The Aims of the Royal Commission

The 1851 Royal Commission’s governing document is its Supplemental Charter of 1851, which requires the Commission to “increase the means of industrial education and extend the influence of science and art upon productive industry”.

This was originally interpreted as a requirement to create a centre of intellectual excellence, which resulted in the acquisition of the South Kensington estate and its subsequent development with museums, academic establishments and a Hall of Arts and Sciences (the Royal Albert Hall).

Later, in 1890, the emphasis was switched to the support of individuals, starting with the award of Science Research Scholarships from 1891.

Today the Commission runs its own schemes for:

- Research Fellowships
- Industrial Fellowships
- Industrial Design Studentships
- Built Environment Fellowships
- Fellowships in Design

In partnership with others it supports:

- Great Exhibition Scholarships
- Enterprise Fellowships

It also supports worthy individuals and appropriate organisations by Special Awards.

The total number of individuals being supported in 2016 was 132

Registered Charity No. 206123
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Chairman’s Report

Bernard Taylor, Chairman of the Board of Management

2016 marked ten years since the 1851 Alumni Association was launched at a Reception at Buckingham Palace, hosted by His Royal Highness The Duke of Edinburgh as President of the Commission. The association has grown steadily and we are now in touch with over seven hundred of our alumni, some of whom received awards over fifty years ago. So it seemed only right that we should celebrate the anniversary and it was a great honour to be invited back to Buckingham Palace in December by Her Royal Highness The Princess Royal for a Reception for 500 alumni and their partners. It was, by any measure, an extraordinary gathering which reflected the strong bond that exists across the many generations that make up the 1851 family. It was an opportunity to catch up with old friends and make new acquaintances during an evening with the special atmosphere created by the presence of our President and Past President together in the fine surroundings of the Palace’s ballroom. It was, without doubt, the highlight of the year.

Our programme continues to grow. This year we have awarded ten Research Fellowships, more than ever before, and ten Industrial Fellowships, equal to last year’s record. We have also joined forces with the Royal Academy of Engineering to launch a new programme, an Enterprise Fellowship for Graduates. This builds on the Academy’s successful Enterprise Fellowship for postdocs by recognising that there are some extraordinarily innovative ideas being developed by undergraduates in their final year projects. We have provisionally agreed to fund three awards a year for an initial period of five years, to enable these ideas to be brought to the market, supported by the Academy’s Enterprise Hub which will provide mentoring and financial support. The first round saw over forty high quality applications and those selected for awards do UK inventiveness proud.

2016 was the second year of our collaboration with the Institution of Engineering and Technology, funding ‘Great Exhibition Scholarships’ to support engineering undergraduates. The scheme has attracted some excellent candidates but to date it has not received the anticipated support from industry to enable it to grow. This is disappointing given that, for a relatively modest outlay compared to normal recruitment costs, companies have the opportunity to nurture the brightest engineering undergraduates through their degrees and into employment. The IET will continue its efforts to expand this scheme which, according to the scholars, makes an enormous difference and allows them to devote more time to their studies rather than having to find work to support themselves.

Our Special Awards continue to support a broad range of activities, mainly focussed on promoting STEM. We have joined the National Science Learning Centre’s Project ENTHUSE, which aims to inspire teachers by providing access to specific professional development, and have agreed to fund a Primary School Science ENTHUSE award for achievement in primary STEM. The first award was made in July and evidenced some truly inspirational science teaching. We have also supported the launch of the Institute for Research in Schools which encourages schools to conduct live research, and the Young Science Journal, a high quality publication entirely written by sixth formers. Both these initiatives underline the extraordinary quality of science teaching and engagement in good schools and both organisations are extending their reach to those less advantaged ones.

It has long been our ambition to team up with the BBC to produce a programme that promotes Science and Engineering. This was realised at the end of May with the recording of a panel programme featuring three world famous civil engineers in the Victoria and Albert Museum for the BBC World Service. ‘The Engineers’ was an instant hit, with the ticket allocation snapped up within two hours of release. The live audience participated well and the programme was a great success. Plans are well advanced for a second programme, this time with a Robots theme, which will be recorded at the Science Museum next June.
The 1851 Group comprising Chairmen and Chief Executives of the legacy institutions continues to meet twice a year to generate ideas for closer co-operation across the estate. These meeting are always productive and I am delighted with the strengthening commitment from everyone to ensure that Albertopolis continues to thrive and with the determination to maintain our position as one of the world’s leading cultural quarters. There is growing support for a collaborative summer Festival, linking the activities of all the institutions with Exhibition Road as a conduit, and more detailed planning will start next year.

I hope these selected highlights of another very busy year will reassure readers of the continuing success and relevance of the Commission. This is only achieved through the hard work and commitment of our small staff and the wholehearted support of the Commissioners and Committee members. I am most grateful to them all and thank them for their hard work.

Bernard Taylor DL FRSC

Secretary’s Report

We continue to put great effort into raising awareness of our awards, particularly the PhD-linked Industrial Fellowships for which we would like more applications. With help from our media consultants, we have achieved significant coverage of these awards in professional media and some have featured in the national press. Much of the research we are funding, from the design of a liquid crystal contact lens to the development of new means of combating hospital superbugs, has excited journalists and is generating ever growing activity on social media. While we have yet to see a step increase in applications for these awards, numbers are growing slowly and the quality of candidates is better than ever.

The website attracts much praise and is proving an excellent way to publicise the extraordinary range of research activity the Commission is supporting and celebrating the achievements of our alumni. More and more of them are in touch with us and some of their achievements are reflected later in this report. Equally the reports of our award holders who completed their Fellowships this year reflect some remarkable successes and underline the real impact that the Commission’s awards are making. I hope you enjoy reading them.

Nigel Williams
The Work of the 1851 Royal Commission

The Commission’s aim is to ‘make a difference’ by providing educational fellowships and studentships to the very best early career scientists, engineers and designers. Success is hard to measure within the confines of a single year, but looked at over the longer term the Commission’s achievement is evident, with 13 Nobel Prize winners and over 150 Fellows of the Royal Society among its previous award winners. The case studies of completing fellows and summaries of alumni achievements later in this report also bear witness to the Commission’s success.

In addition to its core fellowship schemes, the Commission also provides special awards to its legacy institutions and to other organisations working to encourage STEM (science, technology, engineering and mathematics) education. Details of some of these awards and the impact they have made can also be found later in this report.

The Commission was originally established by Royal Charter in 1850 under the Presidency of Prince Albert, to organise and stage the Great Exhibition. Held in the spectacular Crystal Palace, constructed in Hyde Park, it was the first ever World Fair, and the most successful. With over 6 million visitors, it also made a substantial profit.

Consolidated by Supplemental Charter, and enjoined to invest the surplus from the Great Exhibition strictly in accordance with the ends of the Exhibition...[to] increase the means of industrial education and extend the influence of science and art upon productive industry the Commission purchased 87 acres of land in South Kensington and helped establish its three great museums, the Royal Albert Hall and renowned institutions of learning, including Imperial College and the Royal Colleges of Art and Music.

When this huge undertaking was complete, there remained sufficient funds for the Commission to initiate, in 1891, a programme of fellowships and studentships to support pure research in science and engineering, applied research in industry, industrial design and other projects.

The Commission continues its work to this day, both managing its freehold estate and awarding around £2.5m a year in research fellowships, design studentships and other grants. The provision of long leases to the legacy colleges and the Royal Albert Hall also make a very substantial contribution to scientific, engineering and artistic education.

Public Benefit

The Royal Commission ensures that its work is for the public benefit and takes full account of the published Charity Commission guidance. The Royal Commission’s grant giving and awards programmes and support of the legacy institutions represent identifiable benefits and are available to all eligible members of the public. They satisfy the primary charitable purpose of the advancement of education.
Grant-making Policies

The Commission pursues its charitable purposes through the award of grants to individuals and organisations. The Commission awards grants under a number of defined programmes. Full details of the terms and conditions for each programme, including application forms and deadlines where appropriate, are provided on the Commission’s website. A brief summary of the major programmes which the Commission supports is provided below:

Schemes administered by the Commission:

Post-doctoral Research Fellowships in Science or Engineering

These are intended to give early career scientists or engineers of exceptional promise the opportunity to conduct a research project of their own instigation; an ultimate objective is to contribute to the knowledge base required for a healthy and innovative national culture. Around eight awards are made each year, including the Brunel Fellowship for the highest placed successful candidate who has proposed a project to be pursued in an academic engineering environment. The awards are for up to three years, subject to annual review and encompass an annual stipend and some support for travel and other expenses.

Industrial Fellowships

These are intended to encourage profitable innovation and creativity in British industry. Projects in any science or engineering discipline will be considered. A variable number of awards is available each year depending on the financial value of individual awards granted. An ERA Foundation Fellowship for the electro-technology sector is awarded as part of the scheme. Fellowships are awarded to selected exceptional graduates with the potential to make an outstanding contribution to industry, for a programme of research, supported by their employing / sponsoring company, leading to a patent, product or process improvement in conjunction with a higher academic award. Awards are for up to three years, subject to annual review, and include a contribution towards living costs, a travel allowance, an honorarium for the host university and in appropriate cases a contribution towards university fees or towards the cost of enhancing the research project.

Industrial Design Studentships

These are intended to stimulate industrial design capability among the country’s most able science and engineering graduates. Around eight awards are offered each year for outstanding engineers or scientists who wish to develop their capabilities in industrial design by taking a recognised masters course and who aspire to become leading designers in British industry. The award is for up to two years and includes a stipend, materials allowance, travel allowance and contribution towards tuition fees.

Fellowships in Design and the Built Environment

Awarded in alternate years, these Fellowships each provide a stipend for up to two years to enable those at a more advanced stage in their career to explore important current issues, selected by the Commission.

Schemes administered by other organisations:

Enterprise Fellowships

Awarded through the Royal Academy of Engineering (RAEng), these fellowships are open to outstanding UK-resident engineering graduates seeking entrepreneurial success. A package of tailored mentoring, training and grant funding will enable recipients to pursue commercialisation of their technological ideas. Up to four fellowships a year are available.
**Great Exhibition Scholarships**

Awarded through The Institution of Engineering and Technology (IET), these scholarships are open to UK residents who achieve 3 A grades or above at ‘A’ level or equivalent joining an IET accredited undergraduate degree. Additional criteria may apply from year to year – full details are available on the IET website. Up to ten scholarships a year are available. Scholars receive an annual stipend.

