

Royal Commission for the Exhibition of 1851

Annual Report and Accounts

For the year ended 31 December 2023



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 Central 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:

Enterprise Fellowships
Technical Teaching Fellowships

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

The total number of individuals being supported in 2023 was 140

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Chairman's Report

I think it would be fair to observe that 2023 has been a period of resurgence and growth for the Royal Commission and its activities. The largest group of new Fellows joined our research, design and innovation programmes and our public events and engagements attracted larger audiences and visitor numbers than for many years. The charity has continued to increase its commitment to supporting STEM education and educators as well as contributing to several impressive, community-based projects. Committing just under £5 million in funding to our charitable outputs has meant it has been a year of endeavour and achievement and has established a strong foundation for the ambitious strategy we wish to deliver in the future.

All of this activity relies on the enthusiasm and dedication of the many volunteers that offer their support to our programmes, whether that be through serving on our various committees or overseeing the governance and strategic direction of the organisation itself right through to being a Royal Commissioner. All our Commissioners are figures of distinction; experts drawn from the worlds of academia, science and engineering, technology and design, finance and public service. All are lauded within their own disciplines as leaders and forward thinkers and who, each year, help the charity to provide substantial support to our extraordinary award recipients. Adding to their efforts, I also have the pleasure of welcoming Lord Burnett of Maldon, who joins us as the latest Royal Commissioner.

In 2023 we awarded 10 Research Fellowships, 15 Industrial Fellowships and 14 Industrial Design Studentships representing our most significant investment in young and emerging research talent within the UK to date. In addition, we funded six new entrepreneurs through the enterprise programme run by our partners at the Royal Academy of Engineering as well as awarding the bi-annual Built Environment Fellowship. We also welcomed the fifth cohort of participants onto our Technical Teaching Fellowship initiative. Across all our long-term education and research programmes, there was a gender balance in successful applicants, an outcome not deliberately sought but wholly commendable that hopefully will be a trend continued into the future.

Our external public engagements this year included the annual Great Exhibition Road Festival. This draws all the cultural and educational institutions and organisations based in South Kensington together over a weekend in June to share a street-based extravaganza of science, history and art. Once again the 1851-der tent was at the heart of the activity, with 15 volunteers from our current programmes and small executive team inviting members of the public to partake in experiments and demonstrations associated with elements of their research projects. It also provided an opportunity to explain the Commission's function and history to some of the 55,000 visitors that came to enjoy the experience.

This July saw the Royal Commission host the eighth recording of *The Engineers* with the BBC World Service. This time the subject for discussion was lunar exploration. The BBC presenter and regular host, Kevin Fong, encouraged engineers leading the renewed space programme to discuss humanity's return to the moon and all that entails, including a powerful rocket and capable spacecraft, a space station in lunar orbit and a permanent moon-base. Howard Hu, the Programme Manager of NASA's Orion Programme, Sara Pastor, the Project Leader for the development of the International Habitat module at the European Space Agency and Libby Jackson, the Head of Space Exploration from the UK Space Agency spent almost two hours discussing and answering questions before an audience of almost 700 at the Royal Geographical Society and radio listeners in their millions on this most ambitious of endeavours.

As part of our ongoing strategy to reinforce both STEM education in schools, and greater public awareness of the career opportunities in the science and technology arena, the Commission gave grants to projects being run by the British Science Association and Primary Engineer providing much needed resources to primary schools. Funds were also awarded to the Humber Science Festival. These allow for wider regional engagement in the STEM environment and enable communities to discover and celebrate local science and engineering-based industries and organisations.

Closer to home, we also acknowledged the achievements of our own community at our Alumni Science Evening and Fellows' Reception. With a revised and expanded format, the annual gathering for past and existing fellows at the Royal Society took place at the end of April. The audience of over 140 enjoyed listening to presentations from Research Fellows Dr Xianxin Guo (Optical Artificial Intelligence) and Dr Adam Smith (Understanding quantum matter using quantum computers) and Industrial Fellows Joseph Lawton (Remote plasma sputtering of thin film materials) and Poppy Oldroyd (Thin-film electrodes for chronic neuromodulation). The evening closed with an address from the distinguished alumna Professor Helen Fielding, who spoke about her achievements after completing her fellowship and described her current work as the Thomas Graham Professor of Chemistry at UCL. There was further sharing of knowledge and achievement at the Fellows' Reception, held at the Royal Geographical Society in the summer. 10 individuals from across all five of the Royal Commission's permanent programmes shared their work with our President, Her Royal Highness The Princess Royal, and current 1851 Fellows and committee members.

There has also been an opportunity to focus on more local matters. My fellow Royal Commissioners and I remain very cognisant of our stewardship responsibilities for the Albertopolis estate. We continue to actively champion the Exhibition Road Cultural Group's SouthKenZen+ project through both direct leadership and ongoing financial support. Creating a benchmark carbon zero and sustainability model for similar urban cultural districts across the world is one of the most important collaborations that the Commission has undertaken in its recent history and is a key focus for us and our colleagues within the 1851 group and the wider South Kensington district.

Since the receipt of its supplementary charter some 172 years ago the 1851 Royal Commission has been committed to the vision of Prince Albert. This remains crucially aligned to the aspirations of modern Britain and our traditional ambition to be one of the world's most innovative and productive economies. Our forebears drew inspiration from the example and ideas of our original President to power their endeavours, and we do the same today. The Princess Royal's support for our activities, as well as her wider public example, remains a source of great pride and encouragement to the Board of Management and all those involved with the Royal Commission. We are deeply honoured by Her Royal Highness's continued commitment to our purpose and people.

The Rt Hon Professor Lord Kakkar KBE PC FMedSci

Secretary's Report

I can only echo the Chairman's comments - one of the constant joys of working for the Royal Commission is the individuals that one is fortunate to interact with on a daily basis. The award recipients are exceptional young scientists, designers and engineers pursuing a personal passion with energy and enthusiasm. Their talents will undoubtedly lead to ground-breaking discoveries, sometimes relatively quickly but in other cases they take what appears to be a very small step forward in research terms and it is only later that their work is credited with creating the paradigm shift in knowledge or process to make a crucial discovery or introduce an innovative product. Whatever the circumstances I am constantly inspired by their focus, knowledge and optimism. Equally I consider myself fortunate to work with the hugely capable and generous volunteers who make up our committees and Board of Management – all give their time, knowledge and commitment to ensure that the charity's various outputs remain true to the original vision of Prince Albert and the task he placed upon the Commission whilst also being relevant to the society of today's demands and expectations. Whilst behind the scenes all is overseen, organised, recorded and administered by a very small but dedicated and highly professional team who support all (including me) in an exemplary manner.

The problems and challenges of today and tomorrow seem more complex with each passing day yet the generation of problem solvers and innovators that the Royal Commission supports seem undaunted and relish the prospect of making an impact in their chosen work environment. Equally laudable are the efforts of the various organisations that are granted special awards by the Royal Commission. Powered by people who want to make a genuine difference, the programmes we support are a positive influence across the STEM environment – whether it be in the classroom or the community. This report captures only a small snapshot of what is being achieved across the broad spectrum of “1851” activity and I hope that the reader will be as enthused by the individual or organisation undertaking the research or programme, as by their achievements.

John Lavery MVO

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, to other organisations working to encourage STEM (science, technology, engineering and mathematics) education and to organisations that can help facilitate access to its incredible archives. Details of some of these awards and the impact they have made can also be found later in this report.

As well as the grants that it makes, the Commission itself organises a number of educational and networking events for the benefit of its award holders, alumni, legacy institutions and the general public, which together make a significant contribution to STEM education.

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 six 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 almost £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 makes a very substantial contribution to scientific, engineering and artistic education.

Public Benefit

The Commission ensures that its work is for the public benefit and takes full account of the published Charity Commission guidance. The Commission's events 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 primarily 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 to ten awards are made each year, including one or more Brunel Fellowships for engineering projects addressing the primary infrastructure needs of modern society. 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 – usually around ten to fifteen - 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. A variable number of awards – usually around ten to fifteen - are offered each year for outstanding engineers or scientists who wish to develop their capabilities in industrial design by taking a recognised master's 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. Originally three fellowships a year were available, but this has now been increased to six.

Technical Teaching Fellowships

Awarded through the Education and Training Foundation (ETF), these fellowships are open to outstanding UK-resident Further Education practitioners who are recognised for their high impact teaching practice. Fellows are expected to share their expertise and learning across the sector as part of the award with the aim of supporting quality improvement in technical teaching and learning. Fellows will receive an award of £5,000 – £15,000 to support knowledge transfer activity and to ensure remission time is guaranteed. They will also be allocated a programme mentor to support them for the duration of the Fellowship and will attend developmental workshops.

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. A small number of grants are also made to facilitate access to the Commission's archives.

In addition to the above schemes, the Commission also administers, in conjunction with the Sir Misha Black Awards Committee, two awards in the field of design education, for which nominations are sought each year. Full details are available on the Commission's website but in brief these are:

Sir Misha Black Medal for Distinguished Services to Design Education

Global in reach, the Medal acknowledges the important contribution of individuals to the teaching of design at all levels, from anywhere in the world – as designers, as champions, as mentors and as educators.

Sir Misha Black Awards for Innovation in Design Education

Salutes educators from across the United Kingdom and celebrates the innovative achievements of institutions and individuals. Recipients may receive a bursary of £10,000 to advance their work in innovative design education.

Together the Sir Misha Black Medal and Awards recognise those who by innovation, vision and contribution to theory or practice have measurably improved the education of designers and enhanced the profile of design education.

Achievements in 2023

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 12 to 21.

The true impact of the Commission's award holders will only emerge over time, but 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 22 to 40.

Many completing Fellows comment on the importance of their Fellowship to their success:

It was an honour to be an 1851 Fellow. Its prestige and flexibility were invaluable to me and I'm in debt to the Commission for giving me the chance to pursue my dreams and ambition.

Dr Farid Shahandeh, Research Fellow 2019

The biggest benefit, personally, from the Royal Commission funding was the career progression that it has afforded me. A primary reason for applying for the Industrial Fellowship was future proofing my skillset and gaining access to experts in the area which I wanted to develop into. At the start of the Fellowship, I was a junior scientist, working in the area of practical marine biology, but with a desire to progress into digital applications and the interface between computational modelling and marine biology. Over the past 4 years my role has diversified to include management of data and databases, strategic planning for data governance and architecture, not only for Fouling Control but for the wider Marine, Protective and Yacht business. I have been promoted several times, most recently in the last few weeks, to now be the Digital Portfolio Leader – a position that neither existed, nor was envisioned at the start of my research, but one which has been realised as a result of the work I have done over the last 4 years.

Marie Dale, Industrial Fellow 2019

For me, having the opportunity to develop as a scientist through self-guided research whilst also maintaining my industrial career progression and employment was the ideal scenario. Without the support of the Commission, I would most definitely have had to sacrifice one of these. Being able to maintain both aspects has been a privilege which I could not place high enough value on, and speaking with colleagues and peers, many of whom have obtained advanced degrees in traditional settings, only solidifies this stance.

Jack Kay, Industrial Fellow 2020

For some it is clear that without the award from the Commission their project would not have gone ahead or would have been much more limited in scope:

Without the Industrial Fellowship award, this DPhil project would likely not have gone ahead, for it allowed me to pursue developing a novel technique that would have otherwise been out of my industrial sponsor's original interests, but through doing so, has now become a keen focus of the company.

Thomas Waddell, Industrial Fellow 2020

Academic and Industrial Supervisors are also very complimentary about the Commission's Fellowships:

We are grateful to the Royal Commission for the Exhibition of 1851 for awarding this fellowship as although we had interest in the area, the fellowship provided us with the means to dedicate resource to its study in a depth, breadth and speed that would otherwise not have been feasible. The results obtained during the course of this project have certainly justified this approach to industrial research enabling the combination of detailed and focussed research in an industrial setting. Furthermore, the opportunity that the fellowship has provided to the Fellow in her development of skills, capability and expertise in this area will provide the company with a long-lasting legacy.

Although the commercial value of this project has yet to be realised the research that the Fellow has undertaken has developed the technology to such a point where both proof of concept and feasibility

has been realised; patent filings are being discussed and drafted, and routes to commercial utilisation are being explored. The further development and scaling of this technology towards commercialisation is a clear next step and will actively be pursued beyond the completion of this project.

Richard Ramsden, Industrial Supervisor

This is our second Industrial Fellowship, and we strongly advocate in favour of the scheme. We believe that the unique manner in which industrial benefit/experience is put at the forefront of the Fellowship benefits all parties.

Dr Scott Baxter, Industrial Supervisor

I have not used the Industrial Fellowship previously, however found the scheme easy to navigate and think that it fills an important niche within the industrial-academic landscape, allowing novel collaborations to be formed and enabling talented researchers within companies to complete a PhD and take a more academic approach to progress industrial research. I have enjoyed the experience and will (and have already) recommended this scheme to colleagues within the appropriate academic areas. I think it is an excellent opportunity for either new or continuing industrial-academic research collaborations to be fostered with a talented researcher at the heart. I have noticed how it has importantly progressed the Fellow's career by providing him the opportunity to study for a PhD while remaining in the industrial setting and he has also used this opportunity to develop other skills (such as teaching, writing, project management and leadership). These have contributed to him receiving Chartered Chemist status recently and this is a big achievement for him.

Dr Kimberley Roper, Academic Supervisor

The ripple effects of this fellowship extend beyond its immediate scope. Several of my doctoral students, inspired by the collaboration and the fellow's work, sought guidance from the company's employees on navigating the intricacies of spinning out a company. From conceptualization to fundraising, their inquiries found a receptive audience within the company's network. Without the foundation laid by this fellowship, such avenues for mentorship and counsel on commercialisation matters would have remained elusive.

In essence, the Industrial Fellowship has catalysed a symbiotic relationship characterised by mutual learning and advancement. It has not only enriched our collective understanding of pressing medical issues but has also empowered us to explore avenues for translating research into tangible societal impact. Through this journey, the bonds forged with the company have evolved into a nexus of collaboration, innovation, and mentorship. I would highly recommend this scheme to other academic colleagues, particularly if they have an interest in commercialisation and/or translation of research ideas.

Professor Ana Namburete, Academic Supervisor

I have enthusiastically recommended the Industrial Fellowship scheme to colleagues (at Plymouth and elsewhere) and I will continue to do so – it is an excellent scheme. It is well resourced and extremely well managed. The Fellowship has helped contribute to the University of Plymouth's reputation for industrial collaboration and visibility in the sector through conference presentations and articles in industry magazines and other sources; such enterprise activities are very well regarded at the institution at the highest levels.

Professor Mathew Upton, Academic Supervisor

A more complete picture of the impact of the Commission's awards comes from the honours and awards bestowed on more senior alumni – some highlights are given on pages 41 – 43.

Many of our alumni tell us that their Fellowship has made a decisive – and lasting - difference to their career:

I was at Imperial College reading geology for my BSc and PhD in volcanology (1968-74). I received an 1851 Fellowship in 1974 hosted at Lancaster University. I had previously been unsuccessful at applying for a NERC fellowship so at the time whether I could continue in academia was in doubt. Receiving the 1851 Fellowship was a pivotal moment in my life and career and enabled me to work with Lionel Wilson at Lancaster to develop the first ever numerical models of volcanic explosions and bubble

formation in exploding volcanic magmas. I will always be hugely grateful to the 1851 Commission.

Professor Sir Steve Sparks, Research Fellow 1974

Without a doubt, my 1851 scholarship set me up for a wonderful science life journey. I couldn't have dreamed of a better start to my career, and I am forever grateful.

Professor Jennifer Martin, Overseas Scholar 1986

In reply to your question on how the 1851 Fellowship influenced my career, I can state, once one sees excellence, one doesn't forget it. The fellowship put me in contact with excellent colleagues. With the fellowship, I was able to undertake a PhD in biochemistry at the University of Cambridge with Sir Tim Hunt, who was awarded the Nobel prize in 2001. I was surrounded by intelligent and imaginative faculty/students who answered questions from which we are still benefiting today. I eventually returned to Canada (2 decades later) but always look to Europe for collaborations and teach Canadian students to think globally.

Professor Roy Golsteyn, Overseas Scholar 1987

I firmly believe that none of my achievements would have happened without the transformational benefits brought about by my Industrial Fellowship. In addition to allowing me to complete my PhD, it propelled me on an accelerated journey to leadership within my previous employer, Luxfer Group. The experiences gained in those roles in the US and Europe are still being put to good use today and are now being applied to some exciting new challenges.

Professor Michael Clinch, Industrial Fellow 1996

I founded Full Matrix Ltd (www.fullmatrix.co.uk) in the midst of the pandemic and shortly after that won a feasibility study with UKAEA looking at how the technology I developed in my Industrial Fellowship could be used to monitor the condition of fusion powerplant supply pipes. This has now developed into a much larger programme of work which we pitched for and won in late 2023. As a result, Full Matrix has now expanded to 6 people. We are currently making a prototype device for fusion powerplant and looking at how we can diversify to other industries too. It's all very exciting and has been made possible by the work I did under the Industrial Fellowship. I'm still incredibly grateful for the opportunity which not only allowed me to carry out the underpinning research but also greatly built my confidence in interacting with and presenting to high level audiences.

Dr Ruth Sanderson, Industrial Fellow 2009

As well as becoming distinguished in their own fields, many of our alumni go on to make interesting contributions in other areas. To take one recent example:

A few years ago, an interest in the traditional methods of celestial navigation lead me and collaborators to examine Captain Frank Worsley's original logbooks from the 1914 Imperial Trans-Antarctic Expedition under the command of Sir Ernest Shackleton. Our initial goal was to understand what methods Worsley had used to navigate the 800 nautical miles from Elephant Island to South Georgia in the 22½ foot vessel the James Caird seeking rescue. Our conclusions were published in the Records of the Canterbury Museum (New Zealand) where the logbooks are now housed.

When it was announced that a search was to be made for the wreck of Shackleton's ship, Endurance, we returned to the logs and were able make a prediction of the position at which the wreck would likely be found. We circulated our conclusions and published them in the Journal of Navigation. The story was picked up by a several media outlets including the BBC and London Times. Ultimately Endurance was found very close to where we had predicted. The full story is told in my YouTube video <https://www.youtube.com/watch?v=y3sMS5p8Pgk>.

