As was discussed at the meeting of the Strategic Board in 2016, this separation of highly related subjects into two different School between in teaching has led both to some reduction in student course choice, and in duplication of some taught material.

Edinburgh Infectious Diseases, through Bernadette Dutia (Roslin Institute) has initiated discussion with the Heads of the BTO and the BMTO, and the Immunology and Infectious Diseases Honours Programme organisers, to explore possible improvements that can be made to programme delivery and integration. Although no major decisions have been made, these discussions have been encouraging and have led to some useful ideas, including, arranging timetabling to accommodate more sharing of elective courses and reassessing 3rd year requirements so that students are able to keep open their options for Honours programmes.

Edinburgh Infectious Diseases has continued to support the current Infectious Diseases Honours students throughout the year. The Executive manager met with the students at the start of the academic year to introduce the network and the activities they can access. The students receive the weekly newsletter listing the Edinburgh-wide seminars and events they can attend. We also supported the class to host a seminar by new chair of Infection Medicine David Dockrell, which was well attended by members from across Edinburgh. Support has also been given to the student-led Society for Immunology and Infectious Diseases, which has hosted three highly successful seminars this year from Edinburgh academics Sue Welburn and Sarah Howie, and from Quentin Sattentau at the University of Oxford.

Undergraduate summer placements at Leiden University Medical Center

We have continued our very fruitful collaboration with Leiden University Medical Center, and again sent a third year Infectious Diseases honours student to spend the July and August 2016 in the Netherlands. Andres Rodriguez Barrientos worked with Prof Annemieke Geluk and her lab on the development of a diagnostic assay for *Mycobacterium leprae* for use in Bangladesh and Leiden.



About his time in Leiden, Andres says: *“Working in the labs of the LUMC has been very special and has educated me more about how ‘real’ investigation happens.... Engaging with different projects helped me understand that research is very much a collaborative activity and involves scientists within and between teams”.*

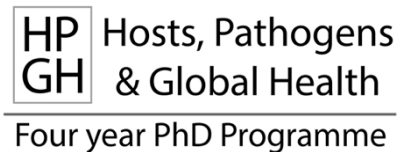
We have already recruited two new students, one each from the Immunology and Infectious Diseases Honours programmes, who will travel to Leiden again in summer 2017.

Postgraduate training

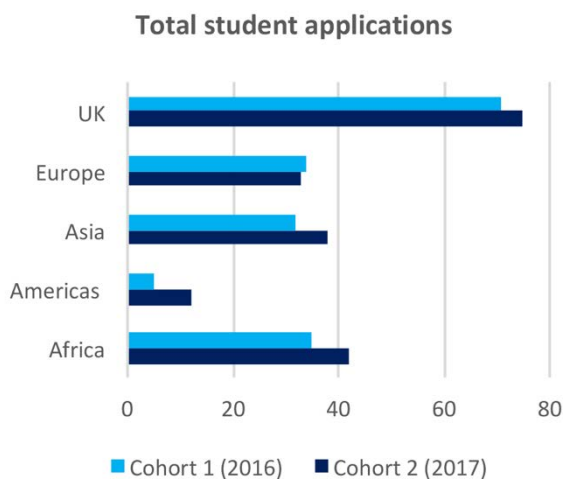
Doctoral training is a vital aspect of fostering young researchers. There are now over 250 PhD students at the University of Edinburgh currently embarked on infectious diseases-related projects.

Wellcome Trust Four Year PhD Programme Hosts, Pathogens and Global Health

The Wellcome Trust Four Year PhD Programme in Hosts, Pathogens and Global Health is led by co-Directors Keith Matthews (Institute of Immunology and Infection Research) and Mark Woolhouse (Centre for Immunity, Infection



and Evolution). It is centered in the Ashworth Labs at Kings Buildings with a total of 23 supervisors, including two based at Little France, and three at the Roslin Institute. The Programme launched in 2016 with the first cohort of students arriving in Edinburgh on 1 October. There are six students in total in this first year, who come from Ireland, Germany, South Africa and the UK. They have had a busy and productive year, carrying out three mini rotation projects, alongside tutorials in the three themes of the programme – Molecular Phylogeny and Epidemiology, Evolutionary Biology and Ecology, and Molecular Biology and Immunology. The programme has also included training in statistics and bioinformatics, presentation skills and relevant career development, to help the students make informed decisions as they navigate the course of their PhDs.