**Special Awards:**

Although the educational programmes described above represent the lion’s share of its grant giving, the Commission also responds to all those requests for funding that commend themselves through the Special Awards procedure. Here the aim is to assist worthy individuals, organisations or projects whose aims in the broadest sense align to the Commission’s, and all applications are carefully scrutinised at an appropriate level according to the amount of support requested. Grants range from a few hundred pounds to over a hundred thousand pounds. While Commissioners retain considerable flexibility in principle, in practice a majority of special awards are made either to institutions on the Commission’s legacy estate or for educational outreach work by like-minded organisations seeking to draw the attention of the young to the opportunities presented by science, engineering and design.

**Achievements in 2016**

The core activity – and primary achievement – of the Commission is identifying early career science and engineering graduates of exceptional promise and supporting their work with its prestigious fellowships and studentships. Full details of the awards made during the year are given on pages 9 to 13.

Some evidence of the success of the various programmes can be gleaned from the achievements of those Fellows who completed their awards during the year and the positions they go on to secure. A representative sample of case studies is provided on pages 14 to 24.

Further evidence comes from the honours and awards bestowed on older alumni – some highlights are given on pages 25 to 26. A selection of more extended descriptions of the long term impact our Fellowships can have are given below; it will be seen that the influence and advantages extend well beyond just academic success:

*I truly believe that the 1851 fellowship has been crucial to my reaching my current position. It gave me a large degree of autonomy and research independence from a very early stage, and also gave me the confidence to apply for other competitive grants and funding schemes.*

Dr Brianna Mulvee, Research Fellow 2012

*The kind support of the 1851 Royal Commission allowed me to pursue postgraduate education that's directly aided the ability for me to unify my skills in business, engineering and innovation and effectively channel this into starting and running a successful, high growth, technology company helping companies across the globe protect their data.*

Mr Timothy Sadler, Industrial Design Student 2012
My 1851 Fellowship enabled me to join a world-leading genomics laboratory at the University of Oxford. The independence provided by this award at such an early stage of my career was critical for my development as a scientist and has since led to fellowships from the Medical Research Council, the Australian Research Council and the Australian National Health and Medical Research Council. I now lead a well-established research group at The University of Queensland using genomics to investigate antibiotic resistant “superbugs”. The Royal Commission for the Exhibition of 1851 Fellowship helped me in more ways than I could have imagined and I will always be grateful for the way it kick-started my career as an independent scientist.

Dr Scott Beatson, Research Fellow 2001

The research I did on holographic visualisation of supersonic air flows during my 1851 Royal Commission fellowship is now a distant memory. However, the impact the fellowship has had on my career has been long lasting.

The benefits have been on several levels. Firstly, the fellowship gave me the kudos, security and support necessary to undertake quality research within BAE, which is a commercial but also a highly innovative company. Without the fellowship, it would have been more difficult to protect a period of sustained research for long enough to make a real impact on the state-of-the-art. The result was innovations in holography that led to further awards, including the Thomas Hawksley gold medal from the Institute of Mechanical Engineers. The skills I learnt regarding the scientific process during this period have underpinned my whole working career, spanning subjects as diverse as telecommunications, video processing and non-destructive inspection of military and commercial aircraft.

In addition to the skills I gained, the recognition the fellowship has given me has been a lasting highlight on my career history that has created many career opportunities. A career is built from the experience amassed by a few key changes in employment and I believe that the 1851 fellowship may have made a critical difference in realising these positions. I therefore encourage students to strive for a fellowship, with the benefits and support it provides.

Dr Steve Parker, Industrial Fellow 1990

I remain eternally grateful for the support of the 1851 Royal Commission when I was a PhD student in Edinburgh. To say that the Commission enabled me to launch my career would be a massive understatement. In addition to my research, I am very active in local and national efforts regarding professional development for PhD students and postdocs. As part of those efforts I sit on the National Academies’ “Next Generation Researchers Initiative Committee” – a mouthful but, in essence, a group charged by the US Congress to address the growing difficulty faced by young researchers hoping to become the next generation of independent investigators in the biomedical sciences. My experience as a PhD student those many years ago helps inform my own thinking in this area, as does my strong connection to the UK (we are looking to other countries for creative thinking on this problem).

Professor John Boothroyd, Overseas Scholar 1976

The 1851 Fellowships have always had an international character and – as the examples above indicate – have had a worldwide impact. Another nice example is highlighted in a recent book entitled The Singapore Research Story, which traces and discusses the historical development of Singapore’s research and development policy, infrastructure and achievements over the last 25 years. In the foreword, Mr Lee Hsien Loong, Prime Minister of Singapore, singles out two key individuals, Professor Sydney Brenner, who helped to establish the Institute for Molecular and Cell Biology in 1985, and Professor Hang Chang Chieh, who made key contributions towards establishing Singapore’s core research and development infrastructure. Both Professor Brenner (1952-1954) and Professor Hang (1970 – 1973) were Overseas Scholars of the Royal Commission.
As well as its core fellowships and studentships, the Commission also runs a very successful special awards programme, supporting individuals and institutions with similar aims to the Commission. As in previous years, many of the awards reflect the Commission’s continuing commitment to raising the awareness of the young to the opportunities presented by science and engineering. In addition to the awards highlighted in the Chairman’s Report above, they include grants to support:

Young Engineers’ Making Knexions programme which inspires young children about engineering by giving them the opportunity to build models using K’Nex kits; London Transport Museum’s Discover Engineering classroom resource packs; the British Science Association Crest Awards, which recognise student project work in STEM; the Smallpeice Trust’s new residential course in electronics; and Kids Invent Stuff for a series of YouTube videos featuring children’s inventions.

Other Special Awards have focused on continuing to develop South Kensington as the premier destination for those interested in science, engineering and design, including grants to support the Victoria and Albert Museum’s engineering season, the Knightsbridge Neighbourhood Forum and the Exhibition Road Cultural Group.

Future Plans

Raising the profile of the Commission and its award schemes remains a high priority. Following a very successful collaboration with the BBC World Service in 2016, the Commission hopes this will develop into an annual public event showcasing the impact of engineering. Plans are already well advanced for a follow up event in 2017, themed around robots. Working with AprilSixProof, there are also plans to do more to publicise the work of our current award holders – in the hope of inspiring more of the brightest and best young scientists and engineers to apply in future.

The Commission also remains strongly committed to its legacy estate and to ensuring the whole is greater than the sum of its parts. As well as supporting greater collaboration between the legacy institutions, perhaps including development of an Exhibition Road Festival to which they would all contribute, the Commission hopes to devote more attention to developing a longer term vision for Albertopolis.

Engaging with our alumni also remains a high priority and the Commission will be giving further thought to ways in which they can help support our work. One obvious way in which alumni can help is through donations and bequests and we are very grateful to the late Professor Norman Sheppard FRS (Research Fellow 1949-1951) for remembering us in his will. Professor Sheppard was the founding Professor of Chemical Physics at the University of East Anglia and one of the pre-eminent chemical spectroscopists in the country.
Awards Granted in 2016

Research Fellows

Dr Obinna Abah
Subject: Quantum information machines in ion-trap systems
Queen’s University Belfast
The main goal of this project is to investigate the theory and possible experimental implementation of a quantum information engine in a cold ion-trap system. An information engine is a system which converts energy acquired through measurement into useful mechanical work. The project will model the ion trap as a time-dependent harmonic oscillator and engineer the heat reservoir with laser beams.

Dr Sinan Açikgöz
Subject: Novel assessment of tunnelling-induced damage for heritage masonry structures
University of Cambridge
Tunnelling can place heritage masonry structures at risk. Therefore, reliable methods to monitor and model response are crucial. This project proposes to monitor heritage structures affected by tunnelling with innovative sensors and use the monitoring data to improve current understanding and mathematical modelling techniques.

Dr Jack Alexander-Webber
Subject: A graphene-organic platform for spin-engineered optoelectronics
University of Cambridge
By engineering interfaces between chiral organic semiconductors and graphene, this project will overcome the obstacles facing chiral organic devices and develop the novel concept of “spin-engineered” optoelectronics, enabling ultra-low power displays and lighting which promise an eight-fold efficiency improvement over current display technologies.

Dr Andrea Cairoli
Subject: Active Lévy matter: emergence and universality
Imperial College London
Many living systems exhibit collective motion. Prominent examples are the flocking of birds and fish schools. At the same time, diverse animals also show Lévy motility patterns, which are usually adopted as optimal foraging strategies. Recent experiments indicate that biological organisms can exhibit Lévy behaviour and collective motion simultaneously. This project will investigate the interplay between the two phenomena and develop a theoretical framework to characterize the resulting universal behaviour.

Dr Brendan Dyck
Subject: Decoding granite microstructures
University of Cambridge
Microscopic structures preserved in rocks contain a unique record of the processes that occur deep in the Earth’s interior. Using powerful new techniques to interpret this record this project aims to construct a model of granite migration and solidification and reveal fundamental insights into the formation and evolution of the continents.

Dr Maria Florencia Iacaruso
Subject: How midbrain circuits integrate sensory information during target selection
University of Oxford
By recording neuronal activity in the superior colliculus while mice choose between visual and auditory cues previously associated with a reward, this project will identify fundamental principles of neural circuit organization underlying cognition and decision making and advance our knowledge about the neural basis for guiding attention in a multisensory world.
Dr Beth Mortimer
Subject: Linking physics and physiology: vibration sensing in insects  
University of Bristol
Using insect legs as model systems, this project will investigate substrate-borne vibration sensing. Useful for biology with potential applications in engineering and medicine, the project will link the physical and physiological vibration filtering mechanisms for three insect species that detect vibrations on different substrates: silk, plant tissue and the water surface.

Dr Ben Pilgrim
Subject: Stimuli-responsive molecular containers for biomimetic catalysis  
University of Cambridge
This project aims to develop self-assembled nanocapsules, capable of binding catalysts and other reactive species, and subsequently use these to control the rates of complex chemical reactions. Sequences of encapsulation and displacement events will produce feedback loops that enable bio-inspired regulation of the overall reaction pathway.

Dr Matthew Pusey
Subject: Notions of non-classicality as sources of quantum advantage  
University of Oxford
Control of individual quantum systems is enabling tasks that would be impossible in a classical world. However, we still understand little about the origin of these quantum advantages, making it difficult to find new ones. This project aims to study these origins in detail, focussing on rigorous notions of nonclassicality.

Dr Mehdi Saravani
Subject: Nonlinear evolution and causality beyond general relativity  
University of Nottingham
This project will focus on modelling evolving systems that exhibit strong gravity – such as stars collapsing to form black holes – in the most interesting alternatives to General Relativity. This is currently the most unexplored regime in gravity, where an alternative theory could still afford to make distinct predictions from GR. The project will shed light into the structure of black holes and compact stars and use them as a tool to test GR against alternatives.