In April of 2023 collaborators Lars Bergman, David Mearns and I were awarded a Certificate of Achievement by the Royal Institute of Navigation "In recognition of their pioneering data analysis and modelling leading to the successful location of the Endurance wreck".

Professor Robin Stuart, Overseas Scholar 1981

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. As well as the awards to the British Science Association, Primary Engineer and Humber Science Festival mentioned in the Chairman's Report, these included awards to Kids Invent Stuff to support their Inventors' Club, the Royal Botanic Gardens Kew to support their Grow Wild initiative and The Geological Society to support their Megalosaurus Month.

The impact of such Special Awards may take some time to become apparent, but a brief look at some of the awards made in the last couple of year gives a flavour of what can be achieved.

The Humber Science Festival supported this year attracted 5,665 people over four days, over half of whom were schoolchildren. Participants could access over 30 events, including a Discovery Zone with over 35 hands on activities. 85% of attendees said the festival had increased their interest in STEM – a promising start for a new initiative.

Meanwhile the Mini YouTube engineering musical created by Kids Invent Stuff in 2022 and featuring a toilet-cleaning robot designed by six-year-old Erin has received over 4,000 views, over 16,000 Instagram mentions and over 54,000 Twitter impressions, with associated educational resources sent to over 250 primary schools.

Another Special Award in 2022 enabled the Smallpeice Trust to pilot nine Engineering Experience courses for Year 8 and 9 pupils and two General Engineering courses for Year 10 pupils. 562 students, over half of them female, attended the three-day residential courses with over 94% of participants saying the course had increased their interest in studying engineering.

As the examples above illustrate, the Commission funds a wide range of innovative STEM initiatives at varying scales, recognising that not all will achieve huge success, but in the hope that most will transform individual lives, and some will go on to have considerable reach. Needless to say, not all Special Awards proceed completely smoothly. Nevertheless, anecdotal evidence suggests that it is interventions such as these that can make all the difference in stimulating young people to become the scientists and engineers of tomorrow and the Commission remains committed to doing what it can.

As well as funding STEM outreach projects, the Commission also provides Special Awards to enhance its legacy estate in South Kensington and help the world leading institutions of Albertopolis to extend their reach. As explained in the Chairman's Report, the main award this year has been to support SouthKenZen+ - a collaborative initiative to accelerate the transition to zero emissions and support nature positive programmes.

These awards, often for major capital projects, can take many years to complete but also have significant impact. One recent award, for example, has enabled the Royal Albert Hall to enhance the public realm including widening footpaths to improve accessibility, providing safe queueing and waiting areas and upgrading security installations. A new pedestrian crossing is also in progress. The revitalised north-west quadrant outside the Hall has been renamed 1851 Place in recognition of the impact of the Commission's grant.

Future Plans

2026 will mark the 175th Anniversary of the Great Exhibition. In preparation, the Commission is starting to plan a number of initiatives and events, including a new history of the Commission, research into the impact of the Commission's educational programmes, a public exhibition and a public lecture series.

The Commission already provides funding, through its Special Award programme, for a number of STEM initiatives. Over the coming year, the Commission will also be exploring whether there is scope for it to do more directly in support of one or two key priority areas, such as improving STEM education in primary schools and widening provision of STEM apprenticeships.

The Commission recognises that its various award programmes are not as well-known as they might be and will also be looking to improve communication with its various stakeholders, including a revamped website, a new annual review document and new marketing materials.

Awards Granted in 2023

Research Fellows

Dr Emma Banks

Subject: Illuminating the mechanistic basis of virus-like gene transfer between bacteria

John Innes Centre

The genes that confer resistance to antibiotics can be passed between bacteria through various horizontal gene transfer mechanisms. One involves a group of poorly understood virus-like gene transfer agents (GTAs). This project will systematically characterise GTA biology, with a view to harnessing GTAs as tools to tackle antibiotic resistance.

Dr Alison Cribb

Subject: Ecosystem engineers, resilience, and climate change through Earth history

University of Southampton

Ecosystem engineers are a type of keystone taxa that alter their environments to maintain resource availability and ecosystem habitability. This project will use the fossil record to understand the long-term effect of the survival and extinction of marine ecosystem engineers through ancient climate catastrophes on resilience and recovery of ocean ecosystems.

Dr Larissa Gomes Franca

Subject: Stimuli-responsive liquid crystal host materials for energy upconversion systems

University of Cambridge

This project aims to design and exploit smart materials that can convert light from low energy to high energy (upconversion) in response to an external stimulus (e.g., an electric field). These materials, based on liquid crystal hosts and molecular dopants, will be explored for applications including optical communication and sensing.

Dr Freya Johnson

Subject: Antiferromagnetic materials for fast and energy-efficient computing

University of Cambridge

This project uses a novel approach, exploiting an unconventional magnetic material that could speed up computers and make them more energy-efficient, reducing their environmental impact. Preliminary data, along with the Fellow's previously published work, promises large-scale low-cost computing technologies, potentially a thousand times faster than current technology.

Dr Dean Lomax

Subject: Novel imaging elucidates hunting behaviours of giant 'sea dragons' *University of Bristol*

Exceptional new discoveries of giant ichthyosaurs ('sea dragons'), including a practically complete skeleton, will be subjected to cutting-edge imaging technologies. Combined with analyses of specimens collected ~200 years ago, the results will feed directly into our understanding of the presumed unique hunting behaviours of these apex marine predators.

Dr Giulia Rubino

Subject: Undoing quantum operations using integrated photonics technologies

University of Bristol

Recent years have seen a breakthrough in the commercialisation of early prototypes of quantum computers, yet much work remains to be done to make quantum computers fault-tolerant and versatile. This project will tackle this challenge by providing the first experimental prototypes of quantum circuits able to undo unknown quantum operations.

Dr Lucas Sá

Subject: Order and chaos in dissipative quantum matter

University of Cambridge

This project involves a theoretical investigation of microscopic quantum systems coupled to an external environment. A central question is how interactions in such systems induce a transition from order to chaos. The expectation is that this work will have technological impact in the fabrication of complex quantum structures and, ultimately, quantum computers.

Dr Benito Wainwright

Subject: How does evolution break functional barriers to fine-tune adaptation?

University of St Andrews

How does nature overcome trade-offs in design to fine-tune adaptations to their environment? This project will use leaf mimicry in katydids as a unique way of understanding (a) how modularity between traits might break functional constraints during adaptive evolution and (b) the general engineering principles by which evolutionary trade-offs are resolved.

Dr Daniel Wilson

Subject: Transition-metal main-group cooperativity: A strategy for catalytic transformations with ammonia

University College London

Amines are one of the most widely used building blocks in the chemical industry. This project will explore the catalytic addition of the N-H bond of ammonia across a carbon-carbon multiple bond (hydroamination) and the coupling of amines to aromatic hydrocarbons (dehydrocoupling) using cooperative catalysts.

Brunel Fellow

Dr Yabin Liu

Subject: Tidal turbine cavitation and gust control with micro jets

University of Edinburgh

This project aims to address two critical issues of tidal turbines, cavitation and unsteady loadings, with a new-concept passive technology with micro jets. By breaking the tip speed ratio limit and by reducing the maximum torque on the drivetrain, it will enable more efficient and reliable turbines at larger scales.

Industrial Fellows

Sara Abreu

Subject: Investigation of factors affecting the downstream purification process of lentiviral vector manufacturing

Sponsor: Autolus

University College London

The aim of this project is to determine the impact of factor-interaction between unit operations involved in lentiviral vector manufacturing to have a simple, scalable, and cost-effective downstream processing that prioritizes high recovery with high purity, exploring different approaches for viral vector purification.

Mark Bell

Subject: Short range interferometric synthetic aperture radar (InSAR) for environmental modelling

Sponsor: Leonardo UK

University of St Andrews

Subsidence and landslips on rail and road infrastructure cause disruption, economic impact and pose a risk to life. This project aims to develop a novel radar-based mapping technology for routine monitoring of embankments and cuttings. This will enable the early detection of changes, reducing the risk of disruption or damage.

Gillian Cameron

Subject: The role of digital interventions in supporting workplace mental health and wellbeing

Sponsor: Inspire

Ulster University

The prevalence of mental health disorders and levels of help-seeking vary amongst employees within different occupational groups and industry sectors. This research will investigate if a personalised digital intervention, employed using a blended approach, could provide tailored support to address the varying challenges faced by organisations and employees.

Peter Doggart

Subject: Artificial Intelligence enhanced electrocardiography in emergency departments

Sponsor: PulseAI

Ulster University

Computer electrocardiogram interpretation algorithms were first introduced in the late 1950s and have since become widespread in clinical practice. However, currently available interpretation algorithms are limited in their diagnostic accuracy and can result in inappropriate treatment. This project aims to use Artificial Intelligence to address the shortcomings of existing systems.

Marina Economidou

Subject: Investigations into the ligand- and oxidation state-dependent extraction of residual palladium from pharmaceutically relevant molecules

Sponsor: GSK

University of Strathclyde

This project aims to delineate the factors influencing the extraction of palladium from pharmaceutically relevant reaction solutions. With current methods of palladium removal lacking generality, the goal is to generate an extraction workflow applicable to all systems, which would reduce the time and costs related to the pharmaceutical industry.

Claudine Greenwood

Subject: Identification of covalent tools for essential parasite proteins implicated in tropical diseases

Sponsor: GSK

University of Strathclyde

Antimicrobial resistance to tropical disease therapies is a global health threat; the identification of novel methods of treatment is urgently required. This project aims to identify covalent tools for essential parasite proteins implicated in visceral leishmaniasis and malaria, providing a novel mechanism to inhibit parasite growth.

Ishbel Jamieson

Subject: The quantification of elastance in digital tomosynthesis images of lungs

Sponsor: Adaptix

University College London

This project aims to develop a tool for producing 3D elasticity maps of the lungs using digital tomosynthesis images. With regions of anomalous lung elasticity strongly linked to areas of clinical interest a sensitive, low-dose, and low-cost technique suitable for image-based assessment of lung functionality is greatly needed.

Aleksy Kwiatkowski

Subject: Closing the loop: A computational-experimental feedback approach for predicting macrocycle closure

Sponsor: MSD

University of Oxford

The synthesis of ring-shaped molecules (macrocycles), a valuable class of medicines, is notoriously difficult. This project combines computation and experimentation to understand the factors influencing successful ring formation and hence will identify accessible macrocyclic scaffolds. The outcome will be user-friendly tools for designing and synthesising potentially life-changing macrocyclic therapeutics.

Paul McHard

Subject: Autonomous robotic detection and correction of surface defects in manufacturing

Sponsor: HAL Robotics

University of Glasgow

This project will develop an AI-based solution, HAL.AutoCorrect, to autonomously detect, characterise, and correct surface defects in manufactured parts during production. This new, innovative software will enable greater manufacturing efficiency, reducing costs, energy consumption, material waste, and productivity loss by utilising computer vision, deep learning and adaptive robotic programming.

Anna Miller

Subject: Feed the world: harnessing nature's molecules for maximising future food productivity

Sponsor: Syngenta

University of Oxford

Inhibition of nitrification is a powerful strategy to improve the efficiency and environmental impact of fertilisers. This is especially important in response to rapidly increasing global populations and climate change. To develop a novel agrochemical that inhibits nitrification, synthesis of natural products and analogues thereof is a crucial strategy.

Sarah Oatway

Subject: Investigation of a novel sensory discrimination training device for the management of phantom limb pain

Sponsor: 2PD

Teesside University

Phantom limb pain (PLP), defined as pain experienced in a limb which has been amputated, affects 76-87% of amputees. Preliminary evidence suggests that therapist delivered sensory discrimination training (SDT) can reduce PLP. This project will investigate the efficacy of a novel, software led, self-management medical device delivering SDT for PLP.

Samantha Ree

Subject: Separation techniques for the recovery of radionuclides suitable for cancer therapy from extant nuclear materials

Sponsor: National Nuclear Laboratory

University of Manchester

This research aims to explore the isolation and recovery of rare alpha-emitting radionuclides from the UK's stock of nuclear legacy materials. Development is required to efficiently produce these radionuclides at high purity. This would allow the radionuclides to be incorporated into a radiopharmaceutical for the treatment of oncological diseases.

Matthew Southern

Subject: Delivering novel 3D-rich building blocks for drug discovery

Sponsor: Sygnature Discovery

University of Oxford

This project will deliver methods for the array synthesis of 3D-rich building blocks featuring sulfonamides, sulfonimidamides, and sulfondiimidamides, which are all motifs in demand in drug discovery. The project will combine technology development and chemical innovation and exploits the complementary expertise of Sygnature Discovery and the Willis group.

Fabian Spoendlin

Subject: Advancing computational methods for the functional characterisation of antibodies using structural and flexibility data

Sponsor: F. Hoffman-La Roche

University of Oxford

This project aims to advance methods for the in-silico engineering of antibody therapeutics. Employing the latest developments in machine learning, it will attempt to use data on antibody structures and flexibility to predict their properties. Developed methods will be implemented to accelerate the antibody development of the pharmaceutical company Roche.

Rebecca Stevens

Subject: High-throughput chemical synthesis and biological testing of proteolysis targeting chimeras

Sponsor: GSK

University of Strathclyde

Proteolysis targeting chimeras (PROTACs) are incredibly interesting molecules for drug discovery; however, their optimisation is slow. This project focuses on developing a high-throughput platform to synthesise and test hundreds of structurally diverse PROTACs simultaneously, offering the potential to thoroughly analyse structure-activity relationships of a thousand PROTACs in a single experiment.

Kate Turley

Subject: Environmentally affective circadian lighting and IoT solution for healthy ageing

Sponsor: Chroma Lighting

Ulster University

The focus of this project is on creating personalised indoor lighting informed by data-driven insights on daily activity, in order to align the circadian rhythm and body clock of individuals with dementia, alleviate their symptoms of depression, poor sleep/restlessness, and improve their wellbeing.

Enterprise Fellows

Gregory Hargraves

Company: Paige

Paige is the world's first affordable, multiline braille display. A novel design drastically reduces the cost per braille character. This enables Paige to create ten lines, each with 20 characters of braille. People will be able to use Paige for reading, writing and maths. Audio has greatly improved access for the blind. However, braille is crucial for spelling, grammar, punctuation, maths and for learning languages which are not phonetic - such as English. Paige can be used alongside a phone, tablet, and laptop in combination with a screen reader which enables sighted peers and parents to collaborate with users.

James Eaton

Company: IONETIC [Financially supported by the ERA Foundation]

IONETIC offers niche vehicle-makers and automotive OEMs an efficient blend of customisation and cost reduction through ARC, their battery design platform. ARC is a hardware and software innovation that allows IONETIC to quickly design and prototype optimised battery packs. Design and manufacture parameters are shared across the platform, meaning IONETIC can reduce cost and accelerate time to market for customers. IONETIC's UK manufacturing facility will allow their clients to further secure their supply chain while ensuring compliance with Rules of Origin.

Idan Gal-Shohet

Company: Fibe

Fibe is revolutionising the waste industry by utilising cutting-edge harmful-chemical-free technology to extract cellulosic fibres from potato harvest waste. This waste, which amounts to 250m tonnes annually, is currently pulverised or incinerated due to being inedible and unsafe to compost (due to risk of blight contamination). Fibe purchases this otherwise valueless waste from UK farmers, providing them with additional income and reducing their operating costs, and applies a series of biological and mechanical steps to extract fibres from the plant which are compatible with conventional textile weaving machinery. This allows Fibe to produce a product that requires no land, 99% less water and saves 82% carbon emissions compared to cotton. Additionally, Fibe's fibres have unique properties making them suitable for conventional apparel, including softness, washability, dyeability and biodegradability. Current waste streams have the potential to meet 160% of global non-synthetic clothing demand.

Beren Kayali

Company: Deploy Tech

Deploy Tech manufactures the first-ever flat-packed, inflatable, concrete water storage units, to empower the rural sector to meet their water needs. Deploy comes on a standard pallet with a built-in concrete slab which is an unforeseen in the infrastructure industry. The Deploy tank is air deployed, and once it reaches the final shape, it's hydrated to harden the material. It is then ready to use in just 24 hours. Deploy combines the best properties of concrete and plastic in one smart solution. Deploy fits in a pick-up truck and is half the price of conventional concrete. It's more durable than plastic and the best option for maintenance convenience. This novel material, combined with a thorough structural analysis, has enabled a typical 150mm wall thickness to be replaced with just 6 mm. This represents massive reductions in the generation of CO₂ and water usage.

Douglas Brion

Company: Matta-AI

Matta's operating system uniquely utilises cutting-edge AI, low-cost sensors, and a new data labelling approach, to enable the reliable and autonomous detection, correction, and prevention of errors across a wide variety of products, materials, and manufacturing approaches such as 3D printing. Matta trains deep neural networks to learn the fundamental physics of manufacturing processes and thus create AIs that are invariant across setups and can even explain to users why an error has occurred and how to fix it. This differs from competitors who just memorise how to manufacture a single part, from a single material, on a single setup. Matta is therefore the first system that could be applied industrially, and excitingly it opens the door to manufacturing platforms that can observe and learn together how to make things better, potentially enabling incredible advances across diverse industries.

Sanzhar Taizhan

Company: TaiSan Motors [Financially supported by the ERA Foundation]

TaiSan Motors has developed a novel battery format called "hexagonal" which increases structural integrity and boosts volume availability by 20%. The batteries have low internal resistance to enable fast charging and higher thermal conductivity to be effective in cooling/heating. The design limits cell-to-cell thermal propagation, absorbing and distributing crash load. The concept eliminates module-level components and reduces overall weight. TaiSan has customised the electrode design using a strategic partner's materials to make sodium-ion cells and eliminate lithium, cobalt and nickel. TaiSan also uses lightweight and fire-retardant thermoplastics for the battery housing to substitute bolting/fastening steps with customised next-gen structural adhesives. TaiSan's team implemented a physics-informed neural network to enable electrochemical models to fit automotive requirements. This allows the chemical reactions inside every battery to be tracked when the car is running, enabling accurate life cycle and thermal runaway prediction.