Recruitment for the second cohort was carried out in March 2017. We received over 200 applications for the available places, 105 from UK and EU candidates, and 95 from international candidates. Overall this represents an increase of 13% on total applications in comparison with 2016. The looming issues surrounding Brexit did not significantly deter candidates from EU countries, but we nevertheless saw a drop in applicants from 19.2 to 16.5% of the total. This year's recruits are from Hungary, Cyprus, Germany, The Gambia and the UK, and we look forward to welcoming them to Edinburgh in October.

Edinburgh Infectious Diseases Ker Memorial PhD Studentship

Edinburgh Infectious Diseases is very fortunate to have the sponsorship of Miss Aileen Ker, who generously supports activities promoting infectious disease research at the University in memory of her father and grandfather who were both physicians in Edinburgh during the first half of the 20th century. Since 2009 some of her donation has been used to fund a PhD studentship, with the most recent recipient of the award, Mariya Goncheva (shown below left), completing her studies with Bernadette Dutia and Ross Fitzgerald at the Roslin Institute in September 2017.



Miss Ker is continuing to sponsor a new PhD student for a further four years, starting in October 2017. We have just appointed Greg Milne from the University of Bath to this studentship which will be held jointly in the School of Biological Sciences and the Deanery of Biomedical Sciences. The new studentship will be structured similarly to a University of Edinburgh Principal's Career Development Scholarship to provide additional training in teaching alongside research.

Ker Memorial Prize

In addition to the PhD studentship, Miss Ker also supports the Ker Memorial Prize, which is awarded annually to the student presenting the best PhD thesis in Infectious Diseases at the University of Edinburgh. In 2016 the Ker Memorial Prize was awarded to Chris Johnston from Rick Maizels' lab in the Institute of Immunology and Infection Research, for his work on helminth-induced immunomodulation during solid organ transplantation. As part of his prize Chris presented his work at the *Edinburgh Infectious Diseases* annual symposium in June 2016 (see above), and received a cheque for £500.

Development of Massive Open Online Course on Antibiotics and AMR

A strand of activity to promote engagement with prospective students is via Massive Open Online Courses (MOOCs). Given the high global profile of antimicrobial resistance, and the broad depth of expertise in this subject in Edinburgh, Tamarai Schneiders in the Division of Infection and Pathway Medicine, supported by *Edinburgh Infectious Diseases*, has been working to develop a course in "Antibiotics and the rise of Antimicrobial Resistance". This course has received support from the Deanery of Biomedical Sciences and has been submitted to the University of Edinburgh MOOC office for approval. The course will be aimed at a general, educated audience, and is intended to highlight the importance of antimicrobial resistance to a world-wide audience, showcasing the contributions made by Edinburgh researchers. If approved, it is anticipated that the course will run in mid-2018.

Communication, collaboration and engagement

One of the key ways in which *Edinburgh Infectious Diseases* adds value to the research environment at the University of Edinburgh and associated organisations, is to provide opportunities for our members to meet with each other, and learn about relevant research going on across the city. On a weekly basis we send a newsletter to all our members with details of relevant seminars and events, and throughout the year we host a variety of events aimed at sharing knowledge and providing fora where new ideas, interactions and collaborations can develop. We have also provided some financial

support for seminar series organised by the Edinburgh Microbiology Forum and the Edinburgh Virology Group.