Industrial Fellows

Mr Aaron Chadha
Subject: High-speed analysis of big video data  
Sponsor: BAFTA Research  
University College London
This project aims to develop robust and scalable methods for video indexing and similarity detection, under the presence of video distortion and with real-world constraints on cost, complexity and storage.

Ms Susanna Challinger
Subject: Work function study of materials including fingerprint recovery by electronic imaging  
Sponsor: KP Technology  
University of St Andrews
This project aims to develop instrumentation and techniques for electrical / optoelectronic characterisation of materials. It will also explore how to apply the technology within forensics.

Mr Thomas Fleming
Subject: Targeting DNA repair to combat chemoresistance  
Sponsor: AstraZeneca  
University of Oxford
This project aims to find new drugs to restore the efficacy of chemotherapy for hard-to-treat cancers, where the development of resistance to the anti-cancer drugs in the tumours leaves patients without other treatment options.
Mr Adam Funnell  
*Subject:* Dynamic photonic networks for UHD production services  
*Sponsor:* BBC Research and Development  
*University College London*

Future live TV productions face major challenges: new workflows based on commercial IT networks, and Ultra-High-Definition media sources with very high bitrates. This project will explore novel photonic network designs, using end-to-end rapidly reconfigurable fibre optic systems, to provide an intelligent, automated network capable of meeting future media requirements.

Mr Arnau Garriga Casanovas  
*Subject:* Robotic deployment of NDE probes inside aircraft engines for in situ inspection  
*Sponsor:* Rolls-Royce plc  
*Imperial College London*

A potentially major cracking issue in aircraft engines currently requires the engine to be dismantled to conduct inspections, with associated costs of near £0.5m per engine. This project aims to develop a snake-robot capable of inserting probes into the engine to perform inspections on-wing, i.e. without dismantling the engine.

Ms Jordan Homan  
*Subject:* Influence of acoustic mixing on energetic materials  
*Sponsor:* QinetiQ  
*Imperial College London*

Resonant Acoustic Mixing offers shorter mixing times, more efficient mixing and mixing in the end vessel. This project will investigate the influence of this novel mixing technique on the post-processing behaviour of energetic materials.

Ms Sheun Oshinbolu  
*Subject:* Analysis of critical quality attributes in monoclonal antibody for biopharmaceutical process development  
*Sponsor:* GlaxoSmithKline  
*University College London*

Monoclonal antibodies are proteins that are used to treat cancer and autoimmune diseases. These antibodies are produced for large-scale manufacture using engineered cells. This project aims to develop a Fluorescence Resonance Energy Transfer based dye assay to monitor aggregated monoclonal antibodies in crude feed materials that will fit within industrial capabilities.

Mr Tim Sudmeier  
*Subject:* Electrochemical ammonia production in molten salt systems for energy storage applications  
*Sponsor:* Siemens Corporate Technology  
*University of Oxford*

This project aims to develop an electrochemical way of producing ammonia to be used in conjunction with wind energy. Such a concept could not only solve the energy storage problems of wind power plants but also disrupt the highly CO2-emitting fertilizer industry which relies heavily on ammonia from the Haber-Bosch process.

Ms Louisa Waine  
*Subject:* Network design for low energy curing  
*Sponsor:* Akzonobel  
*University of Sheffield*

Low-energy cure is a key driver for the next generation of coatings across multiple coating business areas. This project aims to develop a step-change understanding in coating and polymer science, to deliver efficient ‘low energy’ coating which would be of significant benefit to the coatings industry and the environment.
Mr Fergus Watson
Subject: The prevalence and relevance of hospital biofilms and their inactivation by hydrogen peroxide vapour technology
Sponsor: Bioquell UK
University of Southampton
Multi-drug resistant organisms (MDROs) are a growing threat in hospitals, globally. Studies are starting to find these MDROs residing within the cracks and crevices of hospital surfaces in large communities known as biofilms. These biofilms are becoming recognised as prime suspects in hospital acquired infections (HAI). This project will investigate the role biofilms play in HAI and the effectiveness of hydrogen peroxide vapour technology in inactivating them.

Design Fellow

Dr Julia King
Subject: Healthier Cities
Mentor: Professor David Satterthwaite, International Institute for Environment and Development
The lack of sanitation, particularly in the context of cities in the majority world, is arguably the largest failure by the modernist planning project. It is also, when experienced at the individual level, the single biggest determinant in leading a healthy productive life. Whilst there is much emphasis on the problem, and the solutions required, it is often a conversation had by engineers, policy makers and human rights activists – not designers. Conventional sewerage systems are too expensive and pilot projects have remained small due to the institutional complexity that arises when attempting to scale projects from a few households to a city – mostly due to the management of the sheer volume of sewage. It is in this space that this project seeks to identify, design and prototype interventions to address the problem of how to deliver sustainable sanitation solutions in the context of disconnected marginalized communities. The intention is to work from the scale of the individual toilet all the way to micro treatment plants. These plants offer the currently largely untapped ability to manage effluent and convert that to water for a community who are deprived of both. An action based research approach will be taken in order to gain a more hands on perspective by actively participating rather than only observing, adding to emergent forms of architectural practice, particularly in contested and marginalized spaces, as the endeavour of a collaborative maker.

Industrial Design Students

- Mr James Bevan  University of Cambridge
- Mr Oliver Burgess  Royal College of Art
- Mr Shankho Chaudhuri  Royal College of Art
- Mr Nick Hooton  Royal College of Art
- Mr Lewis Hornby  Royal College of Art
- Mr David Leonard  Royal College of Art
- Mr Douglas Mann  Royal College of Art
- Mr Robert Turner  Royal College of Art
Great Exhibition Scholars

Mr Alexander Harri Bell-Thomas  University of Cambridge
Ms Shusma Balaji  University of Cambridge
Ms Felicia Cheut Wing Chang  University of Cambridge
Mr Callum Coghlan  University of Oxford
Ms Abigail Collins  Imperial College London
Ms Elizabeth Hawkings  University of Cambridge
Mr Oliver George Jones  University of Cambridge
Ms Sophie Oldroyd  University of Oxford
Ms Poppy Jo Oldroyd  Imperial College London
Mr Charles Spicer  University of Cambridge
Ms Käthe-Marie Klehe White  University of Cambridge

Enterprise Fellows

Mr Ming Kong  Tangi0
Mr Yang Lu  Vivacity Labs
Mr Henrik Hagemann  CustoMem
Mr Jack Hooper  Doppel

Special Awards Granted

Institute for Research in Schools – Launch event
Knightsbridge Neighbourhood Forum – Developing a Neighbourhood Plan
London Transport Museum – Discover Engineering classroom resource packs
Young Engineers – Making Knexions programme
Design and Technology Association – South Kensington lecture series
Victoria and Albert Museum – Engineering Season
Armourers’ and Brasiers’ Company – Cambridge Forum
Surrey Wildlife Trust – Nower Wood Education Centre
Foundation for Science and Technology – Sponsorship of debate
Thomas Luxford – Conference attendance
Progressive Palaeontology Organising Committee – 2017 Conference
Arkwright Scholarships Trust – Liaison officers
Campaign for Science and Engineering – Shaping the Future of Science event
British Science Association – Crest Awards portal
Smallpeice Trust – Electronics programme
University of Leicester – CENTA conference prize
Engineering Development Trust – First Edition
Engineering Development Trust – Engineering education scheme
Tomorrow’s Engineers – Impact research study
Institute for Research in Schools – Hub school pilot project
Kids Invent Stuff – Big Inventor, Little Inventor
Exhibition Road Cultural Group – 1851 Group projects
Imagine trying to solve a 5000 piece jigsaw puzzle. Finding the right arrangement among the many pieces can take days of searching, but one can tell if the puzzle has been finished correctly just by looking at it. The language of Turing machines allows one to discuss families of problems by how difficult they are. The family of “easy” problems is called “P”. The family of apparently difficult problems, for which solutions can be easily verified (such as jigsaw puzzles) are called “NP”. The P versus NP problem asks “is P=NP?” or “can a computer solve a jigsaw puzzle quickly?” A “yes” or “no” answer would have huge implications for artificial intelligence, cryptography and logistics.

Geometric Complexity Theory is a new approach to solving the P vs NP problem. It tries to understand the difference between these “easy” and “difficult” problems by characterising these problems in terms of their underlying symmetries. Surprisingly, these complicated symmetries are not new at all. Over the past eighty years, pure mathematicians have studied these symmetries in terms of “Kronecker” and “plethysm” coefficients. Each “coefficient” is simply a number which tells one what a certain symmetry looks like. Christopher’s research tries to understand the blueprints for constructing these complicated symmetries from their simplest building blocks. This is the same as being able to calculate the value of any Kronecker or plethysm coefficient. Christopher’s aim is to understand the whole blueprint by first considering what it looks like “generically” or “almost all of the time”. Put another way, he hopes to sketch an artist’s impression before doing the technical drawing.

During his fellowship, Christopher solved one half of this problem. Going forward, he aims to solve the other half of the problem and hence generically understand the symmetries underlying the P versus NP problem.

Christopher remains a postdoctoral research fellow at City University.

Dr Stephen Farry

*Project:* Probing the standard model using W boson decays at LHCb

Stephen’s research has concentrated on investigating a property of the Standard Model of Particle Physics known as “lepton universality”. Lepton universality states that three of the particles in the theory, the muon, electron and tau, are identical except for their mass. This property is a cornerstone of the model and can be tested by analysing data collected in proton-proton collisions at the Large Hadron Collider (LHC) in Geneva, Switzerland.

Stephen performed this measurement at the LHCb detector, one of the four main detectors on the LHC ring. He compared how often the W boson, a massive, unstable particle in the theory, decays into muons and taus respectively. Lepton universality predicts that they should occur at the same rate but previous measurements at the LEP collider indicated a slight excess of tau decays. Stephen exploited the unique features of the LHCb detector and developed new techniques to efficiently identify and reconstruct tau decays. While no deviation has yet been observed in W boson decays, other measurements made at LHCb have since added to the intrigue by reporting deviations in the decay of composite particles known as B mesons.