Built Environment Fellow

Dr Xiang Xie

Subject: Integrating Self-programming Artificial General Intelligence in UK Clean Air Zones Using Large Language Models

Mentor: Professor Mohamad Kassem, Newcastle University

In the UK, poor air pollution stands out as a significant threat to public health, responsible for an estimated 29,000 to 43,000 deaths annually among other harmful health effects. This challenge is underscored by the United Nations' Sustainable Development Goal 11.6 'Reducing the Environmental Impact of Cities'. The introduction of Clean Air Zones (CAZs) across many UK cities aims to improve air quality and public health by discouraging the use of polluting vehicles or other policy interventions. Evaluating the effectiveness of various policies relies on AI-driven insights derived from data acquired through distributed air quality monitoring stations. However, due to the unique characteristics of urban areas, such as the type and percentage of different emission sources, the intellectual and cognitive capabilities need to be integrated to support the customisation of the Artificial General Intelligence (AGI) solution and the self-programming. Taking advantage of the impressive capabilities of humanlike understanding and reasoning, two large language models will be trained, namely the reasoning agent and coding agent. Through a conversational interface, the reasoning agent combines the complicated human intent with accumulated knowledge encoded, translated into the Chain-of-Thoughts (CoTs). CoTs, as intermediate reasoning steps, are sequentially delivered to realise the intervention assessment. Finally, the coding agent transforms CoTs into executable codes tailored to the CAZ's circumstances. Without the roles of data scientists and programmers, this transition towards self-programming AGI puts stakeholders in the driving seat, improving the transparency and explainability of the AI solution to CAZ stakeholders and the trustworthiness of the solution.

Sir Misha Black Medal for Distinguished Services to Design Education

Professor Marie Redmond

Università Ca' Foscari Venezia

Professor Marie Redmond was born in Ireland and graduated from Trinity College, Dublin in 1972. She worked in the software industry in the UK and then in the USA for twelve years. While in the US, she spent time working in Cupertino at Apple Computer as part of a team building a network gateway between Digital Equipment Corporation's platform and Apple's software platform. Here she discovered the contribution and impact creative people could make to the overall design process for software.

Concurrently she taught at MIT (Massachusetts Institute of Technology), working in The Writing Program in collaboration with the Media Lab and again witnessed the impact of cross disciplinary thinking and practice.

In 1990 Professor Redmond returned to Trinity College, Dublin and was asked to set up a research group in Multimedia Systems (now called Interactive Digital Media). The first researchers she engaged were designers, video producers, musicians, writers and software engineers. A spin-off company was set up in 1994, called X Communications, as a campus company, which, under Professor Redmond's direction, created interactive installations in national cultural institutes.

In 2013 Professor Redmond designed and created a new MPhil course in Trinity College in partnership with the Institute of Creative and Cultural Entrepreneurship in Goldsmiths, University of London. The course was accredited by both Trinity College and Goldsmiths.

In 2015, Professor Redmond was invited by Ca'Foscari in Venice to develop a Masters' programme in Digital Humanities followed by a second Master's programme in Digital and Public Humanities, where she taught Design Thinking, Critical Theory and Creative and Cultural Entrepreneurship.

Professor Redmond has been a consultant with the European Commission on digital media and related sectors. She has curated shows on robotic art and been a board member of theatre companies and film festivals and arts organisations.

Sir Misha Black Award for Innovation in Design Education

Haleh Moravej

Manchester Metropolitan University

Haleh Moravej is best known for the creation and establishment of her globally recognised, award-winning, student-led MetMUnch programme. In 2011 MetMUnch, brought Nutritional Science out of the lecture theatre and to the public. Its central premise was to demonstrate how design-led techniques, combined with the keen creative minds of students and graduates, could make healthy foods more appealing and accessible, first to students and then to the wider public. Sustainability is the underpinning ethos for every aspect of MetMUnch, working with diverse professionals nationally and internationally to design sustainable food systems, from food production, distribution and creating consumer awareness. Consumers are empowered to develop healthy eating habits through informative, fun packaging and labelling. What might be considered 'food waste' such as coffee grounds are used by students to grow mushrooms and food is preserved through fermenting.

Industrial Design Students

Mohamed Azman	Innovation Design Engineering	Royal College of Art and Imperial College London
Chris Bellamy	BioDesign	University of the Arts London
Grace Broom	Global Innovation Design	Royal College of Art and Imperial College London
Ruta Czaplinska	Innovation Design Engineering	Royal College of Art and Imperial College London
Joseph Jones	Global Innovation Design	Royal College of Art and Imperial College London
Tarika Kumar	Global Innovation Design	Royal College of Art and Imperial College London
Lucie Legrandois	Innovation Design Engineering	Royal College of Art and Imperial College London
Julita Napieralska	Product Design Engineering	Brunel University
Ori Nevaes	Global Innovation Design	Royal College of Art and Imperial College London
Peter Neyra	Design Products	Royal College of Art and Imperial College London
Holly Souza-Newman	Global Innovation Design	Royal College of Art and Imperial College London
Julia Szewczyk	Integrated Industrial Design	Loughborough University
Sabrina Tian	Global Innovation Design	Royal College of Art and Imperial College London
Guy Turner	Innovation Design Engineering	Royal College of Art and Imperial College London

Technical Teaching Fellowships

Paul Gartside	South Central Institute of Technology / Milton Keynes College
Amy Hollier	Heart of Worcestershire College
Bradley Collier & Kumaran Rajarathinam	Blackburn College
Kevin Pollard	MKC Training / Mid Kent College

Special Awards Granted

STEM education and outreach

- British Science Association** – Primary kit boxes
- Primary Engineer** – Primary Engineer Curriculum
- Smallpeice Trust** – Arkwright scholarships
- British School at Rome** – Summer School placements
- Education and Training Foundation** – Technical Teaching Fellowships
- Oxford University Development Trust** – OXbOXes
- University of Hull** – Humber Science Festival
- Kids Invent Stuff** – Inventors' Club
- Royal Botanic Gardens Kew** – Grow Wild
- All Party Parliamentary Engineering Group** – Event sponsorship
- Foundation for Science and Technology** – Debate sponsorship
- Geological Society** – Megalosaurus Month
- MadeHereNow** – Website support
- J Mallinson & E Townsend** – STEM materials
- G Lamb** – STEM outreach

Support for legacy estate

- Imperial College London** – Great Exhibition Road Festivals 2025 & 2026
- Science Museum Group** – Power Hall refurbishment
- Exhibition Road Cultural Group** – SouthKenZEN+
- Royal Society of Sculptors** – Florilegium

Awards completed in 2023

Research Fellows

Dr Keith Andrews

Project: Addressing diabetes: glucose recognition with a bespoke molecular glove

University of Oxford

Keith describes the Fellowship as an overwhelming success. Although the science didn't always turn out as expected, looking back, the project has yielded more than he hoped for. The "molecular glove" that he set out to make (which he refers to as an organic cage) looks very different to the initial design. This is because he soon discovered that the field of supramolecular cages (i.e., the state of the art for synthesising large, robust, soluble cage-shaped molecules) was not as advanced as the literature suggested. This led him to design new chemistry protocols to access the molecules he required. This went spectacularly, and he published his new procedure in January 2023. Remarkably, this new type of cage has ground-breaking properties, and has led to three high-profile academic collaborations. The cage shows strong host-guest recognition (i.e., it is an excellent "glove" to detect molecules) and one collaboration is incorporating these cages into electronic sensors. Whilst studying the potential for this cage to recognise glucose, Keith discovered two surprising and high impact functions. First, the cage performs chemical catalysis just like an enzyme. This data, which will be published soon with the title "Enzyme-like acyl transfer catalysis in a bifunctional organic cage", is the first clear example of this sort of catalysis in synthetic enzyme mimics and has yielded a strong proposal for the other key goal of the Fellowship: to selectively modify glucose. Because glucose is complex and hard to modify, new reactions will enhance access to sugar polymers for biomedical research (such molecules are used in cell-signalling and for identifying bacteria). The second remarkable discovery was that, if polymers of glucose are threaded into the cage, it is possible to selectively break them down into glucose monomers. This has yielded further proposals to apply the cages as industrial catalysts for the conversion of waste biomass into glucose, which could be fermented to access biofuel. This Fellowship has therefore furthered the state of the art in supramolecular organic cage synthesis and initiated a new sub-field of supramolecular covalent organocatalysis.

Keith is now Assistant Professor of Organic Chemistry at Durham University where he hopes to translate the promising findings from his Fellowship into tools for studying enzymes and for biosustainable synthesis challenges.

Dr Xianxin Guo

Project: End to end optical training of neural networks

University of Oxford

In his Fellowship proposal for end-to-end optical training of neural networks, Xianxin set forth some rather ambitious objectives. At the end of his Fellowship, Xianxin is delighted to report that he has successfully accomplished all of these goals, and the results have surpassed his initial expectations.

Over the past three years, Xianxin carried out a series of experiments as outlined in the proposal. Working closely with his fellow group members, he built a large-scale programmable optical matrix multiplier, which can serve as the core of advanced optical processors. Subsequently he constructed a large-scale optical neural network based on that optical multiplier. Finally, he built an all-optical neural network and achieved the world's first end-to-end optical training of neural networks. Remarkably, all the crucial operations were executed optically following the innovative optical training method detailed in the Fellowship proposal.

The impact of this Fellowship project extends far beyond groundbreaking research. Xianxin founded a spin-out, Lumai Ltd. (originally known as OxONN Ltd.) to commercialise the optical computing technology. Lumai has secured venture capital investment to develop advanced optical processors for high performance computing.

Xianxin is now Head of Research at Lumai, and his goal is to deliver optical computing to power the next generation of machine learning.

Dr Thomas Macdonald

Project: Exploring nanostructured light absorbers: from optoelectronics to innovative photovoltaics *Imperial College London / Queen Mary University of London*

In the first year of his Fellowship, Tom developed a robust platform to investigate emerging nanomaterials, particularly phosphorene nanoribbons, in the field of optoelectronics. Simultaneously, he mentored students in synthesizing and analysing alternative nanomaterials like nanocrystals, studying their interactions within solar cells.

In the second year, Tom successfully established a framework to understand the crucial roles played by phosphorene nanoribbons in optoelectronics. He also participated in projects focused on comprehending interfaces in third-generation solar cells. By the end of the second year, he had gained insights into defects at perovskite solar cell interfaces, employing advanced microscopy at the Henry Royce Institute.

During the third year, Tom published his findings on phosphorene nanoribbons in respected journals such as the Journal of the American Chemical Society and Joule. Overall, Tom's Fellowship yielded 40 papers in top-tier journals including Advanced Materials, Angewandte Chemie International Edition, and Nature Communications. Tom secured seven grants totalling over £1 million, along with a prestigious Royal Society University Research Fellowship, leading roles as a Senior Lecturer in Materials Science at Queen Mary University of London and subsequently Associate Professor at UCL, specializing in nanomaterials in renewable energy conversion.

Dr Farid Shahandeh

Project: Constructing a unified resource-theoretic framework to characterise quantum computation processes *Swansea University / Royal Holloway, University of London*

This ambitious project aimed to establish a toolbox for identifying the physical resources required by quantum computers. During his Fellowship, Farid demonstrated that contextuality, a phenomenon arising from the limitation of classical physics in modelling data, is a geometric property of many theories, including quantum mechanics. Moreover, he showed that when suitably adapted to computational schemes, quantum contextuality is an essential resource for any meaningful advantage. Shortly after, colleagues from Poland and Canada developed a linear program to characterise the contextuality of data. Although this program alone cannot characterise resources in quantum computations, when combined with Farid's earlier findings, it paves the way to achieve the project's overarching goal in the near future. Consequently, Farid's project laid the foundations for understanding why quantum computers outperform classical computers in solving specific problems.

The Fellowship played a crucial role in fostering collaborations, leading to spin-off projects, such as partnerships with colleagues in Singapore, Spain, and Germany. It enabled Farid to effectively disseminate his results to the community and facilitated his organising the inaugural workshop Foundations of Quantum Computing (FQC2023) at RHUL, UK, on September 5-6, 2023. FQC2023 brought together experts and practitioners at the intersection of quantum computing and quantum foundations to exchange ideas, share insights, and cultivate collaborations on the fundamental aspects of quantum computing.

The Fellowship also facilitated support for Farid's PhD student, Mrs Zeynab Zolghadr. During her visit to the UK, she and Farid discovered that approximating quantum tomography, the most informative method for studying quantum systems, is impossible.

During the Fellowship, Farid secured a tenure-track lecturer position at Royal Holloway, University of London, ensuring the continuity of his research on this project.

Dr Benno Simmons

Project: How invasive species transform a critical ecosystem function *University of Exeter*

Benno is an ecologist and biodiversity conservationist. His Fellowship focused on understanding and mitigating the threat invasive species pose to pollination, a critical ecosystem service that supports crops and wild plant species globally. Previously, methodological limitations had prevented the effects of invasive species on pollination being detected. Benno therefore aimed to deploy novel, more sensitive, techniques to understand the current and future threat invasive species pose. He discovered a number of important results during his fellowship, with perhaps the most notable resulting in a joint-first author publication in PNAS. In this paper, they showed that very small amounts of field data could be scaled up to make big picture conclusions about the health of entire ecological communities subject to species invasions. This finding has significant implications for monitoring biodiversity, as it allows ecosystems to be monitored much more efficiently, with only tiny amounts of data required.

During his Fellowship, Benno was offered a permanent Lectureship in Ecological Data Science at the University of Exeter, which he started in October 2023. He is now a PI with a research group (simmons-lab.com), focused on using data science, AI and technology to help understand and reverse biodiversity loss. Notable projects running at the moment include using AI to identify species in camera trap images, working towards fully automated biodiversity monitoring.

Dr Adam Smith

Project: Understanding strongly-correlated matter using quantum computers

University of Nottingham

The 1851 Research Fellowship allowed Adam to pursue research into the applications of quantum computers for studying the physics of strongly correlated materials. Quantum computers perform computations in a radically new way that makes them more naturally suited to certain types of problems. One such problem is the simulations of quantum mechanics, a famously complex field of physics, which currently available computers struggle with. During his Fellowship Adam introduced new algorithms for quantum computers for simulating dynamics of quantum systems. This is important for understanding experimental measurements of material properties and will ultimately guide the synthesis of new materials with desired properties.

After his first year, Adam was appointed Assistant Professor at the University of Nottingham and the remainder of his 1851 Fellowship was converted into a start-up grant. This allowed Adam to start his own research group by hiring a postdoctoral researcher, who has since been joined by a second postdoc and a PhD student. In 2023 Adam was awarded an ERC Starting Grant, with which he will extend the work started during his Fellowship and which will allow him to expand his research group further.

Dr Patrick Stowell

Project: Cosmic ray neutron detectors for smart agriculture / civil engineering monitors

Durham University / University of Sheffield

The 1851 Fellowship allowed Patrick to drive forward his research into cosmic ray sensing, a technique that allows non-invasive soil moisture sensing over typical field scales. Patrick has shown that new boron sensors can be used to build cosmic ray sensors over twenty times cheaper than existing systems, making them viable for irrigation monitoring on farms. The Fellowship gave him the flexibility to set up partnerships between farms in the UK and abroad to test and optimise these systems. Partnering with Sao Paulo state's Lanapre Precision agriculture facility he developed hardware that allows cosmic ray sensors to be added to internet of things smart farm networks. Combined with COSMICSWAMP, a precision irrigation platform he developed, these sensors can be used to automatically perform studies of crop water stress and optimise irrigation in arid regions completely autonomously. COSMICSWAMP is now being tested at two pilot farm sites in South America with additional deployments expected in the coming year.

During the last few months of his Fellowship Patrick was offered a permanent lecturer position at the University of Sheffield, where he now works in both neutrino particle physics and applied neutron physics. He has taken over as the manager of the University of Sheffield neutron irradiation labs. Over the next few years, Patrick will be working to establish several dedicated neutron and gamma

test stands in these labs with a focus on soil characterisation and monitoring using radiological techniques in partnership with colleagues at Leeds University smart farm and Rothamsted Research.

Brunel Fellow

Dr Roy Bartle

Project: Thermal desalination with renewable hydrogen energy

University of the Highlands and Islands – Lews Castle College

Roy's Fellowship has investigated the production of fresh potable water from seawater, mainly by thermal desalination, which uses heat to remove the salt content by evaporating out the water. His research suggests that the future of potable water production is in reverse osmosis (RO) desalination, which is a mechanical method of separating the water from the salt, rather than in thermal desalination systems, mainly because of the much superior economic case of RO systems. The exception is where a ready supply of low-grade waste heat is available from, for example, power stations or industrial manufacturing facilities, which give a heat supply for thermal desalination at minimal economic cost. These findings are currently being written-up for journal publication in 2024.

Following the Fellowship, Roy is maintaining an affiliation with the University of the Highlands and Islands for further energy engineering research as well as working to introduce renewable energy systems for irrigation and crop drying on his arable farm in Zambia. However, Roy's research interests are moving towards theology, including theology of the built environment, so his primary academic affiliation going forwards will be with Mukhanyo Theological College in South Africa, where he will be lecturing in ecclesiology and church history.

Industrial Fellows

Daniya Aynetdinova

Project: Cationic cyclisation cascades mediated by carbon electrophiles for the formation of novel polycyclic products

Sponsor: Vertex Pharmaceuticals (Europe)

University of Oxford

During her Fellowship, Daniya successfully completed her aim to develop a robust polyene cyclisation methodology with the results published in the well-respected scientific journal: *Chem. Eur. J.* 2023, 29, e2022037 (doi: doi.org/10.1002/chem.202203732).

This project has paved the way for a new research direction in the field of polyene cyclisation. In an industrial setting at Vertex Pharmaceuticals, the successful completion of this project has introduced a novel methodology for the efficient stereoselective construction of complex 3D molecules, applicable to the synthesis of steroid analogues. To demonstrate this, a formal synthesis of rac-18-nor-estradiol has been achieved.

A further objective, which was to develop a diastereoselective cascade heterocyclisation methodology, has also been achieved, demonstrating the robustness of the carbocation-triggered cyclisation approach. Financial support from the Commission was critical in allowing Daniya to explore challenging enantioselective approaches to achieve carbo- and heterocyclisations.

Following her Fellowship, Daniya will be working at the University of Vienna as a postdoctoral researcher in the field of organic chemistry.