Table 3: <i>Edinburgh Infectious Diseases</i> events over the past year		
When	Event	Location
February 2016	Common Ground 1 – Finding the connections in social sciences	Institute for Advanced Studies in the Humanities, UoE
May 2016	Common Ground 2 – Finding the connections in social sciences	Institute for Advanced Studies in the Humanities, UoE
June 2016	Annual Symposium 2016	The Hub, Castle Hill
June 2016	Seminar by Michael Hsieh	Ashworth Laboratories, UoE
September 2016	Mini-workshop with SynthSys	Roger Land Building, UoE
November 2016	Public Winter Lecture	Playfair Library, UoE
November 2016	Student forum with Wendy Barclay	Old Medical School, UoE
February 2017	GCRF Metabolic Modelling for Infectious Diseases workshop	Roslin Institute, UoE
March 2017	ID4 seminar by David Dockrell	Queen’s Medical Research Institute, UoE
March 2017	Edinburgh AMR symposium	Playfair Library, UoE
Upcoming		
April 2017	Global Challenges in Infectious Disease – Social Science Showcase	50 George Square, UoE
June 2017	Annual Symposium 2017	John McIntyre Conference Centre

Symposia and workshops organised by *Edinburgh Infectious Diseases*

Our flagship event is the Annual Symposium. The 2016 symposium was held at The Hub on the Royal Mile and was attended by 200 staff, postdocs and students. As ever we had an extremely varied programme with everything from *Theileria coinfections* and East Coast Fever (Mark Woolhouse, Centre for Immunity, Infection and Evolution), to squirrel pox in UK red squirrels (Colin McInnes, Moredun Research Institute), translational genomics in critical care medicine (Kenny Baillie, Roslin Institute) and controlling sleeping sickness in Southern Sudan (Pete Kingsley, School of Social and Political Science).



Left: A full house at The Hub, Castle Hill for our 5th Annual Symposium; right: Gordon Dougan, the Ker Memorial Lecturer, Chris Johnson, winner of the Ker Memorial Prize, and Ross Fitzgerald. (Photos Norrie Russell)

We were very pleased to have Prof Gordon Dougan FRS from the Sanger Institute as the Ker Memorial Lecturer who concluded the day with an excellent presentation on *Genetic analysis of host-pathogen interactions during infection*.

Another highlight of the day was the lively and well attended poster session. Over 40 posters were displayed, with the prize for best student poster awarded to Filipa Henderson Sousa from Edinburgh Napier University for her work on “Cationic Host Defence Peptides as novel therapeutics for rhinovirus and influenza virus infection”, and the postdoc poster prize going to Perna Vohra at the Roslin Institute for her work on “Understanding the dynamics of Salmonella infection in cattle”.



Left and centre: Lively poster sessions at the annual symposium; right: poster prize winners Filipa Henderson Sousa and Perna Vohra with Ross Fitzgerald. (Photos Norrie Russell)

Adding value to existing University of Edinburgh activity

In addition to the main symposium, over the past year we have sought to identify particular topics of interest to our members and develop opportunities where these can be explored in more detail. We are also very aware of the need for our members to identify research programmes that are aligned with the Grand Challenges Research Fund.

One area where there is great potential for synergy in Edinburgh the use of synthetic biology to address questions in vaccine design and production. To help build links between infectious diseases researchers and colleagues in the Centre for Synthetic and Systems



Biology, we ran a successful mini-workshop in September 2016. More recently, members of *Edinburgh Infectious Diseases* also took part in a sandpit with synthetic biology researchers from several research organisations in China, to help developing collaborative projects that could be funded by the GCRF. In February 2017 we organised a workshop with Paul Michels (School of Biological Sciences) in February 2017 on how metabolic modelling can be used to inform control of infectious disease. Three visiting scientists from Brazil and Mexico joined

colleagues from the Universities of Edinburgh and Glasgow. The event was funded by a BBSRC Impact Accelerator Award to promote GCRF-relevant collaborations.

We also seek to add value to existing seminar programmes, hosting visiting speakers when appropriate. This year Michael Hsieh from the Biomedical Research Institute, Maryland, gave a widely attended seminar on the ABCs of schistosome infection and met with a number of researchers to explore collaborations opportunities.