Stephen will continue his research on the LHCb experiment as a Research Associate at the University of Liverpool and exploit the ever increasing dataset collected by the LHC at even higher energies to make more and more precise tests of lepton universality. Any cracks in the Standard Model could open the window to the discovery of a more fundamental underlying theory governing our Universe.
Dr Robert Fordham  
*Project:* Defining the contribution of stromal cells in colorectal cancer  
*Cancer Research UK Beatson Institute, University of Glasgow*

Colorectal cancer (bowel cancer) is the third most common cancer, and the second biggest cause of cancer-related mortality, in the UK. While we know an increasing amount about the genetic faults (mutations) that lead to cells becoming cancerous, how cancer cells interact with their neighbours is less well-understood. The bowel is lined with epithelial cells, responsible for nutrient absorption; this layer is continually replenished. Underneath the epithelium are ‘stromal’ cells, including fibroblasts, blood vessels and muscle cells. Robert’s project studied the early events that occur during colorectal cancer formation, in particular the interactions that occur between mutated epithelial cells and underlying stromal cells. Using genetically-modified mouse models of human cancer containing fluorescently tagged fibroblasts he identified and isolated stromal cells from developing and established tumours and interrogated their secreted proteins, alongside analyses of collagen remodelling in vivo. Realising that most existing mouse models of human colorectal cancer actually present with tumours in the small intestine, rather than the colon, Robert also established a new mouse model for colorectal cancer by transplanting cells directly into the colon to generate colon tumours. Furthermore, using an unbiased genetic screening approach, Robert identified a gene called Med22, involved in the process of DNA transcription, which is essential for intestinal epithelial cells to divide and form tumours.

During the course of his Fellowship Robert took a keen interest in the clinical development of new biological therapies for cancer. As a result Robert has now taken his skills into the pharmaceutical industry as a Medical Scientific Liaison in Oncology with Merck Sharp and Dohme (MSD).

Dr Kallol Gupta  
*Project:* Understanding the gating mechanism of nicotinic acetylcholine receptors  
*University of Oxford*

Membrane proteins are molecular sentries of the cell, regulating exchange of molecules and information across the hydrophobic cell wall. Approximately 60% of marketed drugs target various membrane proteins. Oligomerisation of membrane proteins in response to lipid binding plays a critical role in many cell-signalling pathways but is often difficult to define or predict. Kallol’s research has developed a mass spectrometry platform that simultaneously determines the presence of interfacial lipids and oligomeric stability and shows how lipids act as key regulators of membrane protein association. Evaluation of oligomeric strength for oligomeric membrane proteins reveals an absence of interfacial lipids in membrane proteins with high oligomeric stability. In contrast, for weak oligomers, presence of interfacial lipids plays a pivotal role towards maintaining the structural assembly of oligomeric states, acting as “molecular glues”. Overall, by correlating interfacial strength with the presence of interfacial lipids Kallol’s research provides a rationale for understanding the role of lipids in both transient and stable interactions within a range of α-helical membrane proteins, including G-protein-coupled-receptors (GPCRs).

Kallol remains a Junior Research Fellow in the Chemistry Department at the University of Oxford where he is now focusing on understanding the various cellular pathways where membrane protein oligomerisation plays a central role and attempting to deconvolute those pathways.

Dr Hannah Joyce  
*Project:* Semiconductor nanowire-based solar cells  
*University of Cambridge*

Semiconductor nanowires are a relatively new class of material with impressive potential for future electronic devices, ranging from solar cells and lasers to quantum computers. Nanowires, featuring tiny diameters of 1/1000th the diameter of a human hair, can be manufactured cheaply, and can be engineered to absorb and emit light efficiently and to transport electrical current controllably. As the electronics industry is continually striving towards cheaper, more compact, more efficient and higher performance systems, nanowire components have emerged as prime candidates to drive electronics into the future.
Hannah’s fellowship broadly aimed to harness nanowires and to exploit their advantages in optoelectronic devices such as solar cells. During her fellowship she developed new techniques for “growing” nanowires with tightly controlled and tunable electronic properties. To ascertain these electronic properties, Hannah employed an unconventional approach using time-resolved terahertz spectroscopy. This technique is contact-free, meaning that the electrical properties can be measured without electrodes in a highly accurate and rapid manner. It was found that both electron lifetimes and electron mobilities in gallium arsenide (GaAs) nanowires can be markedly improved by overcoating the nanowires with a thick aluminium gallium arsenide (AlGaAs) shell layer at a high temperature. By tuning the growth parameters the crystal structures of indium arsenide (InAs) and GaAs nanowires could be switched between defect-free zinc-blende and perfect wurtzite, to achieve distinctive optical and electrical properties. Devices demonstrated included optically-switchable terahertz polarisers based on aligned GaAs nanowires and surface-sensitive transistors based on wurtzite InAs nanowires.

During the course of her fellowship, Hannah was appointed a University Lecturer at the University of Cambridge, where she now runs her own research group. She won the biennially-awarded Harold M. Manasevit Young Investigator Award in 2014 and has just been awarded the IEEE Photonics Society Young Investigator Award for 2017. In 2016 Hannah was awarded an ERC Starting Grant from the European Research Council to pursue her project “A CrossWire: A Cross-Correlated Approach to Engineering Nitride Nanowires”.

Dr Imran Rahman
Project: Echinoderms: A model system for investigating the origin of animals
University of Bristol / Oxford Museum of Natural History

The origin of animals was an incredibly significant event, which occurred deep in the history of life, more than half a billion years ago. To better understand this fundamental evolutionary radiation, Imran studied echinoderms (e.g. sea urchins, starfish), which are an ideal group for addressing major evolutionary questions because they possess an excellent fossil record (dating back over five hundred million years). Imran’s research used cutting-edge methods, including high-resolution CT scanning and computer simulations, to investigate the evolution of form and function in early fossil echinoderms. The results strongly support the theory that echinoderms evolved through stages with different types of symmetry, ultimately arriving at the five-fold pattern that characterizes all modern species. This pattern is thought to reflect changes in ecology through time and evolution. More broadly, these results are consistent with the idea that animals evolved through the gradual, stepwise acquisition of characters, even during their earliest history. Imran has also used digital imaging and computer simulations to investigate a wide range of other groups, including some of the oldest complex organisms on Earth, the iconic fossil trilobites, dinosaurs, and modern insects and brittle stars.

Imran has been awarded a three-year Museum Research Fellowship at the Oxford University Museum of Natural History. He will continue to work on the echinoderm fossil record, focusing on the pattern and process underlying the evolution of symmetry.
Dr James Shepherd  
*Project:* Towards accurate energies for actinide compounds  
*Rice University / Massachusetts Institute of Technology*

The aim of ab-initio theoretical chemistry is to understand all chemical properties with only atomic identities as a starting-point. This is extremely challenging because electrons are not classical particles, but instead exhibit correlated behaviour due to quantum mechanics. James’s project attempted to produce new electronic structure techniques grounded in wavefunction theories to compute the total energies of semi-metallic and metallic solids. Technology in high-accuracy wavefunction theory still lags behind prominent successes in density functional theory, especially when it comes to the treatment of solids. James therefore restricted himself to model systems. These model systems abstract away the details of the problem, whilst retaining the essential physics. There are two main models that James used: the Hubbard model, and the uniform electron gas. While at Rice University, James worked with colleagues to develop a new electronic structure theory that allows one to find the total energies of metals with approximately 5x greater accuracy and 1000x greater speed than conventional methods. His subsequent move to the Massachusetts Institute of Technology allowed him to collaborate with experimentalists and examine how electronic structure calculations can be used alongside experiment in exploring reaction mechanisms on the surfaces of solids.

James remains a postdoctoral fellow at MIT.

Dr Samuel Sinayoko  
*Project:* Identification of acoustic energy in turbulent flows  
*University of Southampton*

Sam’s research focused on understanding aeroacoustic noise sources with applications to aircraft noise and fan noise.

Fan noise has many applications including wind turbine noise and turbofan or propeller noise. Wind turbine noise is hampering the development of on shore wind turbines due to noise pollution concerns. This problem is likely to become even more acute in the future as turbine manufacturers continue to increase the diameter of wind turbines for greater energy efficiency. Sam’s research focused on developing analytical models that can be used to predict fan noise. During his Fellowship, Sam published a high impact paper that correctly models the effect of rotation on fan noise. Sam was able to identify and fix a long standing error in the literature with regards to this problem. Furthermore, Sam’s prediction methodology can also be used to predict the noise of high speed turbo fans such as those currently used in modern aircraft engines. Last but not least, Sam conducted a pioneering theoretical study on reducing fan noise with the help of sawtooth serrations placed at the trailing edge of the wing. This study improves the accuracy of previous theoretical works by an order of magnitude.

During his Fellowship, Sam also conducted several studies on jet noise, the primary source of aircraft noise during take-off. Sam authored two ground breaking papers on the importance of nonlinear effects on the sources of jet noise and on the usefulness of describing turbulent jets in the Fourier domain.

Sam is now a Data Scientist at BMLL Technologies Ltd.
Industrial Fellows

Dr James Bannock
Subject: High volume production of polymeric materials for organic solar cells
Sponsor: Millenium Inorganic Chemicals
Chemical flow reactors (micro-reactors) are an emerging technology with exciting potential for manufacturing a broad range of low-volume, high-value advanced materials. Interest from UK industry is being driven by favourable cost economics in combination with rapid process development. James’s project sought to develop a combination of new flow reactor technologies and process chemistries to establish the capability to prepare large quantities of high performance electronic materials. This aim has been achieved through the development of a large-scale reactor capable of producing in excess of one kilogram of semiconducting polymers per day. Optimised synthesis and purification processes resulted in best in class electronic performance – with 7% peak power conversion efficiency photovoltaic cells having been fabricated by his collaborators. James has supplied flow-synthesised polymers for a broad range of academic and industrial led projects in organic electronics and bioelectronics, leading to a total of fifteen academic publications over the fellowship period.

Working in collaboration with Millennium Inorganic Chemicals, James placed a strong emphasis on developing general-purpose solutions that can be adapted to a variety of chemical reactions. As a result, he has generated a portfolio of flow reactor hardware, including fluid delivery systems, process control instruments and on-stream analytical instrumentation.

James is currently an EPSRC Doctoral Prize Fellow in the Department of Chemistry at Imperial College London.

Mr Jordan Conway
Subject: Novel materials for bone growth
Sponsor: Sirakoss Ltd
Jordan’s fellowship involved detailed analysis and characterisation of the synthesis mechanism for a novel granule bone graft product and assessment of the impact of the introduction of new equipment, installation, operation and performance qualification to ISO13485 standards to demonstrate product efficacy and repeatability in synthesis. This enabled the complete technology transfer from university lab based research synthesis to large scale, original equipment manufacturer (OEM) manufacturing.

Once full scale OEM production had been demonstrated, a feedstock supply of granules was provided which enabled a new gel formulation to be researched and developed which incorporated these granules. This involved numerous synthesis formulations to produce polymeric gels which were combined with bone repairing matrix to enable a novel handling material, ready to use in orthopaedic procedures. Lab based testing of these samples involved dissolution soaking experiments, cell culture based experiments, consideration of sterilisation methods and finally preclinical study design so that this product could be scheduled for OEM mass production towards the end of 2016.