Maral Bayaraa

Project: Satellite-enabled early warning system for geotechnical structures

Sponsor: Satellite Applications Catapult

University of Oxford

Maral's Fellowship research combined InSAR monitoring, geotechnical modelling, and deep learning to create tailings dam failure early warning systems. The Fellowship has produced valuable research outcomes (including two high quality journal publications), has provided a real-world context and demonstrators for academic work in the field, and promises to deliver a commercially viable early warning solution.

Maral's project received the Prototypes for Humanity award at COP28 in Dubai, within the category of Data Science and AI. This generated considerable media exposure, including on BBC radio 4 and in videos from the ceremony with the Princess of Dubai. Maral was also awarded a Keeley senior scholarships prize from Wadham College, University of Oxford.

Maral has been able to engage with high level policymakers on the importance of her research, including engagement with the Deputy Prime Minister of Mongolia Mr. Amarsaikhan. Her research also led to a TV interview on Mongolian National Broadcasting MNB World and various podcasts.

Maral's research has already helped the Satellite Applications Catapult secure commercial mining projects. Her machine learning/AI expertise is opening up new opportunities, such as the development of an AI prototype within the Catapult's accelerator space commercialisation engine and the delivery of new sustainable finance interventions.

Maral remains with the Catapult, where she has been promoted to be a senior earth observation consultant.

Sam Bourne

Project: Characterising genetic variants associated with pain to improve the clinical translation of novel therapies

Sponsor: LifeArc

University of Kent

Pain is a serious unmet medical need globally, and a major barrier to addressing this is poor clinical translation. Indeed, other than reformulations of existing drugs, no novel disease-modifying pharmacological therapies have been approved over the past few decades. With pharmaceutical industries increasingly considering the disease area as high risk, innovative approaches are required to improve clinical success by selecting better prospective therapies and their appropriate patient population.

Sam's Fellowship undertook a large-scale approach to improve the clinical translation of novel pain therapies. This was done by examining human genetic biobanks that collectively comprise over 750,000 genomes to validate in-house pre-clinical analgesic drug targets and stratify complex patient populations. Over 135,000 mutations occurring in the general population were examined within 15 two-pore domain potassium channel (K2P) genes, which represent novel pain drug targets. Each of these was assessed for its ability to statistically influence an individual's susceptibility to 136 pain-related traits. In total, 18 mutations were discovered that significantly modulate a patient's likelihood of developing pain such as migraine, seeking clinical analgesic treatment or chronically using pain medications. Several mutations were shown for the first time to significantly alter the gene activity of ion-channels which prevent pain sensing signals from reaching the sensory cortices.

These efforts have provided novel translational validation of K2Ps as drug targets in large-scale patient populations for the first time, while pointing towards appropriately stratified patient populations for which specific drugs may be of most effect. This genetic approach has supported LifeArc's efforts by de-risking their pre-clinical development for K2Ps and by adding weight to growing consensus in the literature for developing novel K2P analgesics. This work has improved LifeArc's external reputation within industrial and academic fields, and particularly strengthened academic collaborations that will continue to be utilised in future projects.

Following the Fellowship, Sam will continue to take a leadership role as a drug discovery scientist at LifeArc. In particular, he will be applying the skills and knowledge he has gained to tackle new disease areas such as motor neuron disease.

Daniella Cheang

Project: Can we keep borrowing from future generations? A green, biomimetic method for controlling chirality

Sponsor: AstraZeneca

University of Oxford

Forming carbon-carbon bonds is one of the most fundamental processes in organic chemistry and forms the basis of making materials for the pharmaceutical industry. Most biological molecules can exist in either a right-handed or left-handed form – a property known as chirality. These two forms are related by reflection in a mirror plane and are known as enantiomers. Nature has an innate ability to control chirality, and this can be seen in many natural materials. Chirality can have significant implication for drug candidates – one form may have therapeutic value, whereas the other may have reduced or even detrimental effects. Therefore, finding new ways to control chirality and form a molecule of single handedness are of high importance to the pharmaceutical industry. Daniella's project used hydrogen borrowing to mimic Nature's sophisticated enzymatic process. Hydrogen borrowing uses feedstock alcohols to elongate carbon chains in one step. During her Fellowship, Daniella developed different hydrogen borrowing methods for synthesising molecules of a single handedness, each with a different focus. In the first method, β -branched acyclic ketones were synthesised allowing formation of sterically hindered carbon-carbon bonds with high enantioselectivity. The second method focused on the synthesis of γ -branched cyclic ketones using a dynamic kinetic resolution strategy. Pharmaceutically relevant heteroatoms, such as nitrogen, were then incorporated to allow synthesis of enantioenriched gamma-aminobutyric acids from starting materials derived from simple racemic amino acids. These methods could be adapted to large scale setup and furthermore purification of the products by crystallisation was possible.

Following the Fellowship, Daniella will be taking up a research scientist position at Boehringer Ingelheim.

Marie Dale

Project: Automated identification and predicted translocation of marine hull invasive species

Sponsor: AkzoNobel

Durham University

Shipping accounts for over 80% of global trade. In addition to transferring goods between ports, shipping can also result in the transfer of non-indigenous species. Biofouling is one of the main vectors for the spread of non-indigenous species, some of which may become invasive.

Invasive species are a major threat to the world's oceans as they cause biodiversity loss and damage to coastal industry and infrastructure. Up to 69% of known aquatic invasive species are introduced through transportation of biofouling; something which is only expected to worsen with the combination of increased trade and global climate change.

The global fleet is large, and resources are scarce – it is important these resources are deployed where invasive risk is greatest, to have the most impact. In her Fellowship research Marie has developed models to predict global species distribution and translocation potential through biofouling transportation on ship hulls, identifying viable translocation pathways both now and in the future (accounting for climate change). These viable pathways can help identify high-risk vessels which may require further scrutiny e.g. by in-water inspection. To make in-water inspections practicable and cost effective at the scale required, the second part of Marie's research has focussed on developing a route to automated image recognition of non-indigenous species.

Following on from the Fellowship, Marie will continue her research and explore opportunities to commercialise the output within AkzoNobel. This supports AkzoNobel's ambition to develop solutions to minimise the impact of invasive species, to support the wider shipping community and ultimately support the goal to reduce the environmental impact of shipping.

Jack Kay

Project: Discovery of novel antimicrobial peptides to combat current and emerging superbugs

Sponsor: Ingenza

University of Plymouth

Jack's Fellowship focused on the identification of a significant number of potent, natural and engineered, antimicrobial candidates, which have promising application in the treatment of antimicrobial-resistant infections in both humans and animals. The discovery of these molecules represents a significant advancement in the field of bacteriocins research, with the number of known 4-helix bundle bacteriocins increasing by more than an order of magnitude, from fewer than 12 to over 200, directly from work carried out in the Fellowship.

Through this Fellowship, Jack has created a pipeline of lead molecules originating from a variety of microbial sources, which are diverse in amino acid sequence, and potency, with the full range of target specificity still to be tested. Promising candidate molecules will be exploited via partnership with Amprologix, which is a spin-out from the University of Plymouth leading the commercialisation of 4-helix bundle bacteriocins. Amprologix has already supported the leading 4-helix bundle bacteriocin Epidermicin through pre-clinical toxicology studies and is seeking further funding to advance to the lead compound Epidermicin NI01 for topical therapy of skin infection, and it is expected further funding will be obtained with the data generated during the Fellowship.

The Fellowship has also enabled Ingenza to keep up with current advancements in the field of biotechnology and become active contributors at the exciting interface with machine learning. Throughout the project, machine learning methodologies were applied in efforts to understand the complex relationship between amino acid sequence and observed activity of the 4-helix bundle bacteriocins. In doing so, the company has dramatically increased its in silico capabilities, as demonstrated by the development of a proprietary codon optimisation algorithm, a service it now offers as part of customer projects.

After completion of the Fellowship, Jack will continue working at Ingenza as a senior scientist in the Molecular Biology Department, further characterising the lead molecules identified and driving the development of Ingenza's in silico capabilities.

Joe Lawton

Project: Remote plasma sputtering of high quality thermochromic thin films for energy conservation

Sponsor: Plasma Quest

University of Surrey

Joe's EngD project focussed on the investigation of Plasma Quest Limited's proprietary remote plasma sputtering technology in the production of important functional oxide thin film materials. Functional oxide thin films and coatings are key materials across many technological industries with demanding film structure and property requirements and the understanding of process parameter selection to produce the desired material is paramount to realising new products or devices.

The project investigated the process-structure-properties relationship of remote plasma sputtering processes and routes towards low-temperature deposition for two key functional oxide materials: thermochromic VO₂ and TiO₂. The research was unfortunately unsuccessful in producing a low-temperature route to thermochromic VO₂. However the project identified key process parameters for controlling the growth and properties of TiO₂ thin films. The study also expanded the process knowledge for the use of substrate biasing technology in conjunction with remote plasma sputtering as a means for low-temperature deposition of crystalline material onto a variety of different materials.

The work feeds into the wider knowledge of the unique processing landscape of the remote plasma sputtering technology at Plasma Quest Limited. The research helps to inform decisions with the development of new technological capabilities and processes for other materials of interest.

Joe is currently finishing writing up his thesis and applying for new jobs in London.

Bojidar Rangelov

Project: Discovering CT imaging biomarkers of exacerbations of COPD

Sponsor: GSK

University College London

During his Fellowship, Bojidar worked on developing machine learning and image analysis techniques applied to Chronic Obstructive Pulmonary Disease, and occasionally to other diseases. He advanced knowledge of the phenotypes and disease progression of COPD, identified imaging biomarker candidates of exacerbations of COPD and developed a comprehensive, machine learning powered suite of CT analysis algorithms, which can be used to extract and analyse these imaging biomarkers of COPD. The results of his research can contribute to the design of pharmaceutical trials by inspiring the study of lung anatomy which might have previously been overlooked. Furthermore, the disease progression techniques have been gaining traction in the field and are considered for patient stratification. Finally, the image analysis suite can be used to analyse further CT datasets and quantify imaging biomarkers in both stable COPD and during exacerbations of the disease, in addition to being applicable to other respiratory diseases.

While GSK does not intend to directly profit from the intellectual property of Bojidar's work, having access to the results of his research is expected to improve inefficiencies in data logistics and access, empower future image analysis studies and aid in patient stratification for clinical trials. Furthermore, the techniques Bojidar has developed should save costs on contracts with image analysis companies (which GSK has used in the past) by providing baseline results and endpoints which can be extracted in-house.

Following the Fellowship, Bojidar intends to continue developing in the machine vision and medical image analysis field by pursuing jobs in companies which focus on machine vision in the medical field. A great motivator is still the increased translation of engineering and AI to medicine and its impact on patient care. To this end, Bojidar is hopeful that in the future he will establish or find a role which would allow him to both spearhead research, collaborate with medical institutions, and translate technology into clinical practice.

Andrei-Claudiu Roibu

Project: Mapping brain network activity from structural connectivity using deep learning

Sponsor: F. Hoffman-LaRoche

University of Oxford

Andrei's Fellowship has helped him make significant advancements in the field of neuroimaging and brain age prediction, which further our understanding of factors which are linked to accelerated brain ageing (which could result in, or be precursors to neurodegenerative diseases), as well as those factors which are associated with resilience to ageing. His work has resulted in the creation of a set of predictive models using innovative AI methods, including convolutional and vision transformer networks, enhancing our capabilities to analyse brain aging with a high level of precision.

Andrei's work has also expanded the field of brain age prediction across 57 different MRI imaging modalities, with each modality capturing a different aspect of the ageing brain. These include aspects such as the brain's structure, connectivity, functional activity, microstructure, element deposition, etc. This research has also expanded the toolset available for analysing and understanding brain age predictions, allowing for a more detailed understanding of how it correlates with different lifestyle and environmental factors.

By identifying deviations from normal brain aging patterns, which could be linked to disease progression, his findings contribute substantially to early diagnostic processes, targeted therapeutic strategies, and clinical trials at Roche. While the project is in its nascent stages regarding commercialisation, it holds substantial potential for future applications in drug development and clinical trials.

Moreover, the Fellowship has strengthened the collaborative ties between Roche Pharma and Oxford University, enhancing Roche's research capabilities and expanding their academic network. This relationship has proven invaluable, fostering an exchange of ideas and methodologies that benefit both academic and industrial research spheres. The insights gained, and the methodologies developed during this Fellowship not only propel Roche Pharma's position in neuroscience research but also underscore the potential for significant future impacts on healthcare and treatment paradigms.

Following the Fellowship, Andrei is moving to a position with Synthara AG in Switzerland.

Thomas Waddell

Project: Causal modelling of obesity and multi-organ dysfunction through magnetic resonance imaging: applying Bayesian networks

Sponsor: Perspectum

University of Oxford

Tom's DPhil project focused on the application of Bayesian networks in healthcare, specifically in Type 2 diabetes and long covid. The project has resulted in three journal publications (with an additional paper currently under review) and several conference publications. The work has greatly contributed to building Perspectum's multi-organ imaging offering and evidence base in the space of metabolic disease and COVID-19. The project has allowed Perspectum to showcase the true utility of multi-organ imaging, showing how (for example) the individual facets of body composition affect the development of non-alcoholic steatohepatitis, a severe form of liver disease which Perspectum's flagship product explores. Tom's work has been presented at multiple international conferences, allowing Perspectum to build their brand awareness and collaborate with several key opinion leaders to assist with industry positioning of Perspectum technology. Furthermore, Tom's Bayesian-network models have been used by Perspectum to illustrate the importance of stepping away from 'black box' AI approaches in healthcare.

Following the Fellowship, Tom will be continuing his employment at Perspectum within the BD Pharma department, in a role that combines his scientific knowledge and the dissemination/communications skills that were greatly improved through the Fellowship.

Declan Williams

Project: Flow versus batch chemistry in the safe manufacture of explosives

Sponsor: QinetiQ

University of Birmingham

Declan's project focused on the use of microreactors for the manufacture of explosives and in particular whether less hazardous approaches can be used in place of current batch processes. As part of this research project the manufacture of conventional explosives (RDX and HMX) and energetic plasticisers (K10 and GlyN), have all been investigated in flow, significantly improving safety and reproducibility. The travel bursary provided as part of the Fellowship also enabled Declan to establish valuable networks within the flow chemistry community.

Declan's research has helped QinetiQ to further its expertise, but also given a large scope to innovate. By leveraging the outputs of this research project and expertise gained, QinetiQ now present a new offering to customers.

On completion of the project, Declan will return to being employed by QinetiQ full time and will continue to conduct research into the use of flow chemistry and microreactor technology in the exploration of novel explosives. He hopes to continue collaborating with Birmingham University, and other organisations within academia and the defence industry, to further develop approaches to the manufacture of explosives in flow, developing innovative, sustainable, and safe methods that are suitable for the large-scale manufacture of explosives.

Declan has recently been awarded the Frank Carver Bursary by the International Pyrotechnics Society.

Industrial Design Students

Erin Carr

Course: Earthquake Engineering and Infrastructure Resilience

University of Bristol

Completing a masters is the only way for civil engineers in the UK to become chartered. Without the support of the Royal Commission, Erin says, it simply would not have been possible for her to further her studies in this way. The opportunity to study this specialised masters at the University of Bristol has further solidified Erin's ambitions and career path in disaster relief while giving her real hands-on experience during the earthquake in Turkey. This opportunity provided her with the skills, knowledge and hands on experience to successfully join the Institution of Structural Engineers Emergency Engineering Field Investigation Team (EEFIT), who create teams of structural engineers to carry out emergency structural assessment and engineering in time of disasters.

Erin's masters thesis, *Parametric Finite Element Analysis of Concrete Beams Reinforced in Shear with Fibre Reinforced Polymers: Informing the National Annex to the new Eurocode for Design of Concrete Structures (EN1992)*, essentially looked at verifying experimental data of fibre reinforced concrete beams to inform the British National Annex of the Eurocodes, which is the set of building codes and standards civil engineers have to follow in order to build safe structures. This was the first time fibre reinforced concrete has been included into the codes signifying the research's importance, and it is hoped that the material's inclusion in the codes creates more confidence in construction in the UK for the future

Erin says: "I will forever be thankful for the opportunity and support the Royal Commission has given me to further my academic and professional ambitions which wouldn't have been possible otherwise. I thoroughly enjoyed this experience and am immensely proud to have been a part of the Royal Commission."

Erin is now working for Momentum Consulting Engineers in Bath and also continuing her nursing training.

Jahan Daya

Course: Global Innovation Design

Royal College of Art / Imperial College London

With a background in Mechanical Engineering, Jahan joined the Global Innovation Design course seeking to combine technical and creative practices in a multidisciplinary and multicultural environment.

The course aims to immerse its students in changing cultural contexts and enabled Jahan to travel to Tokyo and New York where he focussed on honing his hands-on prototyping skills and learned a bit of Japanese. During the New York exchange at Pratt Institute, he worked on an experimental project to create biodegradable sunglasses frames from processed seafood waste (Chitosan). This project aimed to address the ever-increasing plastic waste issue in our oceans, generated from the production, sale, and loss of cheap sunglasses.

Upon returning to London, Jahan's final year solo project explored the problems surrounding shoulder injuries in swimming and water polo athletes and the complications arising when returning to their training. His project sought to give confidence and customised training benchmarks so that each athlete can monitor their rehabilitation and training progress while minimising the risk of re-injury. The outcome resulted in the development of a mobile app and wearable device fitted on both hands that tracks the athlete's motion to analyse their technique variations and muscular fatigue levels. By identifying the rate and volume of fatigue incidents, the system can estimate acute and chronic shoulder strain and subsequently evaluate how their training affects their rehabilitation and their risk of re-injury. Athletes can use this data to make informed decisions to tailor their training so they may safely and quickly return to sport.

Following the Studentship, Jahan has secured a six-month internship at Gurin Energy, a renewable energy developer based in Singapore. The company focuses on the development, ownership, and operation of wind, solar, and storage solutions in Asia.

Grace Duan

Course: Innovation Design Engineering

Royal College of Art / Imperial College London

During her Studentship Grace explored the interdisciplinary intersection between design and technology, diversifying her skillset with various projects, including developing the *Leafeon System*, a circular system that has the potential to simultaneously bridge the nutrition gap and create more sustainable, organic agriculture by upcycling legume waste and surpluses into Leaf Protein Concentrate, a promising and innovative food source that is the cheapest, most abundant source of protein.