We have also connected with a broad audience at our public Winter Lecture, this year given by Professor Wendy Barclay from Imperial College, London, on the highly topical subject of influenza vaccines. This was held in the Playfair library and attracted a wide audience of over 180 people.

Public engagement

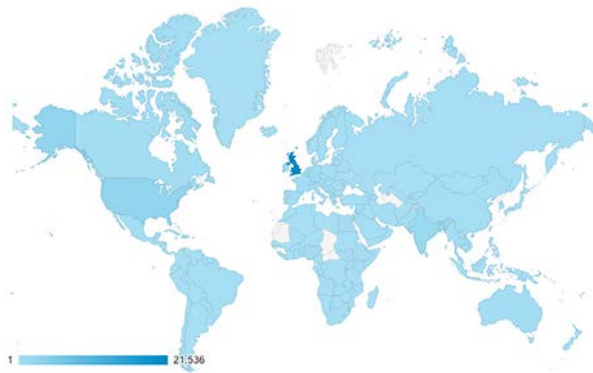
We continue to promote public engagement through supporting researchers to develop their own outreach projects, and through the existing resource of the “Bugs and Bones” in the Ashworth Treasure Chest. These samples travelled throughout Edinburgh during the course of the year at a variety of science festivals. We have also used them to run workshops in primary schools in Midlothian and the Borders, on the spread and control of infectious disease. These activities have given us the opportunity to give training to undergraduate students on the Science Communications programme about how to educate, enthuse and inspire the next generation of scientists. Additionally *Edinburgh Infectious Diseases* has been actively involved with the College of Science and Engineering Public Engagement team to develop a new strategy for public engagement that supports all staff and students to engage with all strata of our society with our research.



Building an online presence

We continue to develop our social media platforms and website in order to reach audiences out with Edinburgh. Twitter is an effective way of disseminating news about events and studentship opportunities, with many of these tweets being widely re-tweeted (@edin_eid). During the past year our followers on Twitter have grown 50% to 2144, with our tweets being read more than 40,000 times a month.

The *Edinburgh Infectious Diseases* website remains a valuable medium for communication about the research of our members and the opportunities to work with us: <http://www.eid.ed.ac.uk/>.

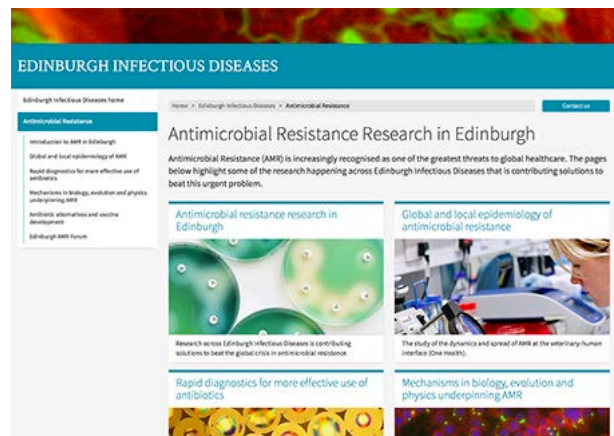


During 2016 we had almost 85,000 page views, from a total of 27,640 individual viewers, 32% of whom were returning visitors. As shown on the map (left), visitors to the site are from around the world: in the last year 69% of visitors were from Europe, 12% from Asia, 10% from the Americas and 7% from Africa. 61% of visitors were between the ages of 18 and 35, which reflects the popularity of the pages for Wellcome Trust Four Year PhD Programme in

Hosts, Pathogens and Global Health, and other student-directed information.

The news and events sections of the website are regularly updated and are also highly visited; a summary of the news stories from the website is presented in Appendix 3. We also use our YouTube channel to publish talks from our Symposia and Winter Lecture.

The launch of the AMR research strategy was accompanied by the development of a new website on the EdWeb platform supported by the University of Edinburgh web development team, <http://www.ed.ac.uk/edinburgh-infectious-diseases/amr>. Over the course of 2017 we will be extending this new website to include all the *Edinburgh Infectious Diseases* content.