Much of this work was of great benefit to the sponsor company and ultimately the pioneering work undertaken was relayed to the company research and development team to enable commercialisation of some aspects of the fellowship activities.

Jordan remains Research and Development Manager at Sirakoss Ltd.
Mr James Palles-Dimmock

Subject: Realisation of a hot carrier solar cell
Sponsor: Sharp Laboratories of Europe Ltd

James’s project involved the development and experimental investigation of a new method of photovoltaic energy conversion: the hot carrier photovoltaic cell. This type of cell has the potential of doubling the efficiency of standard photovoltaics by more efficiently using the sun’s energy and reducing the energy lost to heat in solar cells. In conventional solar cells, light incident on the cell generates electrons, with shorter wavelengths of light generating electrons with higher kinetic energy. This extra energy is lost in a conventional cell, as the electrons lose energy to the lattice before being electrically extracted. The aim of a hot carrier cell is to extract the electrons quickly enough such that this extra energy can contribute to the device efficiency, promising a thermodynamic maximum efficiency of 85%.

Two methods of realising such a cell were conceived and experimentally verified during James’s project: one using absorption of light in a semiconductor and one using absorption of light in a metal. The first method, using a semiconductor absorber, showed that hot carrier extraction was possible from a structure which could operate as a photovoltaic cell. The second method, using a metallic absorber, built on this proof of principle but with a higher total absorption possible. These inventions resulted in two patents and generated follow on projects investigating the promise of hot carrier effects in optical sensors.

James remains a senior researcher in optoelectronics at Sharp Laboratories of Europe and is building on the work started during the fellowship to develop optical sensors using hot carrier effects.

Mr Stephen Greenland

Subject: Rapid realisation of novel nanosatellite mission
Sponsor: Clyde Space Ltd

Stephen’s project involved the development of a series of products and services focussed around the core principal of opening access to space. Following the launch of the UK Space Agency UKube-1 mission, Stephen was able to build a case for strategic investment by a number of large national organisations, in turn enabling development of an end-to-end missions development kit for nanosatellites called NANOBED. Stephen concentrated on consolidating the architecture around four nanosatellite systems engineering pillars: a ‘FlatSat’ equipped with a flight representative hardware and software; the *craft CubeSat Design Tool software, supporting system engineering design and deployment; peer to peer centric standardized processes around integration; and application-specific development for payloads. With prototype infrastructure in place across the UK, Stephen also took the opportunity to export the concept to Mexico, securing an international partnership through a UK Space Agency grant. NANOBED now represents a key offering from the sponsoring company, supported by other UK commercial partners in delivery. In addition, the university, with its own NANOBED missions lab facility, continues to play a key role in follow-on research and development, hosting visits from a number of high profile potential collaborators and customers.

Stephen is now focusing on completing his PhD at the University of Strathclyde.
Ms Brianna Stubbs  
**Subject:** Effects of ketosis on human performance  
**Sponsor:** TdeltaS Ltd  
**University of Oxford**  
Ketone bodies are biological molecules produced naturally as a result of a period of prolonged carbohydrate deprivation. They act as a metabolic fuel or as a signal and have the potential to improve human performance and to be used as an adjuvant in the treatment of a wide variety of diseases. In order to harness the broad benefits of ketosis, TdeltaS Ltd has developed a ketone ester drink, ΔG®, that rapidly elevates levels of ketones in the blood to create ‘fed ketosis,’ without the need for fasting or a strict low-carbohydrate diet.

Brianna’s research has investigated the effects of ketone drinks on resting physiology. ΔG® drinks were shown to reliably raise blood ketone levels with a repeatable metabolic effect; lowering blood glucose and free-fatty acid levels, with a low incidence of side effects. Ketone appearance was decreased following consumption of a meal but was no different when drinks were consumed in series, showing that ΔG® would be effective if taken 3 times daily around meals. Through comparison with ketone salt drinks, it was illustrated that only the physiological enantiomer of β-hydroxybutyrate, as exclusively delivered by ΔG®, could be readily removed from the body. Finally, it was discovered that muscle carbohydrate facilitated ketone oxidation, meaning that ‘fed ketosis’ is a unique state in which the body can benefit from using ketones and carbohydrate as a fuel. Insights gained through her work will be vital for future wider use of ΔG®.

Brianna has been awarded a Gold level EIT Health Doctoral Innovation Fellowship to support her continued work on the development of ΔG® until September 2017.

Mr Patrick Cottam  
**Subject:** Novel fabric construction methods for solar thermal chimney power plants  
**Sponsor:** Lindstrand Technologies Ltd  
**University College London**  
Solar thermal chimneys (STCs) are large-scale solar power plants consisting of a transparent canopy (the solar collector), a tall chimney and a set of turbines and generators. Economically viable STCs need to be very large to increase plant efficiency, with a large, circular collector and a tall chimney, generating upwards of 100 MW. Such large structures present significant engineering challenges which conventional construction practice may not be able to meet at a cost that would keep the technology competitive. This project proposed and developed innovative solutions for both canopy and chimney design and construction. A comprehensive thermodynamic model of the solar power plant was developed and showed that significant and cost-effective performance improvements can be achieved through novel designs of the collector canopy and careful matching of the dimensions of the collector and chimney.

This project also assessed the feasibility of the concept of a suspended chimney – a chimney manufactured from industrial gas-tight fabrics and held aloft with envelopes of lighter-than-air gas. This solution overcomes the traditional structural issues caused by the chimney self-weight. The project has produced a scalable fabric chimney design with sufficient lateral stiffness to withstand wind loads. Theoretical models were developed and three prototypes of increasing size were successfully manufactured and tested in close collaboration with the industrial partner, Lindstrand Technologies. Preliminary design calculations for the scaling of the design to the heights required for STC power plants have been conducted, indicating the technical feasibility and potential for the fabric structures to provide significant cost savings compared to current solutions.

Patrick is now training to become a physics teacher with Researchers in Schools (RiS). This is a new charitable organisation, formed from the highly-successful Brilliant Club, which takes doctoral and post-doctoral researchers and enables them to move into secondary school education, providing a bespoke programme and resources to enable them to make the most of their research expertise in a school environment. Patrick has an additional focus beyond his lessons to widen university participation among under-represented groups, such as ethnic minorities, female students (in certain subjects), or those from unconventional or difficult backgrounds (e.g. involvement with local authority care institutions). Patrick is working at Digitech Studio School in Bristol, a new school with a focus on creative digital technologies. Studio schools are a new model of school designed to respond to current issues with education identified by employers. Students wear suits and attend a “normal” working day. Digitech works closely with several local employers and holds regular project immersion weeks for all students in the school, where employers set a project-based task for the students to complete.
Dr Jethro Coulson  
**Subject:** Spatially resolved acoustic spectroscopy technology development project  
**Sponsor:** Renishaw plc  

Jethro’s EngD research focused on the development of a new piece of technology, spatially resolved acoustic spectroscopy (SRAS), with the overarching goal to adapt the technique from a laboratory based concept demonstrator, to an industrial prototype suitable for manufacture.

SRAS is a laser ultrasound technique which remotely generates and detects surface acoustic waves (SAWs). Through careful analysis of these waves, the crystallographic microstructure of a metallic sample surface can be characterised. Although small in scale, typically 10’s of microns, this microstructure can strongly influence the macroscopic properties, and behaviour, of engineered parts. Thus validation and characterisation of these parts is essential. SRAS provides a means to perform this inspection non-destructively on as-formed components.

With the support of Renishaw, SRAS has been adapted into an industrial prototype based on a novel opto-mechanical platform. Significant progress has been made in incorporating sophisticated processing techniques to the measurement of SAWs, providing improved quality SRAS data. New auto-focus algorithms have been developed which allow far greater automation of sample inspection. Finally, a model of laser-generated ultrasound has been developed and used to provide insight into the process of SRAS measurements.

Jethro has accepted an offer to continue as a design and development engineer at Renishaw plc.

Mr Julian Hodgson  
**Subject:** Editing fluid simulations  
**Sponsor:** Passion Pictures / Cinesite VFX Ltd  

Julian’s research involves designing and editing fluid flows for special effects in movies and animation, with the final year of the fellowship at Cinesite providing an opportunity to develop his research in an industrial environment. Working closely with effects supervisors on the film *Independence Day: Resurgence* he was able to create tools that addressed specific production needs arising during the show. The tools enabled the creation of fluid like flows to augment existing simulations in a physically plausible manner within the latest production environment, avoiding costly new fluid simulations. The workflow developed has the potential to accelerate production of smoke simulations by rapidly addressing feedback from directors and clients. Through the efficient and targeted creation of realistic alternative flows, valuable time can be saved.

For greater accessibility by artists, the software was built into the 3D applications Houdini and Maya, being the most commonly used applications in the special effects industry. It was further integrated into Cinesite’s software pipeline to take advantage of their high performance computing cluster.

Julian is now working for the animation studio Mikros, leading the development of effects tools in Houdini. He plans to continue developing his techniques in industry, focusing on real-time fluid simulations.

Dr Alessandro Marco Lizzul  
**Subject:** Integrated production of algal biomass  
**Sponsor:** Varicon Aqua Solutions Ltd  

Marco’s project focused on better understanding the use of wastewater as a feedstock to grow microalgae and the development of a UK cost model for wastewater treatment using a novel algal photobioreactor. Marco has overseen the design, construction and characterisation of a novel airlift photobioreactor (the ALR), which has a broad range of applications within the sector. The ALR has been commercialised with Varicon Aqua with a number of units sold. Varicon expect this market to expand considerably in the coming years.

Marco is now the Innovation Manager for Varicon Aqua Solutions Ltd. Since commencement of full time employment at Varicon Aqua, Marco has updated website and communications materials, improved project management practices, developed a strategy to expand the company’s network of suppliers and customers and made a successful application for an innovate UK grant for the development of a ‘next generation’ photobioreactor, which could lead to a step change in technology.
Mr Shuning 'Steve' Bian  
*Subject:* 3D real time imaging for ultrasound enhanced drug delivery  
*Sponsor:* Lein Applied Diagnostics  
*University of Oxford*  
Cancer chemotherapy is limited by the fact that drugs cannot penetrate into the core of tumours. Many methods of enhancing drug penetration are being investigated. One of the most promising is to mix drugs with microbubbles and then burst the bubbles with a blast of ultrasound. This has been shown to create shockwaves which can push drugs into and through tumours. Studying these processes is very challenging as existing instruments cannot image within samples during ultrasound exposure due to limited working distance and depth discrimination. Steve’s project involved the design and development of a long working distance confocal laser scanning microscope and associated software that enables, for the first time, the concentration of a drug within a tissue sample or a tissue mimicking phantom to be mapped in three dimensions in situ in real-time during ultrasound exposure. The developed instrument has been successfully used to study the cavitation patterns in tissue mimicking phantoms generated by acoustically activated droplets, (nanoparticle loaded) microbubbles and drug eluting beads.