For the final major group project Grace looked at the growing problem of microplastics in our oceans and waterways. Current methods for detecting microplastics in water bodies are resource-intensive, requiring a great deal of expertise, expensive equipment, labour and time. *MicroSentry* is a low-cost and field-deployable in-situ sensor that can be attached to existing infrastructures such as data buoys, research vessels, and piers. It is designed to be used for continuous data collection,

providing real-time representative data that is relevant to scientific research and contamination monitoring for water companies. The sensor not only detects microplastics but also transmits the data to a data visualisation platform providing readable data for the public. This allows for easy access and understanding of the microplastic pollution levels in our water bodies. *MicroSentry* went on to be exhibited nationally and internationally, as well as making it to the finals of the Mayor's Entrepreneurship Competition 2023.

Following on from her studies, Grace is now an Associate Partner Manager at Amazon in London, working on the future of home devices.

Daniel Hale

Course: Innovation Design Engineering *Royal College of Art / Imperial College London*

In his first year, Daniel explored the future of distributed creation, geometric craft and circular manufacturing.

Daniel's second year group project, *Pleural*, aimed to create an autonomous device designed to help people with respiratory conditions combat mucus. Unlike anything else available, the innovative handheld device offers comprehensive guided chest physiotherapy to be carried out autonomously by patients at home. *Pleural* reached the finals of Imperial College's Venture Catalyst Challenge and the Mayor's Entrepreneur Competition and received a James Dyson Award and the Helen Hamlyn Award for Creativity.

For his solo project Daniel knew he wanted to work on something related to the environment and utilise principles of regenerative systems design. After becoming interested in the whales that drive the ocean nutrient cycle, he started looking into nutrient cycles at a domestic level and specifically addressing the mess that is the way we manage our biodegradable waste from the home. The final output from the project is a new kitchen sink appliance that processes all biodegradable waste into usable biogas and nutrient fertiliser for regrowth.

Daniel is now a Mechanical Design Engineer with Shellworks, a design-led company that creates compostable packaging solutions made from naturally-derived materials.

Eden Harrison

Course: Innovation Design Engineering *Royal College of Art / Imperial College London*

During his Industrial Design Studentship, Eden studied Innovation Design Engineering, transitioning from his prior work as a mechanical/structural engineer into the worlds of design and innovation. While in the first year of IDE, Eden worked on diverse projects, from vision-tracking and machine learning for gaze-prediction, to the computational modelling of flocking behaviour for sculpture. Eden's solo project during this year focused on the ability of phase-change materials to alleviate thermal stress in humanitarian camps.

During his second year, Eden worked with Liz Lee, Ori Blich and Juan Ignacio Rion to develop a novel biomaterial replacement for polystyrene that went on to place as a finalist in — amongst others — WE Innovate, the Mayor's Entrepreneur competition, and the Green Alley Award. It has also exhibited at major design festivals, from London to Dubai. This project has since flourished into a startup, Carbon Cell, winning a place on two competitive accelerator programmes and is currently based in Somerset House.

Eden's master's thesis, developed during the final six months of his second year, involved a novel post-humanist design approach to addressing underwater sound pollution. The result, *reef dB*, was a national runner up for the James Dyson Award, as well as winning the Innovation Design Engineering 'Outstanding Achievement Award'.

Since graduating Eden continues to work as CTO and co-founder for Carbon Cell, pushing the project towards a commercially successful future that can have a serious positive impact on our world.

Samuel Jones

Course: Design Products

Royal College of Art

During his Studentship, Sam evolved his design practice through impactful projects that have explored topics such as minimising furniture waste, exploring innovative alternatives to cars, and repairing electronic appliances. These have been great test beds for learning, alongside being formed around some of the world's most currently pressing topics.

In addition to the core course, Sam made sure to actively engage in additional projects such as OPPO X RCA and Design for Good, while also attending numerous training courses, talks, on-site visits, and exhibitions. What stood out most to him was the opportunity to consistently engage with some of the best people in industry and education. He has made contacts that he would never have been able to reach otherwise, with whom he looks forward to staying connected for many more years to come.

Sam's graduation project was a focused exploration of how we can apply the convenience of cars to the micromobility realm. Even though it was intended as a platform for learning, it gathered great interest, showing potential for real impact. It has now become a valuable asset, poised for further development and ultimately, market realisation.

Following his Studentship, Sam has set up his own consultancy, Jam Scones Design.

Steph Jump

Course: Innovation Design Engineering

Royal College of Art / Imperial College London

During her master's programme, Steph researched how spatial skills are vital for succeeding in STEM but are not taught in schools. These skills forecast future mathematics success, foretell which students will choose STEM careers, and even predict who will drive STEM innovation.

On average, girls have less spatial experience than boys, making them three times more likely than boys to struggle with this ability. Low-income students also lag significantly behind their wealthy peers. Steph's research suggests that spatial training can even out girls' abilities with boys', increase women's engineering retention by up to 30%, and improve students' STEM grades regardless of gender or income.

During her Studentship, Steph developed spatial skills training games. She received a scholarship from the Pokémon Company, was a finalist in the London Mayor's Entrepreneurial Prize and a competitor in Imperial's WE Innovate Programme.

Following her Studentship, Steph has become the founder and CEO of Alytica (www.Alytica.studio), a start-up driving equity in STEM education through spatial skill training games.

Vedika Lall

Course: Global Innovation Design

Royal College of Art / Imperial College London

Vedika's major project during her Studentship focused on uterine contraction monitoring. The experience of contractions preceding labour is truly unique, as each woman encounters them in her own distinct way. However, this crucial indicator of the mother's health is often overlooked and poorly communicated. Shockingly, over 40% of women struggle to discern whether they are in labour or not.

Uterine contraction monitoring is important because it is a critical biomarker of maternal health and a reliable indicator of labour progression to delivery. At present, uterine contractions are monitored using apps or manually, which is unreliable and frequently leads to women miscalculating.

Bia is an at-home uterine contraction monitoring system designed to seamlessly integrate into a mother's rest routine. Codesigned with recent mothers and clinicians from St. Mary's Hospital, London, *Bia* is intended to be comfortable and flexible; it incorporates a digital interface and novel sensing technology to listen, recognise and measure contraction activity reliably.

Bia is currently patent pending, and Vedika hopes to bring together a team to bring it to market. In the meantime, she is acting as a Design Mentor at the Srishti Manipal Institute of Art, Design and Technology.

Jasper Mallinson

Course: Innovation Design Engineering

Royal College of Art / Imperial College London

Jasper came from a background in design engineering, with personal roots in ‘nuts and bolts making’ – working at a younger age in roles across metal fabrication and carpentry. In the years before joining the Innovation Design Engineering programme, he worked in the world of tech start-ups, developing drones for humanitarian landmine clearance and microfluidic blood testing devices.

During his Studentship, Jasper focused on regenerative design and digital fabrication, including using eco-acoustics to tackle agricultural soil degradation and modelling the natural shrinkage of fresh wood for use as a computational design tool.

His major project, *Mecha-morphis*, explores the concept of ‘augmented makers’ – the reimagining of digital fabrication technologies (technologies that control tools through computers) to augment, rather than replace, human making abilities, developing a wearable robotic device that gives humans the capabilities of digital fabrication machines.

Jasper is now a Product Design Engineer at AcoustoFab, which focuses on mid-air ultrasound manipulation.

Hunaid Nagaria

Course: Innovation Design Engineering

Royal College of Art / Imperial College London

Hunaid entered the Innovation Design Engineering programme at Imperial and the RCA, wanting to build a practice around his interests in Industrial and Interaction Design. Receiving the Commission’s support made it possible for him to explore themes in accessibility and how to build technology for people living with varying abilities and circumstances.

During the programme, Hunaid’s solo pursuits focused on building technology that facilitated recreation, such as musical instruments for people living with dementia and a gaming controller for people living with Muscular Weakness, which turns anything you touch into a control interface. A key piece of work that lies outside these themes was the development of *Guerrilla*, a patent-pending device that tackles polluted road runoff as part of a group project. Hunaid’s work in the IDE programme culminated in a distinction and recognition from institutions such as the Mayor of London’s office and the Interaction Design Association.

Since graduating, Hunaid and his co-founders have transitioned *Guerrilla* from an academic project to an award-winning startup approaching real-world trials.

Following this, Hunaid has joined the design team at Nothing(R), a leading consumer electronics manufacturer. As a Creative Technologist, Hunaid will work with the team on research and development for new products and helping to realise an alternative, more ‘fun’ future for consumer electronics.

Fintan Pritchard

Course: Integrated Industrial Design

Loughborough University

Fintan’s course and continued education have allowed him to make substantial progress with various advanced skills and software within design. Surface modelling in solidworks and Rhino alongside high-fidelity prototyping with CNC manufacture have equipped him to design and test complex and modern products with precision. Additionally, he pursued a good understanding of AI theory and product development, being one of only a few to successfully program a focused AI in TinyML, a new skill which is increasingly relevant and sought after.

Beyond these technical accomplishments, he enjoyed collaborating with designers with vastly different backgrounds and training, helping him develop his management and collaborative abilities. His business management project simulated a startup with the activity involving every aspect of running a business, from concept development and seeking investment to product distribution and everyday operation.

Following the course, Fintan has secured a role designing and marketing luxury audio equipment for EAR Yoshino, a high-end audio tech company.

Mia Shepherd

Course: Product Design

University of Strathclyde

During her Studentship, Mia successfully navigated a variety of taught modules alongside an industrial group project and an individual endeavour, the latter of which was inspired by a personal passion for fibre arts (knitting, crochet, embroidery etc). Informed by her awareness of individuals within the crafting community who exclusively employ one hand for crocheting, she observed that remarkably, none of these crafters were utilising a commercially available assistive device. Furthermore, user-made solutions provided for their own specific needs, often lacking the versatility required to address all scenarios in which someone might exclusively use one hand. This could include relying on the arm's weight or clamping capability where only the hand dexterity is compromised compared to a complete upper limb amputation. Thus, Mia discerned a critical gap to design an inclusive assistive device for single handed crocheting.

In collaboration with a stakeholder, Mia developed a novel solution providing for a spectrum of crafters ranging from those devoid of manual dexterity in one hand to those with a single amputation extending from the shoulder. Mia's solution goes beyond the current market by providing on-the-go use and independence, removing the need for reliance on additional surfaces for mounting or stability.

Following the Studentship, Mia has accepted a position at the University of Strathclyde as a doctoral candidate under the title of Designing Cycling Health. She intends to blend her experiences in Sports Engineering and Product Design to craft insightful contributions aimed at engaging more people in Glasgow with sustainable infrastructure.

Annie Tang

Course: Global Innovation Design

Royal College of Art / Imperial College London

During her Studentship, Annie embarked on a global journey from London to New York and Tokyo, delving into the intricacies of design on a worldwide scale.

One notable project involved developing a medical device tailored for individuals with Chronic Fatigue Syndrome (CFS) to better manage their symptoms. This endeavour led Annie to investigate ways to adapt 12-lead electrocardiograms (ECGs) for continuous commercial application, facilitating the collection of high-quality heart rate (HR) and heart rate variability (HRV) data for both patients and researchers. A novel solution emerged in the form of electrode 'tattoos'.

Another significant undertaking was a co-design initiative with residents of a social housing complex. Here, the focus was on addressing the challenges faced by older residents in navigating an increasingly digitized world. Annie's collaborative efforts resulted in the creation of a print logbook complemented by online resources, offering a bridge to essential services.

Lastly, Annie explored methods to enhance the relationship dynamics within familial care pairs dealing with chronic conditions, aiming to boost morale and overall quality of life. Through interactive activities featuring guided questions and prompts, she sought to foster understanding, joy, and moments of respite for these caregiving pairs.

Following the Studentship, Annie plans to continue to apply these insights and methodologies to tackle real-world challenges in the field of design, striving to make meaningful contributions to global communities.

Eve Townsend

Course: Innovation Design Engineering

Royal College of Art / Imperial College London

Eve joined the Innovation Design Engineering program at Imperial College London and the Royal College of Art, focusing on combining technical innovation with human-centred design. With a background in physics, much of her work draws on the application of scientific knowledge to advance technologies that promise societal and environmental impact. Bridging industry and academia, she hopes to accelerate the transition of early-stage research into usable products, while designing new technologies, systems, and user experiences.

During her masters, Eve's research specialised in advanced human-computer interactions, developing *Loqui*: a wearable assistive device for people with Parkinson's disease. The device translated speech parameters into tactile biofeedback mitigating challenges associated with altered speech perception, volume and rate, thus enhancing users' quality of life by enabling autonomous engagement in real-life conversations.

In the environmental sciences, Eve worked on two main projects: *Biofonic* and *Xellyfish*. *Biofonic* is an eco-acoustic monitoring device that detects key soil health indicators and enabled agricultural researchers to quantify the impact of ecosystem-focused farming, accelerating progress towards Net Zero. *Xellyfish* is a bio-designed device that captured microplastics from water sources, earning finalist positions in the Terra Carta Design Lab, Mayors Entrepreneur Awards, and presentation at COP26.

This studentship has significantly helped Eve to further advance her career in research, design and engineering. Eve has now joined Riverlane, a company specialising in quantum error correction (QEC), where her focus on software decoding advances the pathway towards fault-tolerant quantum computing by turning unreliable physical qubits into reliable logical qubits.

Enterprise Fellows

Rowan Armstrong

Company: Bioliberty

Bioliberty is a robotics start-up that aims to empower every human, particularly those affected by stroke, to live a longer independent life through assistive and rehabilitative robotics.

In their recent report, 'Stroke rehabilitation in adults', the National Institute for Health and Care Excellence (NICE) suggested stroke survivors should get at least three hours a day, five days a week of rehabilitation. This will put considerable pressure on an already stretched NHS, so robotic solutions like theirs, which can be used without carer supervision, could be an extremely timely, cost-saving resource.

Lifeglov employs cutting-edge soft robotics technology for precise force generation and control, ensuring a tailored approach to rehabilitation. The device features adjustable force levels, allowing for personalised hand rehabilitation that promotes optimal recovery. When coupled with Bioliberty's virtual therapy environment, *Lifeglov* becomes a versatile tool for stroke survivors at every stage of their rehab journey.

Acting as both a passive and active device, it can either facilitate movement independently or provide assistance to complete specific motions. In its passive mode, *Lifeglov* does all the work to help mobilise movement, while in the active mode, it collaborates with the user to help them complete movements. Bioliberty's soft robotics can detect subtle movements, and, through trained AI algorithms, translate these intentions into actions.

In April 2023, Bioliberty secured £2.3m in funding from a consortium of investors, including Archangels, the business angel investment syndicate. This new funding will go towards developing the machine learning and data collection elements of the product. This is extremely important for therapists and other clinicians as it can help them monitor the progress of their patients as well as tailor their treatment.

Bioliberty has further exciting developments on the horizon, including the upcoming launch of *Lifeglov* in the US market.

In the meantime, they are conducting clinical investigations in collaboration with a leading rehabilitation hospital in the US. These research efforts aim to substantiate the effectiveness of Bioliberty's technology in aiding individuals to achieve a more optimal level of function post-stroke.

Joseph Bentley

Company: ACT Medical

ACT Medical is a MedTech start-up looking to revolutionise the standard of care for penetrative trauma and reduce the mortality rates associated with violent crime.

In London, it takes 7 minutes for an ambulance to arrive, but only 5 minutes for a victim to bleed to death. Consequently, half of all violent trauma related deaths occur before the patient is able to reach definitive care. Providing first responders with a method of applying direct pressure to the wound site would drastically reduce the trauma mortality rate. This method needs to be intuitive, without knowledge of complex techniques such as wound packing, and easy to remove once the patient reaches surgery. ACT Medical are designing a device that directly addresses this need and aims to stem bleeding as quickly as current methods.

In July 2023, Joseph was awarded Entrepreneur of the Year and ACT Medical received the Innovation and Technology Award at the Generation Next Awards.

Fergal Mackie

Company: Metacarpal

While foot and leg prosthetics have been incredibly successful at restoring the functional and psychological needs of amputees, the same cannot be said for hand devices. The NHS estimate 26-45% of upper-limb amputees wear no prosthetic at all! And some estimates are even higher. This problem is worsened when you consider that for those missing only one hand, this typically leads to overreliance on the sound side that can rapidly develop into arthritis or similar problems.

Centrally, the problem here is that these health problems are actually less of a sacrifice than current upper-limb prosthetics. No matter what, if any, device someone chooses - they must make a huge compromise to either their well-being, their function or their self-perception. Metacarpal is looking to make a product which does not compromise across any of these aspects.

Metacarpal aim to design a functional device, with accessible pricing, that's comfortable to wear all day long and looks so good that it makes the wearer feel good. They hope to achieve this with better materials and more advanced engineering than competitors.

In January 2023 Fergal was awarded a Young Innovators Award by Innovate UK and Metacarpal secured a Scottish Enterprise SMART grant to fund research and development.

Built Environment Fellow

Dr Tijana Blanusa

Subject: Putting the 'Green' into Green Infrastructure

Mentor: Dr Ross Cameron

This project compared the performance of mixed hedge species with that of single species monocultures and examined their ecological benefits.

Hedges were chosen as the study focus due to their simplicity, space-saving nature, and cost-effectiveness, offering promising solutions to local environmental issues and the replacement of conventional urban barriers. The project's objectives included establishing and conducting outdoor growing experiments, as well as applied research in an urban school. This explored the opportunities associated with using hedges as a tool for environmental education, engaging the school pupils in novel research aiming to address challenges in planting implementation on school grounds.

Results revealed that mixed hedges, especially during autumn and winter, provided structural benefits for water retention. Moreover, the educational interventions positively influenced students' perceptions and appreciation of plants' environmental benefits, particularly in mitigating pollution and climate extremes.

Project outcomes will be showcased at the RHS Chelsea Flower Show in May 2024. Insights are already being incorporated into future planning of green interventions to support inclusion of planting into school grounds and its use as an educational resource, within the RHS's Campaign for School Gardening and the National Education Nature Park project. Looking further ahead, experiments will evaluate long-term hedge performance.