Appendix 1

Publications from *Edinburgh Infectious Diseases* members in 2016

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Appendix 2

Summary of *Edinburgh Infectious Diseases* accounts for FY2015/16

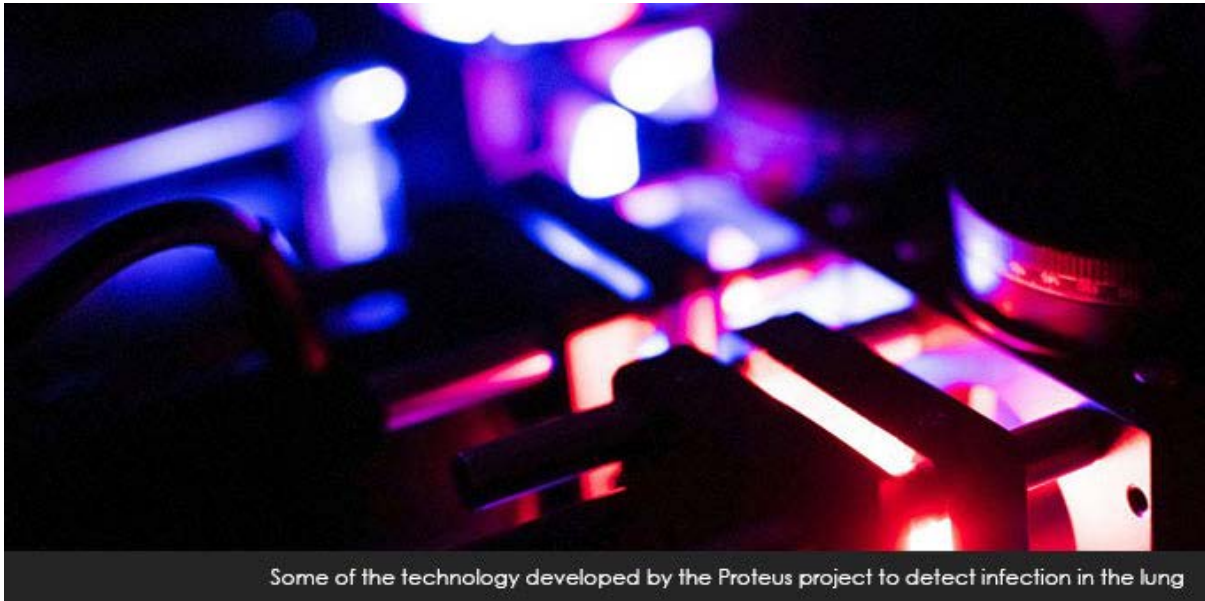
Details	Income (£)	Expenditure (£)
Events		4005.11
Meeting support		1137.1
Network support		1600
Office support		1055.57
Printing		451
Prizes		200
Public Engagement		71.81
Salaries		38436.85
Sponsorship	-3000	
Symposium 2015		3818.74
Symposium 2016		9826.09
UoE	-45600	
Vacation Studentship		1988.12
Total in		-48600
Total out		62590.39
Carried forward	-30024	
Total		-16033.61

Appendix 3

News stories from around *Edinburgh Infectious Diseases*

The full stories can be read at <http://www.eid.ed.ac.uk/newsdb>

- £10m investment in Roslin Technologies set to boost impact of animal science innovations
- Lung probe developed in Edinburgh spots infections and aims to cut antibiotic overuse



- Members of Moredun Research Institute help launch the SEFARI Centre for Knowledge Exchange & Impact
- Work from the Roslin Institute shows gut macrophage dysregulation key to Inflammatory Bowel Disease
- New study from the School of Biological Sciences finds spread of ages is key to impact of disease
- New musical theatre show to spread message about antimicrobial resistance in schools
- Meriem El Karoui has won £955K from The Wellcome Trust to study how antibiotic resistance emerges
- Professor Dave Robertson has been appointed as Head of the College of Science & Engineering at the University of Edinburgh
- Gene-edited pigs produced at the Roslin Institute show signs of resistance to major viral disease
- Eleanor Riley to be new Director of the Roslin Institute