Steve is now a lead engineer at BioCarbon Engineering, a UK-based start-up with the aim of combating climate change through industrial reforestation using UAVs on the scale of billions of trees every year.

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**Industrial Design Students**

Mr John Bertolaso  
*Course:* Global Innovation Design  
*Royal College of Art*  
Throughout his studies, John has worked at the intersection of art and science to tackle complex challenges and defy the status quo.

For his solo project, he focused on the apparel industry and its enormous social, cultural and environmental significance. With growing outputs and dropping prices, it is currently built on a linear model which promotes the disposal of garments. His project *Generations* was an exploration of more sustainable ways to create garments. In collaboration with menswear designer Bianca Saunders, John developed a range of modular garments suitable for transformation. By combining modular patterns with assembly processes which allow for deconstruction and reconstruction, it is possible to extend the life of textiles and re-use them in different forms. The major driving force behind this approach was the concern to keep apparel out of waste streams and to reduce our dependency on raw materials.

John’s final year group project explored the future of food and agriculture. With a world of unsustainable farming practices, record high obesity rates in the West and huge amounts of food waste, it is clear that our relationship with food and its production is flawed. Together with fellow student Gabriel Brückner and fellow award holder Edward Brial, he developed *Spring*, a compact automated growing environment that empowers anyone to cultivate fresh produce in the home. More than a simple appliance, *Spring* serves as a probe into ways in which we can live more symbiotically with nature.

John is currently working as a designer and a mechanical engineer in the field of interactive arts and design. He aims to provoke, question and inspire through delightful immersive experiences. His ultimate goal is to apply his experience and knowledge in the international development sector.
Mr Edward Brial

Course: Global Innovation Design

Edward’s final group project, Spring, is a compact growing environment that empowers anyone to cultivate fresh produce in the home, by combining hydroponics and environmental control. Looking at contemporary urban lifestyles, a strong desire was found for people to grow their own food, however a lack of space and time resulted in this need being ignored and unresolved. Spring was designed in response to this problem with fellow award holder John Bertolaso and Global Innovation Design student Gabriel Brückner. By confronting people with the growing process and the provenance of their food in a simple and convenient way, Spring is a means to rebuild a fading relationship between us and what we eat.

For his final year solo project Edward designed Promethean, a platform for teaching young teenagers about the relevance and application of creativity and its broader importance in life. The project was borne out of an interest in how people from different cultures and socioeconomic backgrounds can be united through youth culture. An investigation into the barriers of socioeconomic mobility led to the core insight that creativity is a key ‘hard skill’ for the future of work. It is a core competency that all workers will need in the future, yet it declines generationally and through current education practices. Promethean teaches creativity through activity-based workshops, which have been developed from cutting edge research. Promethean has now been piloted through multiple creative cooking workshops and a web application. It was also a finalist for the Helen Hamlyn award for creativity 2016.

Edward is now exploring ways in which to combine his background in art, design and engineering to look at the communication of ideas around the social and environmental sustainability of energy, food and clothing.

Mr Antoni Pakowski

Course: Innovation Design Engineering

Antoni’s final year solo project, AURA, explored the potential for reducing food waste in households by amplifying the natural beauty of food in a household fridge, making it look more appealing to the consumer. Supermarkets have very specific lighting in each aisle, designed to make the particular food groups look optimal. When such food is brought home and stored in the refrigerator, it loses this aesthetic dimension.

As a result of this project Antoni has developed an innovative, dynamic lighting system, which detects the contents of a refrigerator shelf through computer vision, and then dynamically adjusts the lighting conditions to tailor it to particular items located on the shelf. The optimized aesthetics encourage the user to consume the products, as opposed to letting them perish.

After completing his course, Antoni, with co-founder Charles Leclercq, went on to create Kodama, a new platform allowing children to engage in interactive gameplay. As opposed to the current standard of touch interfaces, which have an isolating effect on children, Kodama aims to bring children to play together, engaging in a new form of gameplay designed to challenge the child’s imagination and build confidence in creativity. Kodama, at its core, focuses on tangible human-to-human interactions.

Mr Karolis Šikšnius

Course: Industrial Systems, Manufacturing and Management

Karolis’ master’s thesis focused on investigating servitization and scaling phenomena. Servitization is a transformational journey where traditional manufacturers embrace new technology (e.g. digital technology) and organisational change to offer product- and outcome-oriented services. For instance, Rolls-Royce provides a “power by the hour” service which includes leasing an engine, servicing, maintenance and flight route planning at a fixed cost per hour of flying time. Although services enable sustainable growth and strengthen cash-flow, it is a challenging strategy. Research suggests that failure rates of scaling such services lie between 50 to 90%, ultimately leading approximately 25% of the companies to bankruptcy.
The thesis made contributions to theory and practice. It highlighted gaps and tensions in the commercial service scaling process, confirmed elements relevant to the success of the scaling journey and helped develop a CIIRCLES framework that guides scaling practitioners. The research also emphasised procedural shortcomings in scaling approaches employed by WHO and IFAD in various development initiatives, aimed at achieving Sustainable Development Goals (United Nations, 2016).

Karolis is now a manufacturing engineer working for an aerospace engine manufacturer, Rolls-Royce, and is collaborating with the Cambridge Service Alliance to advance the knowledge of service scaling.

Ms Faye Webber  
*Course:* Industrial Systems, Manufacturing and Management  
*University of Cambridge*  
Faye undertook four paired industrial projects and one individual project. The first paired project focused on increasing end of line electrical first time through performance in a new assembly area at Jaguar Land Rover. Faye retrieved and analysed data to reduce the number of vehicles failing the end of line assembly test and proposed a new solution which could potentially increase the end of line performance by 7%.

The second project was undertaken at GPS PE Pipe Systems, a UK leading piping manufacturer. Faye was tasked with improving the services layout for a polyethylene extrusion process. Using Computer Aided Design techniques and data analysis, Faye proposed multiple floor layouts (short, medium and long term) for a hopper feeding system to enable maintenance and alterations to be carried out more efficiently.

A third paired project was completed at Milbank, a concrete panel manufacturer, to utilise Faye’s knowledge of marketing. Faye proposed a clear vision of where the company should be in five years’ time and a strategy on how the company could achieve profitable growth by penetrating different markets.

The last paired project was at Rolls-Royce where Faye researched advanced technologies for aero and marine engines and proposed new concepts. The four projects presented Faye with challenges in genuine industrial and business environments and enabled her to apply her knowledge gained at university to resolve current industrial problems.

Her individual project spanned four months, researching into Reconfigurable Manufacturing Systems (RMSs) which have emerged as the new manufacturing paradigm in the twenty first century to economically mass produce customised products. Faye conducted multiple case studies, speaking to a variety of companies to understand how industries are economically manufacturing customised products and if RMSs are utilised. Her conclusions were summarised into three frameworks.

Faye is now a Graduate Design Engineer at Dyson working within the Research, Design and Development Department at Dyson's Headquarters in Malmesbury, UK.
Alumni Awards, Honours and Achievements

A selection of the alumni appointments, publications, honours and awards notified to the Commission. The Commission encourages all alumni to keep their alumni profiles up to date so that their successes can be celebrated.

Overseas Scholars

Professor John Boothroyd (1976-1979)
– Appointed Burt and Marion Avery Endowed Professor in Immunology, Stanford University
– Elected to National Academy of Sciences, USA

Professor Hugh Bradlow (1974-1977)
– Appointed President of the Australian Academy of Technological Sciences and Engineering

Professor John White (1959-1961)
– Made Officer of the Order of Australia in the Queen’s Birthday Honours List for distinguished service to science globally in the field of chemistry, as an academic, mentor and researcher, and through leadership of synchrotron and neutron science projects in Australia and the Asia-Oceania region

Research Fellows

Dr Scott Beatson (2001-2003)
– Awarded Frank Fenner Award, Australian Society for Microbiology

Dr Stephen Montgomery (2011-2014)
– Awarded NERC Independent Research Fellowship

Dr Brianna Mulvee (2012-2015)
– Awarded EPSRC Early Career Fellowship

Dr Elizabeth New (2009-2011)
– Awarded NSW Early Career Researcher of the Year, Premier’s Awards for Science and Engineering

Dr Suzie Sheehy (2010-2013)
– Awarded Science in Society Prize, Institute of Physics High Energy Physics Group

Industrial Fellows

Dr Alan Bloodworth (1996-1999)
– Appointed Principal Teaching Fellow and Course Director for the MSc Tunnelling and Underground Space in the School of Engineering, University of Warwick

Dr Jon Otter (2005-2008)
– Appointed Honorary Senior Lecturer, National Institute for Health Research Health Protection Research Unit, Imperial College London
Industrial Design Students

Mr Duncan Fitzsimons (2005-2007)
– Awarded Red Dot Award for Dial (dateable food storage container)
– Awarded Patient Innovation Award for Morph Wheel (folding wheel for wheel chair)
– Awarded MediWales and Medilink Healthcare Start Up of the Year for Salar Surgical’s SP-Eye (intravitreal injection device)

Mr Yusuf Muhammad (2006-2008)
– Awarded Red Dot: Best of the Best award for Automist Smartscan (innovative, retrofittable fire sprinkler)
– Featured in BBC documentary, the Big Life Fix

Mr Timothy Sadler (2012-2014)
– Awarded best machine intelligence start-up by LegalGeek for CheckRecipient (using artificial intelligence and machine learning to secure enterprise information across email networks)
– Awarded best UK security start-up by WIRED magazine for CheckRecipient
– Selected as one of Forbes’ ‘30 under 30’ for technology

Mr Adam Sutcliffe (2005-2006)
– Appointed Co-Director of the Design, Innovation and Creative Engineering degree programme at Queen Mary University of London

Design Fellows

Mr Adrian Westaway (2009-2011)
– Awarded Red Dot Product Design Award for QardioBase (internet connected weighing scale)
– Awarded Helen Hamlyn Alumni Award for services to Inclusive Design
Organisation

The Board of Management has appointed the Finance Committee as a sub-committee to supervise the Commission’s finances and investments; this Committee meets at least twice a year and during 2016 met two times.