On a broader scale, these learnings contribute progress towards an overarching goal of creating green infrastructure that addresses the challenges posed by urbanisation and climate change, whilst championing more diverse, and more loved urban environments.

Tijana remains Principal Horticultural Scientist at the Royal Horticultural Society.

Design Fellows

Aran Dasan

Subject: Design for Resilience - Enki: Technologies for Resilient Biodiverse Oceans

Mentor: Professor Michel Kaiser, Heriot-Watt University

The ocean contains invisible underwater weather patterns. Temperature gradients, haloclines, cold water upwellings of nutrients, and climate-change induced warming waters.

These dynamic phenomena influence the presence of marine species who have preferred habitats. In terms of commercial fishing, this applies to target quota species as well as 'bycatch' species that fisheries do not wish to catch at all.

Aran and his colleagues proposed 'Enki': an internet-connected ocean sensor for fishing vessels, to observe these underwater patterns and correlate them with their fishing catch, in order to inform future fishing practices - to avoid bycatch and spend less fuel in achieving their mandated fishing quotas.

Enki sensors are attached to commercial fishing gears, which create measurement profiles of the water column during the fishing process. They measure key parameters such as temperature, salinity, depth, location, and turbidity. These measurement profiles are automatically uploaded to the cloud, where they can be viewed by skippers and other interested parties via a web application for analysis.

During this project, Aran and his colleagues took Enki from an early concept through to field-tested software and hardware prototypes. Their process involved human-centred design, design engineering and ecology. The prototypes were used by commercial crab fishing vessels in Orkney for a month. The results give an early indication of the usefulness of subsea measurements to inform responsible fishing practices.

During the project, a strong academic collaboration was created with Heriot-Watt University, who are continuing to deploy Enki in new fisheries around the UK to further prove the concept's value to sustainable fishing.

Professor Jacqui Cole

Subject: Techno-push consumer-pull - Stimulating innovation of solar-powered windows for energy sustainable future cities: a user-centred approach

Mentor: Professor Peter Littlewood, Argonne National Laboratory

This project sought to understand the 'techno-push consumer-pull' of a next-generation photovoltaic device technology for use as solar-powered windows. These 'smart windows', which generate electricity from sunlight, could meet the entire energy demands of buildings for future cities, in a fully sustainable fashion. Achieving such a radical transformation requires driving 'smart windows' to innovation.

Jacqui is a research expert in this environmental technology. With this 'techno-push' in hand, she aimed to generate a concerted 'consumer-pull' on 'smart windows' by testing Rogers' five criteria for the successful diffusion of innovation: relative advantage, compatibility, complexity, trialability, observability. The project focused on testing the last two of these criteria: observability and trialability. These tests took the form of a 'pop up' exhibit that was showcased to 720 members of the public at the Visitors Centre of the Rutherford Appleton Laboratory (RAL) in August 2022, during two open days of the ISIS Neutron and Muon Source. This 'smart window' technology was showcased to promote public awareness, while soliciting questions from attendees to obtain feedback on this technology from a 'consumer-pull' perspective. The nature of the questions that were raised revealed that macroeconomic considerations about pricing and technical readiness of the 'smart window' technology predominated public thinking. These findings were checked via a subsequent event that focused on a different demographic: school children; whereby, this technology was presented as part of Protect the Planet Day 2022. The same macroeconomic notions about the technology prevailed in the line of questioning from this different demographic of the population. Thus, it was concluded that while Rogers' criterion, observability, is important in the form of gaining public awareness of this technology, Rogers' criterion of relative advantage is also at the front of everyone's minds. The recent rise in energy prices owing to the global energy crisis is likely to be a key influence in this regard. i.e. timeliness of this exhibit is also important. Therefore, the "Techno-push" needs to frame its findings more in terms of these macroeconomic concerns, rather than worry too much about the fineries of which chemical colour one should use for the light-harvesting part of the device technology, except on account of its financial viability. Nonetheless, the "Techno-push" part of this project generated 44 publications about these solar cell components that stand to be useful to the research scientist in this field.

Sir Misha Black Award for Innovation in Design Education

Judah Armani

Subject: Co-creating an innovative and pioneering approach to design education to empower young people, with neurodiversity, who find themselves in extreme poverty and/or profoundly challenging circumstances

Over the last year Judah has collaborated on new initiatives focused around place-based probation services and developing education in American youth prisons.

The following observations have been established:

1. Collaboration can lead to desistance from crime.
2. Collaboration increases communication - social capital.
3. Collaboration increases empathy - group accountability.
4. Collaboration increases the legitimacy of the initiative.
5. Collaboration fosters unity across a divided stakeholder group.

In addition, through observing place-based service delivery, Judah has shown that:

1. Place based services make the services more accessible.
2. Place based services improve the quality of services.
3. Place based services provide the scope for new emergent services.

These observations have led him to believe that through developing meaningful collaborations in prisons and place-based delivery of services across probation, the conditions for meaningful and genuine design education can take place in a profound and impactful manner. More so, the role of design within the development of the Criminal Justice System should be an imperative.

Judah was able to meaningfully journey with 50 men over the course of the year. In every location across Wales, England and America, profound development has taken place through impact measurement, full time employment and new education systems in place.

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 Jennifer Martin (1986)

- Awarded Ralph Slatyer Medal, Australian National University
- Chaired the worldwide Protein Data Bank Advisory Committee
- Appointed a Trustee of the Cambridge Crystallographic Data Centre
- Appointed a member of the Scientific Advisory Board of the Maurice Wilkins Centre, New Zealand
- Presented a Plenary Public Lecture for the International Union of Crystallography Congress in Melbourne
- Awarded an Undergraduate Certificate in Family History from the University of Tasmania

Research Fellows

Professor Sinan Açıkgöz (2016)

- Awarded Manby Prize, Institution of Civil Engineers

Dr Jo Ashbourn (2002)

- Organised one-day conferences at the St Cross Centre for the History and Philosophy of Physics on: Physics Feuds Throughout History; Order and Chaos; and Polymaths Across the Eras

Dr Steven Beard (1983)

- Member of the MIRI development team awarded the Royal Astronomical Society Group Achievement Award in Astronomy for the James Webb Space Telescope

Professor Helen Coxall (2000)

- Participated in a research expedition on board the RS Joides Resolution as part of the International Ocean Drilling Program Expedition 400 which recovered deep sediment cores on the margins of Northern Greenland for deciphering the long-term history of the Greenland ice sheet

Professor David Cumming (1996)

- Awarded IET Achievement Medal in Electronics

Dr Barnali Ghosh (2003)

- Awarded John Mitchell Award, Institution of Civil Engineers

Professor Brianna Heazlewood (2012)

- Appointed Professor of Chemical Physics, University of Liverpool
- Awarded Philip Leverhulme Prize in Chemistry

Professor Adrian Horridge (1954)

- Published *How do Bees (And Humans) See Grey Levels?*

Dr Russell Low (1995)

- Appointed President and CEO of Axcelis Technologies

Professor Emilio Martínez-Pañeda (2018)

- Appointed Associate Professor of Engineering Science, University of Oxford
- Awarded ERC Starting Grant
- Awarded Young Investigator Medal, Spain's Royal Academy of Engineering

Professor Gavin Morley (2009)

- Appointed Professor, Department of Physics, University of Warwick
- Appointed lead PI for MAST-QG (Macroscopic superpositions towards witnessing the quantum nature of gravity) funded by the Sloan and Moore Foundations

Professor Sir Steve Sparks (1974)

- Awarded Imperial College 2023 Distinguished Alumni Award

Professor Ed Tate (1999)

- Appointed to the GSK Endowed Chair in Chemical Biology, Imperial College London

Industrial Fellows

Professor Mike Clinch (1996)

- Elected Fellow of the Royal Academy of Engineering
- Appointed Director, Innoval Technology Ltd

Dr Mariastefania De Vido (2018)

- Selected to be included in the 100 Esperte, a high-profile Italian initiative to raise the profile of Italian female researchers and scholars available to communicate as experts in the media and with organisations such as schools and universities, to dispel stereotypes on female participation in male-dominated fields
- Technical lead for team that developed world record holding DiPOLE 10 J, 100Hz laser
- Awarded MBA, Heriot-Watt University

Professor Rob Deaves (1994)

- Awarded Honorary Professorship, School of Engineering, University of Birmingham
- Elected a Fellow of the Royal Academy of Engineering

Enterprise Fellows

Ryan Beal (2022)

- SentientSports (data scientist in a box for sports) closed its pre-seed funding round and restructured its board. Since its inception, SentientSports has tested its models with more than 30 professional teams across Europe and the US as well as the English Premier League, the Football League, the Scottish Premiership and leading global sports agencies, who have all used its revolutionary AI technology to analyze data and recruit players

Natalie Kerres (2021)

- Awarded Innovation UK Women in Innovation Award

Harish Pesala (2021)

- Awarded Innovate UK Young Innovators Award

Varun Sarwal (2020)

- Hammer Missions (adaptive flight automation software for UAVs) increased revenues by 500% in 2023, received backing from Ordnance Survey and saw increased take-up by companies, charities and search and rescue organisations.

Built Environment Fellows

David Rudlin (2019)

- Published (with Vicky Payne and Lucy Montague) *High Street: How our town centres can bounce back from the retail crisis*

Rome Scholars

Susan Allix (1968)

- Published *On Books: The creative work of Susan Allix with a catalogue raisonné*
- Published *A Catalogue of Fine Press Artists Books from 1973 – 2023*

Report by the Chairman of the Finance Committee

Introduction

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. I would like to thank all members of the Committee for their ongoing valuable contribution in overseeing the Commission's finances.

During 2023 there were two formal meetings of the Committee. In the spring meeting we reviewed the annual accounts and met with the Commission's auditors. We also heard presentations from investment consultants. In the autumn meeting the Committee focused on reviews of the Commission's investment strategy and estate strategy.

Investment Policy

Over the long term, the Commission aims to disburse 4% per annum of the trailing three-year average value of the portfolio. However, the Commission has few if any fixed liabilities and annual budgets include an allowance for Special Awards that can be adjusted without detriment to other programmes so this can vary from year to year depending on grant making opportunities and investment returns.

The investment objective is to generate a return of at least inflation plus 4% per annum over the long term, after expenses. This should allow the Commission to at least maintain and ideally grow the real value of the assets, whilst generating a stable and sustainable return to fund annual expenditure as set out above. The Finance Committee has determined that the inflation measure most relevant to the Commission's expenditure is the Consumer Price Index.

The Finance Committee is charged with agreeing a high-level asset allocation strategy with the investment managers, which is set so as to achieve the overall Commission investment objective. The Finance Committee is also responsible for identifying and monitoring investment managers and investment vehicles for the Commission. The Committee has appointed Stanhope Consulting to assist with monitoring and reporting of investment performance, and to advise on the most appropriate strategic asset allocation and the most suitable managers for the Commission's portfolio.

During the year under review, the neutral strategic asset allocation was 80% equities, 15% property (the South Kensington Estate), 5% cash and bonds. The Committee has reviewed the strategic asset allocation. Recognising the more volatile investment environment, and the improved returns from corporate bonds, it has decided that going forwards the strategic asset allocation should be 75% equities, 15% property (the South Kensington Estate), 10% cash and bonds, with ranges of plus or minus 5% in each case (outwith which a discussion as to whether rebalancing is required would automatically be triggered). The Committee is currently reviewing the investment performance of the legacy estate. As a result of this review, it is anticipated that certain properties may be excluded from the investment portfolio for the purposes of setting return and disbursement targets. If this proves to be the case, and the property component of the portfolio decreases substantially as a result, the strategic asset allocation will be reviewed again.

The Committee is also reviewing the balance of active and passive strategies within both the equity and bond components of the portfolio.

The Finance Committee will revisit the strategic asset allocation at least every three years and consider the need for tactical deviations from it on at least an annual basis.

The Commission adopts a total return approach to investment, generating the investment return from income and capital gains or losses. Recognising the likely volatility of the capital, the Commission will typically aim to generate an overall income return of between 2% and 3% per annum to reduce the risk that losses will need to be crystallised to fund commitments.

The Commission recognizes that long term investment is subject to market, political, economic, counterparty and other risks, with financial instability in particular being a key risk. The

Commission also recognizes inflation as a significant risk to the long-term sustainability of its activities and one that the investment policy should mitigate against.

The Commission's liabilities are primarily in sterling. However, the Committee does not require the equity portfolio to be hedged as it believes currency fluctuations should wash out over time, is confident the Commission can ride out short-term volatility and recognizes that in periods of market stress sterling investors tend to benefit from unhedged portfolios as their dollar assets generally appreciate - the dollar, unlike sterling, being a global reserve currency.

The Commission is able to tolerate volatility of the capital value of the portfolio, provided it is able to meet its short-term grant making commitments through either income or liquid capital assets. To allow for volatility of capital values, the trustees wish to maintain at least 5% of the portfolio in cash or lower risk fixed income investments hedged to sterling. Bearing in mind income generated by the portfolio and the flexibility to curtail Special Awards, this should allow three years' worth of Fellowships to be funded without needing to sell risk assets.

Ethical Investment Policy

The Commission recognizes that its investments have wider impacts and seeks to align its investment strategy with its aims, reflecting the views of its stakeholders and taking into account broader public benefit. The Commission expects its investment managers to integrate Environmental, Social and Governance (ESG) considerations into the normal investment process and to fulfil the requirements of the UK Stewardship Code, actively engaging with the companies in which they invest to promote best practice corporate behaviour and sustainable business practices. Given its limited staff resources, it is not practical for the Commission to engage directly with individual companies, but it does expect its investment managers to report annually on their engagement activities and results.

The Commission expects its investment managers to apply ESG considerations to both segregated holdings and pooled holdings, taking account of the extent to which suitable alternative investment vehicles are available and bearing in mind de minimis considerations. The Commission will only appoint managers who are signatories to the UN Principles of Responsible Investment (UN PRI) and will take into account the ranking assigned to those managers by the UN PRI.

The Commission may exclude certain stocks or sectors where these are seen to be in direct conflict with its objects and activities. Equally, where consistent with the financial objectives, the Commission seeks to invest in areas with positive environmental and / or social impact, such as clean energy and various areas of new technology.

The Commission recognizes that climate change is a key challenge for the next decade and that limiting global temperature rises will require significant change in business, investment, technology development and fossil fuel use. The Commission monitors the carbon emissions of its main equity investment portfolio and through its investment managers seeks to reduce these emissions over time. The Commission is very aware, however, that certain companies and sectors that are critical to the transition to net zero are currently carbon intensive. The Commission does not exclude investment in such sectors but expects its investment managers to prioritise investment in companies that have a carbon reduction roadmap aligned with the goals of the Paris Agreement.

Investment Performance 2023

Despite the volatile geopolitical environment and challenging economic environment, including the ongoing war in Ukraine, hostilities in the Middle East, persistent high inflation and elevated interest rates, equity and bond markets performed well in 2023 with the MSCI ACWI Index up 15.3% for the year and the Bloomberg Barclays Global Aggregate Index (GBP Hedged) up 6.2%. Against this backdrop the Commission achieved a total return net of fees of approximately 13.6% (2022: -8.9%). CPI + 4% was 8% (2022: 14.5%).

The Commission's portfolio is invested by three investment managers: Schroder & Co. Ltd; Charles Stanley & Co. Ltd and JP Morgan Asset Management (UK) Ltd. The Commission also has direct property holdings on its legacy estate in South Kensington. The asset allocation of the combined portfolio as at 31 December was 77.4% in global equities, 4.4% in listed alternative assets, 5.2%

in cash and bonds and 13.1% in the legacy estate (at the end of 2022 the proportions were 70.7%, 4.9%, 9.2% and 15.2% respectively).

Schroder & Co. Ltd and Charles Stanley invest globally, predominately in equities and returned 19.5% and 11.3% respectively (2022: -9.1% and -15.6% respectively). JP Morgan Asset Management (UK) Ltd manage a short duration bond account and returned 6.0% (2022: -2.6%). The directly held property returned 1.5% (2022: 0.9%) rental income of £776,165 (2022: £528,991) and realised gains on lease extensions of £246,000 (2022: £nil) compensating for unrealised losses on revaluation of £805,000 (2022: unrealised losses of £175,000), the latter reflecting the difficult small office market and the impact on investor sentiment of proposed leasehold reforms.

Managers are asked to measure the carbon emissions of their portfolios. As at the balance sheet date, companies comprising the segregated equity portfolio, managed by Schroder & Co, had a carbon footprint of 3,743 tonnes of CO₂ (2022: 3,866 tonnes) vs the MSCI AC World (TRI) USD of 9,493 tonnes of CO₂ (2022: 7,990 tonnes). Charles Stanley have estimated that the carbon intensity (T CO₂E/\$M Sales) of the companies in the underlying ETFs was 144.8 versus 124.4 for their index, the iShares MSCI World ACWI ETF (in 2022 the comparable figures were 131.5 versus an index of 148.2). While the carbon intensity of the Charles Stanley portfolio is higher than that of the index, this is primarily due to the high carbon intensity of holdings associated with the transition to decarbonisation, including the iShares Global Clean Energy ETF, Legal & General Battery Value ETF, and components of the Legal & General Global Infrastructure Index Fund.

Long term performance vs investment objective

The investment objective is to achieve at least a 4% real return over the long term. The annualised real return over the past ten years has been 4.9%. High inflation and disappointing equity returns in 2022 mean that the investment objective has not been met over shorter periods. The five year and three year real returns have been 3.3% and -2.5% respectively.

While inflation and interest rates are hopefully stabilising, tighter monetary policy, geopolitical uncertainty and market volatility are all set to continue, with the risk of a recession in some markets. The Commission recognises that meeting the investment objective over the short to medium term will be challenging and so remains flexible in its disbursement policy.

Financial performance for the calendar year to 31 December 2023

Over the 12-month period the investment portfolio generated income of £2,559,838 (2022: £2,386,031). When combined with capital gains of £16,630,182 (2022: capital losses of £15,790,681) this meant that, after grants and other expenditure, the total funds of the Commission increased from £130,375,737 to £143,838,891 as at 31 December 2023.

Expenditure on core Fellowships and Studentships increased from £3,671,284 to £3,963,890. However, fewer large Special Awards meant that total expenditure on charitable activities decreased from £5,470,448 to £4,957,163.