- Immune cell study from Edinburgh University's Centre for Inflammation Research prompts rethink on how to tackle infections
- New bacteria study from University of Edinburgh finds killing off rivals makes for happy families
- Major drug initiatives are best way to curb threat from parasites shows new study from the University of Edinburgh
- Researchers in the University of Edinburgh's Usher Institute to lead €29m research grant that will assess risk posed by deadly lung infections
- Gut cells are gatekeepers of infectious brain diseases, finds new study from the Roslin Institute's Neil Mabbott
- Infections that pose greatest pandemic risk identified by experts from the Roslin Institute and School of Biological Studies
- Red squirrels in Britain are stricken by medieval strain of leprosy, shows a new study from Edinburgh researchers



- Antibiotics Awareness Week 14 – 20 November 2016
- Breakthrough in the control of Amoebic Gill Disease by researchers at the Roslin Institute
- Immune cell insight offers hope for tackling the deadly lung condition Acute Respiratory Distress Syndrome

- Migration routes hold key to bird flu spread, global study finds
- New Ker Memorial PhD Studentship available at the University of Edinburgh for 2017
- Andrew Rambaut from Institute of Evolutionary Biology awarded the 2016 Chancellor's Research Award
- Researchers at University of Edinburgh find skin's own defences point towards new eczema therapies
- A global call for global zoonotic TB control and eradication
- Africa Week at the University of Edinburgh highlights infectious disease research in the School of Biological Sciences
- Edinburgh researchers find there is no silver bullet for forests under climate change
- Great day of Biology on Doors Open Day at the University of Edinburgh
- An infectious diseases undergraduate student talks about his experiences on a project at Leiden University Medical Center



- Vaccines; a new weapon in the arsenal to fight against the worms that turned?
- Global superbug response needs \$5bn each year, experts predict
- Bugs' flair for foraging inspires quest for new smart therapies at the University of Edinburgh
- New malaria study by University of Edinburgh researchers shows how multiple infections make disease worse

- Food security focus for major research and teaching initiative at the University of Edinburgh
- New collaboration between Edinburgh researchers and Immunovaccine Inc. to study malaria vaccine
- Researchers at Royal (Dick) School for Veterinary Studies launch red squirrel study to assess leprosy infection
- International Day of Immunology 2016: The Edinburgh Immunology Group
- New study shows Nigerian cattle carry zoonotic pathogens with implications for human health



Nigerian herdsmen manually remove parasites from their fulani cattle

- Arthritis and other inflammatory conditions could be helped by new insights from the Centre for Inflammation Research
- Roslin Institute scientists part of landmark WHO consultation to galvanise action against Zoonotic Tuberculosis
- New paper published: Beyond killing: can we find new ways to manage infection?
- New PhD position available on Wellcome Trust 4 year Hosts, Pathogens and Global Health PhD programme
- The Roslin Institute receives Scottish Government funding for research into infectious livestock diseases
- Edinburgh researchers part of study shedding light on how malaria parasites jumped from chimps to humans
- Treatment and prevention of life-threatening infections could be improved by research that reveals how bacteria are kept in check
- Roslin Technologies launches to boost animal sciences company creation

- Researchers from the School of Biological Sciences win Royal Society Brian Mercer Feasibility Award
- Bid to beat infant RSV infection boosted by immune study from Centre for Inflammation Research
- Luciana Brondi featured on Sputnik radio programme discussing the current Zika virus outbreak
- Pigs' genetic code altered in bid to tackle infection with deadly African Swine Fever virus
- Ivan Morrison at The Roslin Institute awarded over £0.7M to develop new vaccines against bovine Tuberculosis
- New lecture series on Neglected Tropical Diseases launches for February and March 2016
- New research from the University of Edinburgh argues pregnant mums can hold key to controlling sleeping sickness
- Decades-long quest to beat river blindness edges towards vaccine
- New study charts the hotspots where bat viruses are more likely to infect humans
- Mother appetites can keep size of wild animal groups in check, finds Edinburgh Infectious Diseases member Tom Little