The Commission’s auditors

In 2008, Kingston Smith LLP was appointed the Commission’s auditors following a competitive tender. The audit partner meets with the Finance Committee at least once each year. In the interests of good governance the audit manager changes at least every five years and the audit partner at least every ten years.

Sources of funding

The Commission’s income and gains derive primarily from its investment portfolio. In 2016, property (the Commission’s estate) made up 15%, cash 1% and stock market investments and bonds 84% of the capital assets (for 2015 the corresponding figures were 15%, 2% and 83% respectively).

On occasion, the Commission is fortunate to receive donations and bequests from alumni. In 2016, the Commission received a bequest of £3,000 from the estate of the late Professor Norman Sheppard FRS, who held an 1851 Research Fellowship at the University of Cambridge 1949-1951. The Commission extends its grateful thanks to Professor Sheppard’s family.

Reserves policy

The total funds at the balance sheet date were £104,944,474 (2015: £92,699,461).

As noted above, these funds originated from the surplus arising from the Great Exhibition of 1851 and have been enhanced by careful stewardship of the assets invested over many years. They are technically unrestricted, giving the Commissioners the ability to spend the funds as they wish in fulfilment of the charitable objectives of the Commission. None of the funds are in assets that cannot readily be realised.

In order to balance the needs of current and potential future beneficiaries of the charity, the Commissioners recognise the need to maintain a strong capital base so as to deliver an appropriate level of return to enable the Commission to continue to fulfil its charitable objectives on a long term basis. Accordingly, all of the Commission’s funds are invested in line with the investment policy described below and normal expenditure commitments are set to match the assumed average return above inflation delivered by the portfolio.

Given the Commission’s flexibility to spend capital if required, the Commissioners do not consider that there is any merit in identifying an optimum level of free reserves that might be readily available if required, but will respond appropriately to spending needs identified as and when circumstances arise.

Investment policy

The Commission’s overall investment objective is to achieve sufficient total returns to fund its existing award programmes whilst also protecting the capital value of its portfolio for the benefit of future beneficiaries. The Commission reviews its asset allocation and manager selection on a regular basis with this objective in mind.
The Commission has determined that a strategic asset allocation biased heavily in favour of ‘real’ assets (equities, properties, commodities, etc) as opposed to ‘nominal’ assets (cash, bonds etc) gives it the best chance of meeting its overall investment objective. In order to ensure sufficient liquidity that grant commitments should always be able to be met without the need to sell assets at distressed prices, Commissioners have determined that a minimum of £10m should normally be held in ‘nominal’ assets such as cash and bonds; beyond this, it is expected that the portfolio will normally comprise ‘real’ assets. In recognition of the current economic environment, in particular the impact of quantitative easing and the likely normalisation of interest rates over the coming period, Commissioners have taken a tactical decision to temporarily reduce the minimum nominal asset holding to £5m.

As at the balance sheet date, the Commission’s portfolio was spread across three investment managers: a global equity fund of approximately £52m managed by Schroders (C.I.) Ltd; a portfolio of exchange traded funds of approximately £30m actively managed by Charles Stanley Pan-Asset and an investment of approximately £8.5m in a strategic bond fund managed by JP Morgan Asset Management Ltd. The Commission also owns the freehold of various properties on its legacy estate in South Kensington valued at £16.5m.

The overall portfolio targets an absolute annual return of RPI + 4%, after all charges; there is no income target although the composition of the portfolio is such that income of around 3% pa is expected. Each fund manager also compares performance against appropriate market and sector benchmarks.

The Commission expects its investment managers to take governance considerations into account when evaluating investments but has not adopted specific social, environmental or ethical criteria as its charitable purposes and activities encompass support for all legal enterprises that involve a scientific, engineering or design element.

Disbursement policy

The Commission’s long term aim is to disburse approximately 4% per annum of the trailing three-year average closing capital value of its investment portfolio.

Liquidity is maintained at a sufficient level to ensure the cash outside the investment portfolio is enough to cover short-term expenditure.

Comments on the results for the year


The total return comprises income and gains. The annual income generated in 2016 by the Commission’s assets was £2,600,909 or approximately 2.7% of opening portfolio value, very much in line with the previous year (2015: £2,603,902, 2.7%). Given the structure of the portfolio, relatively stable income can be expected from year to year. Stock market volatility means that the level of investment gains is unlikely to be as stable, although over time gains should outweigh losses. In 2016, the Commission’s liquid investment portfolio enjoyed gains of £12,304,743 (2015: losses of £1,778,434) with a further boost from revaluation gains on directly held property of £858,367 (2015: gains of £866,718).

Expenditure on raising funds – which primarily comprises investment and property management fees – increased from £482,330 to £520,772. This increase primarily reflects fees incurred in connection with property transactions on the Commission’s South Kensington estate, including a lease surrender and freehold enfranchisement claim.

Total expenditure on charitable activities of £2,934,812 was £139,415 more than the previous year, primarily reflecting the award of an additional Research Fellowship, an additional Industrial Design Studentship and the costs of the Alumni Reception held at Buckingham Palace, which collectively outweighed a reduction in the number of high value Special Awards.
Overview

2016 was a surprisingly good year for UK based investors, with the fall in the value of sterling following the June referendum providing a boost to returns on overseas assets.

Overall the Commission achieved a total return of approximately 16%, comfortably ahead of the RPI + 4% target for the year of 6.5%, peer group indices such as the ARC Equity Risk Charity Index (10.7%) and of course LIBOR (0.5%), although below the MSCI AC World ex UK Index (29.1%), FTSE All Share Index (16.8%) and IA Global Equity Index (24.0%). This contrasts with 2015 when the total return was 1.4%, compared to a target of 5.2%, a FTSE All Share return of 1.0%, MSCI AC World ex UK return of 0.6%, a LIBOR rate of 0.5%, ARC Equity Risk Charity Index of 1.0% and IA Global Equity Index of 4.1%.

Looking at the last five years together, since the current investment policy was established, the value of the portfolio has grown by approximately 9% pa, well above the 2.2% pa rate required to keep pace with inflation. Clearly, the financial position and performance of the Commission year to year is sensitive to movements on world stock markets but the outperformance over recent years means the Commission’s financial position is extremely strong. Moreover, while volatility will affect short term performance, the portfolio is well positioned to capture returns over the long term.

Disbursements during the year fell slightly to 3.3% of the trailing three year average closing capital value of the portfolio compared to a target of 4.0% (2015: disbursements of 3.5% compared to a target of 4.0%); this despite the award of an additional Research Fellowship and an additional Industrial Design Studentship. The fall largely reflects the fact that there were fewer high value special awards this year. The under spend will be carried forward for future use and Commissioners will be conscious of the scope to increase disbursements over the coming years.

Sir William Castell LVO
Royal Commission for the Exhibition of 1851


<table>
<thead>
<tr>
<th>Notes</th>
<th>Unrestricted Funds 2016</th>
<th>Unrestricted Funds 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>£</td>
<td>£</td>
</tr>
<tr>
<td><strong>Income from:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donations</td>
<td>3,000</td>
<td>–</td>
</tr>
<tr>
<td>Investments</td>
<td>2,593,945</td>
<td>2,598,480</td>
</tr>
<tr>
<td>Other</td>
<td>3,964</td>
<td>5,422</td>
</tr>
<tr>
<td><strong>Total income</strong></td>
<td>2,600,909</td>
<td>2,603,902</td>
</tr>
<tr>
<td><strong>Expenditure on:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raising funds</td>
<td>520,772</td>
<td>482,330</td>
</tr>
<tr>
<td>Charitable activities</td>
<td>2,934,812</td>
<td>2,795,397</td>
</tr>
<tr>
<td><strong>Total expenditure</strong></td>
<td>3,455,584</td>
<td>3,277,727</td>
</tr>
<tr>
<td><strong>Net income / (expenditure)</strong></td>
<td>(854,675)</td>
<td>(673,825)</td>
</tr>
<tr>
<td><strong>Other recognised gains and losses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gains on property</td>
<td>858,367</td>
<td>866,718</td>
</tr>
<tr>
<td>Gains / (losses) on investments</td>
<td>12,304,743</td>
<td>(1,778,434)</td>
</tr>
<tr>
<td>Actuarial gains / (losses)</td>
<td>(63,422)</td>
<td>36,991</td>
</tr>
<tr>
<td><strong>Net movement in funds</strong></td>
<td>12,245,013</td>
<td>(1,548,550)</td>
</tr>
<tr>
<td><strong>Total funds brought forward</strong></td>
<td>92,699,461</td>
<td>94,248,011</td>
</tr>
<tr>
<td><strong>Total funds carried forward</strong></td>
<td>104,944,474</td>
<td>92,699,461</td>
</tr>
</tbody>
</table>
Royal Commission for the Exhibition of 1851

Summarised Balance Sheet
as at 31 December 2016

<table>
<thead>
<tr>
<th>Total Funds</th>
<th>Total Funds</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>2015</td>
</tr>
<tr>
<td>£</td>
<td>£</td>
</tr>
</tbody>
</table>

**Fixed asset investments**
- Investment properties: £16,520,685 (2015: £14,010,935)
- Listed investments: £90,855,103 (2015: £79,624,179)
- Cash held as part of the investment portfolio: £1,361,833 (2015: £1,945,769)

<table>
<thead>
<tr>
<th>Total</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>108,737,621</td>
<td>95,580,883</td>
</tr>
</tbody>
</table>

**Current assets**
- Debtors: £146,074 (2015: £151,148)
- Cash at bank and in hand: £795,124 (2015: £1,079,335)

<table>
<thead>
<tr>
<th>Total</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>941,198</td>
<td>1,230,483</td>
</tr>
</tbody>
</table>

**Liabilities**
- Creditors: Amounts falling due within one year: (£2,496,239) (2015: (£2,039,293))
- Net current liabilities: (£1,555,041) (2015: (£808,810))

<table>
<thead>
<tr>
<th>Total</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>107,182,580</td>
<td>94,772,073</td>
</tr>
</tbody>
</table>

- Creditors: Amounts falling due after more than one year: (£1,679,106) (2015: (£1,559,612))
- Net assets excluding pension liability: £105,503,474 (2015: £93,212,461)
- Defined benefit pension scheme liability: (£559,000) (2015: (£513,000))

<table>
<thead>
<tr>
<th>Total</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>104,944,474</td>
<td>92,699,461</td>
</tr>
</tbody>
</table>

**The funds of the Charity:**

**Capital Funds**
- Balance as at 1 January: £92,699,461 (2015: £94,248,011)
- Movement in year: £12,245,013 (2015: (£1,548,550))

<table>
<thead>
<tr>
<th>Total</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>104,944,474</td>
<td>92,699,461</td>
</tr>
</tbody>
</table>
1. CHARITABLE ACTIVITIES