Expenditure on raising funds – which primarily comprises investment and property management fees – decreased from £799,328 in 2022 to £766,633 in 2023. The higher figure in 2022 primarily reflected the write off of rent relating to the lockdown period following an arbitration settlement.

Going concern

The Commissioners do not believe there are any material uncertainties that call into doubt the Commission's ability to continue and the accounts have therefore been prepared on a going concern basis.

The Commission, like every other organisation, has been impacted by the pandemic, Russia's invasion of Ukraine and the hostilities in the Middle East, which have resulted in ongoing supply chain disruption, persistent high inflation, increased interest rates and a cost-of-living crisis. Investment markets have been much more volatile, and the day-to-day value of the Commission's portfolio has inevitably reflected that. The Commission is a long-term investor, however, and Commissioners remain confident in the underlying strength of the portfolio; they see no evidence

at this stage of any permanent loss of value – indeed, the portfolio has shown significant gains over the past year. Similarly, while the Commission has had to defer or write off a certain amount of rent, there is not considered to be any risk to the long-term value of the estate. The Commission has sufficient assets, and sufficient liquidity, to ride out the current market disruptions. The Commission’s core grant-making activity has therefore continued largely as planned and Commissioners expect it to continue to do so.

Reserves Policy

The Commission’s 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 above 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.

The Commission’s Auditor

In 2008, Moore Kingston Smith LLP was appointed the Commission’s auditor 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.

Statement of Commissioners' Responsibilities

The Commissioners are responsible for preparing the Trustees' Report and the financial statements in accordance with applicable law and United Kingdom Accounting Standards (United Kingdom Generally Accepted Accounting Practice.)

The law applicable to charities in England and Wales requires the Commissioners to prepare financial statements for each financial year which give a true and fair view of the state of the affairs of the Commission and of the incoming resources and application of resources of the Commission for that period. In preparing these financial statements, the Commissioners are required to:

- select suitable accounting policies and then apply them consistently;
- observe the methods and principles in the Charities SORP;
- make judgements and estimates that are reasonable and prudent;
- state whether applicable accounting standards have been followed, subject to any material departures disclosed and explained in the financial statements;
- prepare the financial statements on the going concern basis unless it is inappropriate to presume that the Commission will continue in business.

The Commissioners are responsible for keeping proper accounting records that disclose with reasonable accuracy at any time the financial position of the Commission and enable them to ensure that the financial statements comply with the Charities Act 2011, the Charity (Accounts and Reports) Regulations 2008 and the provisions of the Royal Charter. They are also responsible for safeguarding the assets of the Commission and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities.

The Annual Report on pages 1 to 48 and 52 to 79 was approved by the Commissioners on 9 July 2024.

Ms Sandra Robertson

Independent Auditor's Report to the Commissioners of Royal Commission for the Exhibition of 1851

Opinion

We have audited the financial statements of the Royal Commission for the Exhibition of 1851 for the year ended 31 December 2023 which comprise the Statement of Financial Activities, the Summary Income and Expenditure Account, the Balance Sheet, the Cash Flow Statement and notes to the financial statements, including a summary of significant accounting policies. The financial reporting framework that has been applied in their preparation is applicable law and United Kingdom Accounting Standards, including FRS 102 'The Financial Reporting Standard Applicable in the UK and Republic of Ireland' (United Kingdom Generally Accepted Accounting Practice).

In our opinion the financial statements:

- give a true and fair view of the state of the charity's affairs as at 31 December 2023, and of its incoming resources and application of resources, for the year then ended;
- have been properly prepared in accordance with United Kingdom Generally Accepted Accounting Practice; and
- have been prepared in accordance with the requirements of the Charities Act 2011.

Basis for opinion

We conducted our audit in accordance with International Standards on Auditing (UK) (ISAs (UK)) and applicable law. Our responsibilities under those standards are further described in the *Auditor's responsibilities for the audit of the financial statements* section of our report. We are independent of the charity in accordance with the ethical requirements that are relevant to our audit of the financial statements in the UK, including the FRC's Ethical Standard, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Conclusions relating to going concern

In auditing the financial statements, we have concluded that the Commissioners' use of the going concern basis of accounting in the preparation of the financial statements is appropriate.

Based on the work we have performed, we have not identified any material uncertainties relating to events or conditions that, individually or collectively, may cast significant doubt on the charity's ability to continue as a going concern for a period of at least twelve months from when the financial statements are authorised for issue.

Our responsibilities and the responsibilities of the Commissioners with respect to going concern are described in the relevant sections of this report.

Other information

The other information comprises the information included in the annual report, other than the financial statements and our auditor's report thereon. The Commissioners are responsible for the other information. Our opinion on the financial statements does not cover the other information and, except to the extent otherwise explicitly stated in our report, we do not express any form of assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit or otherwise appears to be materially misstated. If we identify such material inconsistencies or apparent material misstatements, we are required to determine whether there is a material misstatement in the financial statements or a material misstatement of the other information. If, based on the work we have performed, we conclude that there is a material misstatement of this other information, we are required to report that fact.

We have nothing to report in this regard.

Matters on which we are required to report by exception

We have nothing to report in respect of the following matters where the Charities Act 2011 requires us to report to you if, in our opinion:

- the information given in the Commissioners' Annual Report is inconsistent in any material respect with the financial statements; or
- the charity has not kept adequate accounting records; or
- the financial statements are not in agreement with the accounting records and returns; or
- we have not received all the information and explanations we required for our audit.

Responsibilities of Commissioners

As explained more fully in the Commissioners' responsibilities statement set out on page 48, the Commissioners are responsible for the preparation of the financial statements and for being satisfied that they give a true and fair view, and for such internal control as the Commissioners determine is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the Commissioners are responsible for assessing the charity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the Commissioners either intend to liquidate the charity or to cease operations, or have no realistic alternative but to do so.

Auditor's responsibilities for the audit of the financial statements

We have been appointed as auditor under section 144 of the Charities Act 2011 and report in accordance with regulations made under section 154 of that Act.

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance but is not a guarantee that an audit conducted in accordance with ISAs (UK) will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

Irregularities, including fraud, are instances of non-compliance with laws and regulations. We design procedures in line with our responsibilities, outlined above, to detect material misstatements in respect of irregularities, including fraud. The extent to which our procedures are capable of detecting irregularities, including fraud is detailed below.

Explanation as to what extent the audit was considered capable of detecting irregularities, including fraud

The objectives of our audit in respect of fraud, are: to identify and assess the risks of material misstatement of the financial statements due to fraud; to obtain sufficient appropriate audit evidence regarding the assessed risks of material misstatement due to fraud, through designing and implementing appropriate responses to those assessed risks; and to respond appropriately to instances of fraud or suspected fraud identified during the audit. However, the primary responsibility for the prevention and detection of fraud rests with both management and those charged with governance of the charity.

Our approach was as follows:

- We obtained an understanding of the legal and regulatory requirements applicable to the charity and considered that the most significant are the Charities Act 2011, the Charity SORP, and UK financial reporting standards as issued by the Financial Reporting Council.

- We obtained an understanding of how the charity complies with these requirements by discussions with management.
- We assessed the risk of material misstatement of the financial statements, including the risk of material misstatement due to fraud and how it might occur, by holding discussions with management.
- We inquired of management and those charged with governance as to any known instances of non-compliance or suspected non-compliance with laws and regulations.
- Based on this understanding, we designed specific appropriate audit procedures to identify instances of non-compliance with laws and regulations. This included making enquiries of management and obtaining additional corroborative evidence as required.

As part of an audit in accordance with ISAs (UK) we exercise professional judgement and maintain professional scepticism throughout the audit. We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purposes of expressing an opinion on the effectiveness of the charity's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the Commissioners.
- Conclude on the appropriateness of the Commissioners' use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the charity's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the charity to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

Use of our report

This report is made solely to the charity's Commissioners, as a body, in accordance with Chapter 3 of Part 8 of the Charities Act 2011. Our audit work has been undertaken so that we might state to the charity's Commissioners those matters we are required to state to them in an auditor's report and for no other purpose. To the fullest extent permitted by law, we do not accept or assume responsibility to any party other than the charity and charity's Commissioners as a body, for our audit work, for this report, or for the opinion we have formed.

Statutory auditor

2 Appold Street
London
EC2A 2AP

Moore Kingston Smith LLP is eligible to act as auditor in terms of Section 1212 of the Companies Act 2006.

Royal Commission for the Exhibition of 1851

Statement of Financial Activities for the Year Ended 31 December 2023

	Notes	Unrestricted Funds 2023 £	Unrestricted Funds 2022 £
Income from:			
Donations	4	1,000	3,300
Investments	5	2,559,838	2,386,031
Other	6	5,103	4,217
Total income		<u>2,565,941</u>	<u>2,393,548</u>
Expenditure on:			
Generating funds	7	766,633	799,328
Charitable activities	8	4,957,163	5,470,448
Total expenditure		<u>5,723,796</u>	<u>6,269,776</u>
Net expenditure before gains and losses on investments		(3,157,855)	(3,876,228)
Net gains / (losses) on investments			
Losses on property		(559,000)	(170,900)
Gains / (losses) on investments		17,189,182	(15,619,781)
Total of net gains / (losses) on investments		<u>16,630,182</u>	<u>(15,790,681)</u>
Net income / (expenditure)		<u>13,472,327</u>	<u>(19,666,909)</u>
Other recognised gains and losses			
Actuarial gains / (losses) on defined benefit pension scheme	14	(9,173)	13,087
Net movement in funds		<u>13,463,154</u>	<u>(19,653,822)</u>
Reconciliation of funds			
Total funds brought forward		130,375,737	150,029,559
Net movement in funds		13,463,154	(19,653,822)
Total funds carried forward		<u><u>143,838,891</u></u>	<u><u>130,375,737</u></u>

The notes on pages 55 to 73 form part of these accounts. Notes 1-2 provide details of the Commission's objectives and accounting policies.

Royal Commission for the Exhibition of 1851

Balance Sheet as at 31 December 2023

	Notes	Total Funds 2023 £	Total Funds 2022 £
Fixed asset investments			
Investment properties	15	19,595,350	20,765,350
Listed investments	16	129,015,825	112,318,792
Cash held as part of the investment portfolio		1,114,160	3,672,152
		<u>149,725,335</u>	<u>136,756,294</u>
Current assets			
Debtors	17	318,916	377,919
Cash at bank and in hand		1,425,099	1,300,378
		<u>1,744,015</u>	<u>1,678,297</u>
Liabilities			
Creditors: Amounts falling due within one year	18	(4,078,902)	(4,595,362)
Net current liabilities		<u>(2,334,887)</u>	<u>(2,917,065)</u>
Total assets less current liabilities		147,390,448	133,839,229
Creditors: Amounts falling due after more than one year	18	(3,206,557)	(3,106,492)
Net assets excluding pension liability		<u>144,183,891</u>	<u>130,732,737</u>
Defined benefit pension scheme liability	14	(345,000)	(357,000)
Net assets		<u><u>143,838,891</u></u>	<u><u>130,375,737</u></u>
The funds of the Charity:			
Capital Funds			
Balance as at 1 January		130,375,737	150,029,559
Movement in year		13,463,154	(19,653,822)
Balance as at 31 December		<u><u>143,838,891</u></u>	<u><u>130,375,737</u></u>

Approved by the Commissioners on 9 July 2024 and signed on their behalf by:

Ms Sandra Robertson
Chairman, Finance Committee

Mr John Lavery
Secretary

The notes on pages 55 to 73 form part of these accounts.

Royal Commission for the Exhibition of 1851

Statement of Cash Flows for the Year Ended 31 December 2023

	Total Funds 2023 £	Total Funds 2022 £
Cash flows from operating activities		
Donations received (excluding donations in kind)	1,000	3,300
Grants and awards paid	(4,691,655)	(4,093,117)
Payments to suppliers	(1,115,782)	(1,033,626)
Payments in respect of employees	(350,414)	(346,594)
Other payments	(32,029)	(24,638)
	<hr/>	<hr/>
Cash used in operating activities	(6,188,880)	(5,494,675)
Cash flows from investing activities		
Dividends, interest and rent from investments	2,648,366	2,299,721
Proceeds from sale of investments	24,930,748	20,366,979
Purchase of investments	(23,823,555)	(15,278,465)
	<hr/>	<hr/>
Net cash provided by investing activities	3,755,559	7,388,235
Change in cash and cash equivalents in the reporting period	(2,433,321)	1,893,560
Cash and cash equivalents brought forward	4,972,530	3,078,970
	<hr/>	<hr/>
Cash and cash equivalents carried forward	2,539,209	4,972,530
	<hr/>	<hr/>
Disclosed as:		
Cash held as part of the investment portfolio	1,114,110	3,672,152
Cash at bank and in hand	1,425,099	1,300,378
	<hr/>	<hr/>
	2,539,209	4,972,530
	<hr/> <hr/>	<hr/> <hr/>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

1. STATUS AND OBJECTIVES

The Commission for the Exhibition of 1851 was set up by Royal Charter in 1850 to plan and promote the Exhibition of Works of Industry of all Nations, which was to be held in London in 1851. When the affairs of the Great Exhibition had eventually been wound up, the Commissioners were appointed, under a Supplemental Charter, as a permanent body to administer the surplus funds at their disposal. These were to be applied in order to “increase the means of industrial education and extend the influence of science and art upon productive industry”.

2. ACCOUNTING POLICIES

The accounts are prepared under the historic cost convention, modified by the revaluation from time to time of certain fixed assets, and in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (effective January 2015) (FRS102), Accounting and Reporting by Charities: Statement of Recommended Practice applicable to charities preparing their accounts in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (effective January 2019) (SORP) and the Charities Act 2011.

In the estimation of the trustees (the Commissioners), there are no material uncertainties that call into doubt the Commission’s ability to continue and the accounts have therefore been prepared on a going concern basis.

The Commission, like every other organisation, has been impacted by the pandemic, Russia’s invasion of Ukraine and war in the Middle East, which have resulted in ongoing supply chain disruption, persistent high inflation, increased interest rates and a cost-of-living crisis. Investment markets have been much more volatile, and the day-to-day value of the Commission’s portfolio has inevitably reflected that. The Commission is a long-term investor, however, and Commissioners remain confident in the underlying strength of the portfolio; they see no evidence at this stage of any permanent loss of value. Similarly, while the Commission has had to defer or write off a certain amount of rent, there is not considered to be any risk to the long-term value of the estate. The Commission has sufficient assets, and sufficient liquidity, to ride out the current market disruptions. The Commission’s core grant-making activity has therefore continued largely as planned and Commissioners expect it to continue to do so.

The Commission meets the definition of a public benefit entity under FRS102.

The financial statements are presented in sterling which is the functional currency of the charity. Monetary amounts are rounded to the nearest pound.

(a) Investments

- (i) Are shown in the balance sheet at market value; any unrealised gain over original cost is shown in the statement of financial activities.
- (ii) Income on investments is included in the accounts when receivable.
- (iii) Cash held as part of the investment portfolio includes short-term deposits held temporarily with the company’s bankers pending re-investment.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

2. ACCOUNTING POLICIES (continued)

(b) Donations, legacies and similar income

Donations, legacies and similar income are included in the year in which they are receivable, that is, when the Commission becomes entitled to the income. Donations received for general purposes are included as unrestricted funds. Where the wishes of the donor are legally binding on Commissioners, donations are accounted for as Restricted Funds with their use limited to that defined by the donor.

(c) Fixed Assets and Depreciation

All purchases of capital items under £10,000 are written off in the year of purchase. Capital items over £10,000 are depreciated over their estimated useful economic lives. Currently no items are being depreciated.

(d) Investment Properties

All the Commission's properties are let to provide an income on a full repairing lease. All properties are inspected regularly by the Commission's Surveyors and revalued by them from time to time. The last full revaluation was undertaken at 31 December 2019 and was based on the existing use and occupation of the land, and the duration of leases at ground rents and rack rents. These valuations are reviewed and adjusted annually as described in note 15.

(e) Realised and Unrealised Gains on Investments

Gains and losses on investments and assets held for the Commission's use are treated in accordance with the Statement of Recommended Practice. They are recognised in the statement of financial activities for the year in which they occur.

(f) Cash and cash equivalents

Cash and cash equivalents include cash in hand, deposits held at call with banks, other short-term liquid investments with original maturities of three months or less, and bank overdrafts. Cash held on capital account pending investment by the charity's investment managers, together with cash for investment in transit between investment managers, is disclosed within fixed asset investments; all other cash and cash equivalents is disclosed within current asset investments.

(g) Lease premiums and licences

Premiums received for lease extensions are treated as capital receipts and included within gains / (losses) on property transactions. Certain other premiums received which do not materially affect the underlying value of the Commission's investment are treated as income receipts.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

2. ACCOUNTING POLICIES (continued)

(h) Charitable activities

The primary charitable activity is the making of grants and awards. Grants and awards payable are accounted for on an accruals basis. Multi-year grants are accounted for in full in the year that the grant is awarded. The Commission recognises future liabilities discounted to their present value where material.

The majority of grants and awards are made to individuals who have been granted Fellowships or Studentships by the Commission. A limited number of awards are made to Institutions in furtherance of their educational needs. Some support is also provided to the legacy institutions on the Commission's South Kensington estate and to organisations facilitating access to the Commission's archives. A full analysis is shown in note 9.

The Commission also undertakes some direct charitable activities, in particular networking and educational events organised for the Commission's Fellows, Students, Alumni and the general public. Further details are shown in note 10.

(i) Allocation of support costs

Support costs are allocated on the basis of board or staff time as appropriate.

(j) Financial instruments

The Commission has elected to apply the provisions of Section 11 *Basic Financial Instruments* and Section 12 *Other Financial Instruments Issues* of FRS 102 to all of its financial instruments.

Financial instruments are recognised in the Commission's balance sheet when the Commission becomes party to the contractual provisions of the instrument.

Basic financial assets

Basic financial assets, which include trade and other debtors and cash and bank balances, are initially measured at transaction price including transaction costs and are subsequently carried at amortised cost using the effective interest method unless the arrangement constitutes a financing transaction, where the transaction is measured at the present value of the future receipts discounted at a market rate of interest.