The total costs of charitable activities are:

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotion and selection costs</td>
<td>45,232</td>
<td>52,853</td>
</tr>
<tr>
<td>Grants and awards committed in the year (analysed below)</td>
<td>2,507,641</td>
<td>2,412,737</td>
</tr>
<tr>
<td>Alumni costs</td>
<td>70,644</td>
<td>5,598</td>
</tr>
<tr>
<td>Support costs</td>
<td>311,295</td>
<td>324,209</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,934,812</strong></td>
<td><strong>2,795,397</strong></td>
</tr>
</tbody>
</table>

Analysis of grants and awards committed in the year:

<table>
<thead>
<tr>
<th></th>
<th>2016 No.</th>
<th>2016 £</th>
<th>2015 No.</th>
<th>2015 £</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Fellowships</td>
<td>10</td>
<td>1,038,398</td>
<td>9</td>
<td>843,904</td>
</tr>
<tr>
<td>Industrial Fellowships</td>
<td>10</td>
<td>567,880</td>
<td>10</td>
<td>544,735</td>
</tr>
<tr>
<td>Industrial Design Studentships</td>
<td>8</td>
<td>350,141</td>
<td>7</td>
<td>275,200</td>
</tr>
<tr>
<td>Built Environment Fellowship</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>110,000</td>
</tr>
<tr>
<td>Design Fellowship</td>
<td>1</td>
<td>100,000</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Enterprise Fellowships</td>
<td>4</td>
<td>187,500</td>
<td>3</td>
<td>187,500</td>
</tr>
<tr>
<td>Great Exhibition Scholarships</td>
<td>11</td>
<td>60,000</td>
<td>10</td>
<td>60,000</td>
</tr>
<tr>
<td>Special Awards</td>
<td>22</td>
<td>203,722</td>
<td>20</td>
<td>391,398</td>
</tr>
<tr>
<td><strong>Total grants and awards</strong></td>
<td>66</td>
<td>2,507,641</td>
<td>60</td>
<td>2,412,737</td>
</tr>
</tbody>
</table>
Administrative Information

Structure, Governance and Management

The Commission is constituted as a limited company incorporated by Royal Charter. Its governing documents are the original Charter dated 3 January 1850 and a Supplemental Charter dated 2 December 1851.

The Commission may have up to twelve trustees, known as Royal Commissioners, at any one time, who together constitute the Board of Management, which meets formally twice a year. Commissioners are chosen to bring wide experience in areas relevant to the Commission’s work – science, engineering, industry, design and finance. To maintain an appropriate balance of skills, Commissioners normally serve for 10 years, and Commissioners themselves identify possible successors, who may serve on a committee prior to election. Following election by the Board of Management, Commissioners are only appointed with the approval of the President.

All other committees are advisory in remit, are subordinate to the Board of Management and report to it, and all committee Chairmen are Commissioners. Ad hoc committees may be formed for limited periods and specific purposes. Any committee other than the Board of Management may have non-Commissioners as members subject to the wishes of the Chairman of that committee. All committees, except ad hoc committees, meet at least once annually. All committees are serviced by the Secretary and, where appropriate, by the Finance Director.

The Secretary also provides full briefing and induction programmes for all new Commissioners and committee members when appointed. As part of this introduction Commissioners are provided with a Governance Book containing full details of the Commission’s history, role, strategy, procedures and Commissioners’ responsibilities, as well as the relevant Charity Commission guidance for trustees. During their tenure, further opportunities for Commissioners to develop their knowledge of areas relevant to the Commission’s activities are provided as appropriate.

Day to day running of the Commission is delegated to the Secretary, assisted by a small staff team. Matters of strategy, and all grants greater than £5,000, are decided by Commissioners.

Full details of Commissioners and Committee members in post during the year, as well as the small staff team, are provided on pages 35 and 36. Details of the Commission’s professional advisers are provided on page 37.

Remuneration

Commissioners are not remunerated in their role as trustees of the charity and do not receive benefits other than reimbursement of expenses incurred in attending meetings.

In order to maximise funds available for grant making, Commissioners are determined to keep staff numbers and associated office costs to a minimum. To attract and retain experienced staff of the right calibre, however, Commissioners recognise the need to set salaries in line with those for other grant-making charities in the London area, based on sector benchmarks and other publicly available data.

Salaries for all staff, including key management personnel, are reviewed annually by the Chairman of the Board and the Chairman of the Finance Committee as part of the performance appraisal process. Pay awards are dependent on performance and set based on increases in the cost of living and average salary increases for the sector. There are no automatic increments and no bonus scheme.

Commissioners recognise the importance of helping employees make adequate provision for retirement. All employees, including key management personnel, are therefore eligible to receive a 10% employer pension contribution to the pension scheme established for auto-enrolment purposes or a personal pension of their choice. All employees are also entitled to an interest free season ticket loan. Employees do not receive any other benefits.
Risk Policy

In discharging their responsibilities for the management of risk, it is the policy of the Commissioners to identify, analyse and seek to manage any risks to the ability of the Commission to carry out its rôle effectively and meet the obligations of its Royal Charter.

To this effect the Commissioners have given consideration to the major risks to which the Commission is, or may be, exposed. A full risk register has been drawn up, which is reviewed regularly. Insurance brokers have been appointed to advise on areas where risk can be effectively mitigated through insurance. Compliance risks are mitigated through taking and following appropriate professional advice.

The main remaining areas of strategic and operational risk and the steps taken to address them may be summarised as follows:

**Investments: security, performance, liquidity**

The Commission has a diversified portfolio, both in terms of investments held and managers appointed. It has adopted investment and disbursement policies designed to maintain the real value of the portfolio over time and hence the support available to current and future beneficiaries. Sufficient liquidity is held outside the portfolio to meet short term commitments. Commissioners have delegated review of investment performance to a Finance Committee comprising individuals with relevant expertise.

**Grant making: applications, assessment, administration**

Commissioners have appointed specialist committees to review fellowship applications, work closely with other organisations active in the STEM arena to avoid unnecessary duplication or administrative effort and have appointed a communications company to assist with marketing of the awards to ensure they are brought to the attention of eligible recipients. Commissioners regularly seek feedback from potential applicants and other stakeholders to ensure the awards remain relevant.

**Legacy estate: character, experience, relevance**

Commissioners take an active interest in the estate, seek to facilitate relevant initiatives across legacy institutions and provide financial support where possible to ensure the estate remains a beacon of excellence and inspiration in the worlds of science, engineering and design.
Commissioners and Committee Members

President

HRH The Princess Royal

Commissioners (and Board of Management)

Mr Bernard Taylor DL FRSC *Chairman, Board of Management*
Professor Sir Michael Brady FREng FRS FMedSci
Professor Sir Richard Brook OBE FREng
Mr Stuart Corbyn FRICS
Sir William Castell LVO
Professor Dame Kay Davies DBE FRS FMedSci
Mr Jim Eyre OBE
Professor Sir Christopher Frayling FCSD FRSA FRIBA
Professor Lynn Gladden CBE FREng FRS
Professor Lord Mair CBE HonDSc FREng FICE FRS
Sir John O’Reilly DSc FREng FLSW

Ex Officio Commissioners

The Lord President of the Council
The First Lord of the Treasury
The Chancellor of the Exchequer
The Secretary of State for Business, Energy and Industrial Strategy
The Secretary of State for the Environment, Food and Rural Affairs
The President of the Institution of Civil Engineers
The President of the Geological Society

Finance Committee

Sir William Castell LVO *Chairman*
Mr Stuart Corbyn FRICS
Mr Nicholas Moakes CFA
Mr John Manser CBE DL FCA
Mr Adam Taylor-Smith
Science and Engineering Fellowships Committee

Professor Sir Richard Brook OBE FREng Chairman
Professor Andrew Briggs
Professor Neil Champness FRSC FLSW
Professor Dame Kay Davies DBE FRS FMedSci
Professor Anne Dell CBE FRS FMedSci
Professor John Dewey FRS
Professor Christopher Dobson FRS
Professor David Ewins DSc FREng FRS
Professor James Feast CBE FRSC FRS
Professor Charles Godfray CBE FRS
Professor Douglas Gough FRS
Professor Cyril Hilsum CBE FREng FRS
Professor Jane Langdale FRS
Professor Stephen Muggleton FREng
Professor Trevor Stuart FIC FRS
Professor John Wood CBE FREng

Industry and Engineering Committee

Professor Lynn Gladden CBE FREng FRS Chairman
Professor Sir Michael Brady FREng FRS
Professor Muffy Calder OBE FRSE FBCS FIEE
Dr Nicholas de Leon
Professor Lord Mair CBE HonDSc FREng FICE FRS
Sir John O'Reilly DSc FREng FLSW
Professor Ron Pethig
Dr Malcolm Skingle CBE DSc
Professor Eleanor Stride

Built Environment and Design Fellowships Committee

Professor Sir Christopher Frayling FCSD FRSA FRIBA Chairman
Professor Rachel Cooper OBE
Professor Chris Wise RDI FREng HonFRIBA FRSA
Mr Jim Eyre OBE

Staff

Mr Nigel Williams CEng Secretary
Mr Amahl Smith ACA Finance Director
Mrs Jenifer Hewett Senior Administrator
Mrs Angela Kenny RMARA Archivist and Alumni Relations
Professional Advisers

Bankers
The Royal Bank of Scotland plc
South Kensington Branch
29 Old Brompton Road
London SW7 3JE

Investment Managers
Schroders (C.I.) Limited
Regency Court
Glategny Esplanade
St Peter Port
Guernsey GY1 3UF

Surveyors
Cluttons LLP
Portman House
2 Portman Street
London W1H 6DU

Charles Stanley
Pan-Asset Capital Management Ltd
25 Luke Street
London EC2A 4AR

Legal Advisers
Farrer & Co LLP
66 Lincoln’s Inn Fields
London WC2A 3LH

JP Morgan Asset Management (UK) Ltd
20 Finsbury Street
London EC2Y 9AQ

Auditors
Kingston Smith LLP
Devonshire House
60 Goswell Road
London EC1M 7AD

Insurance Brokers
Lark Insurance Broking Group
9th Floor, Colman House
King Street
Maidstone
Kent ME14 1DN

Actuaries
Punter Southall
Albion
Fishponds Road
Wokingham RG41 2QE
Royal Commission for the Exhibition of 1851

453 Sherfield Building
Imperial College
London SW7 2AZ

Telephone: 020 7594 8790
Fax: 020 7594 8794

e-mail: royalcom1851@imperial.ac.uk
website: www.royalcommission1851.org
http://alumni.royalcommission1851.org