Other financial assets

Other financial assets, including investments in equity instruments which are not subsidiaries, associates or joint ventures, are initially measured at fair value, which is normally the transaction price. Such assets are subsequently carried at fair value and the changes in fair value are recognised in the statement of financial activities, except that investments in equity instruments that are not publicly traded and whose fair values cannot be measured reliably are measured at cost less impairment.

Trade debtors, loans and other debtors that have fixed or determinable payments that are not quoted in an active market are classified as 'loans and receivables'. Loans and receivables are measured at amortised cost using the effective interest method, less any impairment.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

2. ACCOUNTING POLICIES (continued)

(j) Financial instruments (continued)

Basic financial liabilities

Basic financial liabilities, including trade and other creditors, are initially recognised at transaction price unless the arrangement constitutes a financing transaction, where the debt instrument is measured at the present value of the future payments discounted at a market rate of interest.

Debt instruments are subsequently carried at amortised cost, using the effective interest rate method.

Trade creditors are obligations to pay for goods or services that have been acquired in the ordinary course of business from suppliers. Accounts payable are classified as current liabilities if payment is due within one year or less. If not, they are presented as non-current liabilities. Trade creditors are recognised initially at transaction price and subsequently measured at amortised cost using the effective interest method.

Other financial liabilities

Derivatives, including interest rate swaps and forward foreign exchange contracts, are not basic financial instruments. Derivatives are initially recognised at fair value on the date a derivative contract is entered into and are subsequently re-measured at their fair value. Changes in the fair value of derivatives are recognised in the statement of financial activities in finance costs or finance income as appropriate, unless they are included in a hedging arrangement.

(k) Retirement benefits

Payments to defined contribution retirement benefit schemes are charged as an expense as they fall due.

The cost of providing benefits under defined benefit plans is determined separately for each plan using the projected unit credit method and is based on actuarial advice.

The net interest element is determined by multiplying the net defined benefit liability by the discount rate, taking into account any changes in the net defined benefit liability during the period as a result of contribution and benefit payments. The net interest is recognised in the statement of financial activities.

Remeasurement changes comprise actuarial gains and losses and the return on the net defined benefit liability excluding amounts included in net interest. These are recognised immediately in the statement of financial activities in the period in which they occur.

The defined net benefit pension liability in the balance sheet comprises the total of the present value of the defined benefit obligation (using a discount rate based on high quality corporate bonds).

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

2. ACCOUNTING POLICIES (continued)

(l) Significant judgements and key sources of estimation uncertainty

In the application of the charity's accounting policies, Commissioners are required to make judgements, estimates and assumptions about the carrying value of assets and liabilities that are not readily apparent from other sources. The estimates are based on historical experience and other factors that are considered to be relevant. Actual results may differ from these estimates. The key sources of estimation uncertainty that have a significant effect on the amount recognised in the accounts are:

- the valuation of investment properties, which are stated at their estimated fair value based on professional valuations as disclosed in Note 15;
- the valuation of multi-year grant commitments, which take into account estimates of future inflation, early withdrawal rates, claim rates and other factors affecting the final amount payable; in this context, given other uncertainties, discounting for the time value of money is not considered material;
- the valuation of the defined benefit pension scheme liability, which is based on actuarial assumptions and a professional valuation as set out in Note 14;
- the valuation of future minimum lease payments under non-cancellable operating leases, which are discounted for inflation in accordance with Bank of England targets and ignore the potential effects of leasehold enfranchisements, as set out in Note 15.

3. FUNDS

All the Commission's income and capital is expendable at the discretion of the Commissioners and is therefore shown as a single unrestricted fund. The Commissioners have designated part of the unrestricted fund as a Special Projects Fund. It is anticipated this will primarily be used to fund activities in connection with the 175th Anniversary of the Great Exhibition in 2026 and the transition to net zero. Movements on the designated fund are disclosed in Note 20.

4. DONATIONS

The Commission received a donation of £1,000 from The Faculty of Royal Designers for Industry. The donation is for the general charitable purposes of the Commission, but with an expressed wish that it be used to support the activities of the Sir Misha Black Awards Committee. The donation was therefore used to part fund the ceremony held on 16 November 2023 at which the 2023 Medal and Award were presented. The Commissioners are very grateful to The Faculty of Royal Designers for Industry for their support.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

5. INVESTMENT INCOME

	2023	2022
	£	£
Rental income from UK properties	776,165	528,991
Income from managed investments	1,735,350	1,847,680
Interest on cash deposits	48,323	9,360
	<u>2,559,838</u>	<u>2,386,031</u>

6. OTHER INCOME

	2023	2022
	£	£
Licence income	5,103	4,217
	<u>5,103</u>	<u>4,217</u>

7. COST OF GENERATING FUNDS

	2023	2022
	£	£
Investment management fees	567,067	542,701
Property management fees	120,068	61,185
Legal fees	27,094	32,438
Write offs	-	104,183
Allocated support costs (note 11)	52,404	58,821
	<u>766,633</u>	<u>799,328</u>

8. CHARITABLE ACTIVITIES

	Grants (note 9)	Direct costs (note 10)	Allocated support costs (note 11)	2023	2022
	£	£	£	£	£
Fellowships and studentships	3,673,356	126,125	164,409	3,963,890	3,671,284
STEM education and outreach	246,075	141,420	56,758	444,253	416,247
Support for legacy estate	340,255	36,290	56,758	433,303	1,299,392
Archives and alumni relations	-	51,991	63,726	115,717	83,525
	<u>4,259,686</u>	<u>355,826</u>	<u>341,651</u>	<u>4,957,163</u>	<u>5,470,448</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

9. GRANTS AWARDED

(a) Fellowships and studentships

	2023 No.	2023 £	2022 No.	2022 £
Research Fellowships	10	1,692,455	9	1,027,845
Industrial Fellowships	15	1,129,088	10	1,312,595
Industrial Design Studentships	14	501,850	13	437,789
Built Environment Fellowship	1	100,000	-	21,598
Design Fellowship	-	(37)	1	100,000
Regenerative Design Fellowships	-	-	2	200,000
Enterprise Fellowships	4	250,000	5	250,000
Sir Misha Black Awards Bursaries	-	-	1	4,500
	—	—	—	—
Total fellowships and studentships	44	3,673,356	41	3,354,327

All of the fellowships and studentships were awarded to individuals. The Annual Report includes more information on the awards granted, including where relevant details of each of the institutions at which individual recipients are carrying out their studies / research.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

9. GRANTS AWARDED (continued)

(b) STEM education and outreach

	2023	2022
	£	£
British Science Association – Primary kit boxes	83,700	-
Primary Engineer – Primary Engineer Curriculum	45,000	-
British School at Rome – Summer School placements	19,500	-
Education and Training Foundation – Technical Teaching Fellowships	15,000	-
Oxford University Development Trust – OXbOXes	15,000	-
University of Hull – Humber Science Festival	11,000	-
Kids Invent Stuff – Inventors Club	10,000	-
All Party Parliamentary Engineering Group – Meeting sponsorship	10,000	-
Royal Botanic Gardens Kew – Grow Wild	10,000	-
Foundation for Science and Technology – Debate sponsorship	9,500	-
Geological Society – Megalosaurus Month	6,000	-
J Mallinson and E Townsend – STEM materials	750	-
G Lamb – STEM outreach	500	-
MadeHereNow – Website development	2,000	2,000
Smallpeice Trust – Arkwright Scholarships / General Engineering course	23,000	10,000
Well North Enterprises – STEM development in Rotherham and Liverpool	-	75,000
Somerscience Trust – Somerscience Festival	-	15,000
WoMars – STEM outreach	-	1,000
Royal Designers for Industry – Summer Schools	-	92,500
EDT – Routes into STEM	-	14,060
	<hr/>	<hr/>
	260,950	209,560
Less: Past awards written back where not utilised in full	(14,875)	(20,500)
	<hr/>	<hr/>
	<u>246,075</u>	<u>189,060</u>

Two of the STEM education and outreach grants were awarded to individuals with the remaining 13 awarded to institutions (2022: all of the STEM education and outreach grants were awarded to institutions).

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

9. GRANTS AWARDED (continued)

(c) *Support for legacy estate*

	2023 £	2022 £
Imperial College London – Great Exhibition Road Festival 2025 and 2026	200,000	-
Science Museum – Power Hall refurbishment	100,000	-
Royal Society of Sculptors – Florilegium at Great Exhibition Road Festival 2023	10,000	-
Natural History Museum – 1851 Garden	-	500,000
Royal Horticultural Society – Plants for purpose	-	300,000
Exhibition Road Cultural Group – SouthKenZen+	30,255	350,000
Exhibition Road Cultural Group – Art installation on Exhibition Road	-	25,000
Royal College of Art – Open resource for purposeful design	-	15,000
	<u>340,255</u>	<u>1,190,000</u>

All of the grants in support of the legacy estate in both 2023 and 2022 were awarded to institutions.

(d) *Archives and alumni relations*

No awards were made in this category in 2023 or 2022.

In total, 17 grants were made to institutions and 46 to individuals (2022: 13 grants to institutions and 41 to individuals).

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

10. DIRECT COSTS

	Fellowships and studentships £	STEM education and outreach £	Support for legacy estate £	Archives and alumni relations £	2023 £	2022 £
Promotion and selection costs	76,708	-	-	-	76,708	84,721
Networking and educational events	49,417	141,420	5,703	18,764	215,304	243,718
Estate memberships, projects and advice	-	-	30,587	-	30,587	30,035
Archive supplies and acquisitions	-	-	-	26,139	26,139	6,457
Alumni website and expenses	-	-	-	7,088	7,088	6,175
	<u>126,125</u>	<u>141,420</u>	<u>36,290</u>	<u>51,991</u>	<u>355,826</u>	<u>371,106</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

11. SUPPORT COSTS

	Cost of generating funds £	Fellowships and studentships £	STEM education and outreach £	Support for legacy estate £	Archives and alumni relations £	2023 £	2022 £	Basis of allocation
Governance costs (note 12)	6,795	6,795	5,436	5,436	2,718	27,180	40,807	Board time
Staff costs (note 13)	36,611	126,519	41,197	41,197	48,971	294,495	299,569	Staff time
Retired staff pension costs	2,018	6,976	2,272	2,272	2,700	16,238	7,240	Staff time
Facility costs	637	2,200	717	717	852	5,123	12,322	Staff time
Office refurbishment	-	-	-	-	-	-	-	Staff time
Office costs	4,409	15,239	4,962	4,962	5,899	35,471	33,919	Staff time
Legal and professional fees	981	3,390	1,104	1,104	1,312	7,891	23,487	Staff time
Travel and entertaining	952	3,290	1,071	1,071	1,273	7,657	7,432	Staff time
	<u>52,403</u>	<u>164,409</u>	<u>56,759</u>	<u>56,759</u>	<u>63,725</u>	<u>394,055</u>	<u>424,776</u>	

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

12. GOVERNANCE COSTS

	2023	2022
	£	£
Audit fees (including VAT)		
– Current year	15,000	13,800
– Prior year under / (over) accrual	-	460
Actuarial fees	2,220	2,040
Consultancy fees	-	3,600
Annual report	4,994	1,861
Meeting costs	4,966	15,026
Commissioner recruitment costs	-	4,020
	<u>27,180</u>	<u>40,807</u>

13. STAFF COSTS AND RELATED PARTY TRANSACTIONS

	2023	2022
	£	£
Salaries (including benefits in kind)	231,903	240,561
Employer's NI	20,713	23,238
Pension contributions	40,954	34,889
Staff recruitment	-	-
Training and development	925	881
	<u>294,495</u>	<u>299,569</u>

The average number of employees during the year analysed by function was:

	2023	2022
	No.	No.
Support and administration	4.0	4.0
Archive	1.0	1.0
	<u>5.0</u>	<u>5.0</u>

The full-time equivalent number of employees during the year analysed by function was:

	2023	2022
	No.	No.
Support and administration	2.8	2.9
Archive	0.4	0.4
	<u>3.2</u>	<u>3.3</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

13. STAFF COSTS AND RELATED PARTY TRANSACTIONS (continued)

One employee earned between £80,000 and £90,000. Pension contributions of £12,600 were paid in respect of this employee. (2022: no employee earned more than £60,000.)

Commissioners do not receive remuneration. During the year re-imbursements were made to three Commissioners in respect of travelling and other expenses totalling £1,423 (2022: to three Commissioners totalling £954). One Commissioner received an honorarium of £900 as a member of the Science and Engineering Fellowships Committee in recognition of specialist services provided in assessing potential candidates (2022: one Commissioner received £600).

The total amount paid in respect of key management personnel (i.e., the Secretary and Finance Director), including employer's national insurance and employer pension contributions, was £180,997 (2022: £194,519 – this figure was in respect of the outgoing Secretary, incoming Secretary and Finance Director).

There were no other related party transactions during the year (2022: none).

14. PENSIONS AND OTHER LONG-TERM EMPLOYEE BENEFITS

All current and new members of staff are eligible to join a personal pension scheme of their choice with the Commission contributing 15% of salary (2022: 15% of salary). There is no requirement for employee contributions. Staff may opt to sacrifice some of their salary in return for an additional employer contribution. Employer contributions of £40,954 (2022: £34,889) were made in the year of which £886 (2022: £820) were outstanding at the year-end. There were no prepaid contributions at the year-end (2022: £nil).

All current and new members of staff also benefit from an unfunded / uninsured death in service scheme under which the Commissioners (at their absolute discretion) may pay a nominated beneficiary a lump sum equivalent to 18 months' salary if an employee dies while employed by the Commission. No liability for the scheme is recognised in the accounts as Commissioners do not believe there is any sensible way to estimate the liability. Actuarial calculations based on assumptions comparable to those used in valuing the defined benefit pension liability (see below) suggest that any liability in respect of the death in service scheme would in any case be immaterial.

All current and new members of staff also benefit from a Group Income Protection policy with Canada Life which covers basic salary and pension contributions for staff unable to work due to long term illness.

The Commission operates an unfunded pension scheme in the UK (the 'Scheme'). The Scheme is an unregistered, non-contributory defined benefit scheme. As the Scheme is unfunded, no contributions are paid by the Commission, other than to meet benefits as they fall due. As no triennial valuations are carried out, a valuation is carried out at the balance sheet date each year by an independent qualified actuary.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

14. PENSIONS AND OTHER LONG-TERM EMPLOYEE BENEFITS (continued)

The Scheme was closed to new members on 14 July 2004. As at 31 December 2023, all four remaining members of the Scheme are receiving a pension and there is no further accrual of benefits. There is therefore no service cost for the year. The amount recognised in arriving at net expenditure for the year is an expense of £16,238 (2022: £7,239) which is fully in respect of net interest on the net liability.

As regards the unfunded, defined benefit pension scheme:

The principal assumptions used by the actuary were:

	FRS102 Valuation 2023 (% p.a.)	FRS102 Valuation 2023 (% p.a.)
<i>Financial assumptions</i>		
Gross investment return		
In-service members		
Pre-retirement	N/A	N/A
Post-retirement	N/A	N/A
Current pensioners	4.5%	4.8%
Pensionable earnings increases	N/A	N/A
Price inflation	3.6%	3.4%
Pension increases	3.6%	3.4%
Allowance for administration expenses	0.0%	0.0%
<i>Demographic assumptions</i>		
Mortality		
Pre-retirement	N/A	N/A
Post-retirement	101%/104% S3PA CMI 2022 1%	S3PA CMI 2021 1%
Withdrawal allowance	No allowance	No allowance
Early retirement allowance	No allowance	No allowance
Proportion married	90%	90%
Wife's age	3 years younger than husband	3 years younger than husband

The assumptions used by the actuary are best estimates chosen from a range of possible actuarial assumptions which, due to the timescale covered, may not necessarily be borne out in practice.

Value of Scheme assets and liabilities:

	2023 £	2022 £
Market value of Scheme assets	–	–
Present value of Scheme liabilities	(345,000)	(357,000)
Scheme deficit	(345,000)	(357,000)
Related deferred tax asset	–	–
Net liability	<u>(345,000)</u>	<u>(357,000)</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

14. PENSIONS AND OTHER LONG-TERM EMPLOYEE BENEFITS (continued)

Movements in the year:

	2023 £	2022 £
Scheme deficit at beginning of year	(357,000)	(399,000)
Current service cost	-	-
Interest on obligation	(16,238)	(7,239)
Actuarial gain / (loss) on liabilities	(9,173)	13,087
Benefits paid directly by employer	37,411	36,152
	<u>(345,000)</u>	<u>(357,000)</u>

The interest on obligation of £16,238 (2022: £7,239) is disclosed within Support costs (note 11) while the actuarial loss on liabilities of £9,173 (2022: gain of £13,087) is disclosed within Other recognised gains and losses on the face of the SOFA.

15. INVESTMENT PROPERTIES AND OPERATING LEASES

	2023 £	2022 £
(a) <i>Movements in value of investment properties</i>		
Balance at 1 January	20,765,350	20,940,350
Sales during the year	(365,000)	-
Unrealised (loss) / gain on year-end revaluation	(805,000)	(175,000)
	<u>19,595,350</u>	<u>20,765,350</u>

The valuation as at 31 December 2023 shown above resulted from a full revaluation of the properties at 31 December 2019, undertaken by Cluttons LLP, Chartered Surveyors and Property Consultants. The valuation was carried out on an open market value basis in accordance with the RICS Appraisal and Valuation Manual and is based on existing usage and occupation of the land, and the duration of leases at ground and rack rents. In reaching the 31 December 2023 valuation, the value at 31 December 2019 has been adjusted, based on advice from Daniel Watney LLP, to take into account movements in local property market indices, changes in estimated rental values, the decreasing length of leases and lease extension / leasehold enfranchisement claims received. All of the investment properties are located in the UK.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

15. INVESTMENT PROPERTIES AND OPERATING LEASES (continued)

(b) *Operating leases – lessor*

The Commission is entitled as landlord to income from investment properties under operating leases. Future minimum lease payments under non-cancellable operating leases, discounted for inflation, for each of the following periods are as follows:

	2023 £	2022 £
Not later than one year	94,538	94,538
Later than one year and not later than five years	–	–
Later than five years	10,903,421	10,429,261
	<u>10,997,958</u>	<u>10,523,799</u>

The Commission's investment properties are let for periods ranging up to 999 years. All leases are on full repairing and insuring terms. Leases of residential property are potentially subject to leasehold enfranchisement; this has been ignored in arriving at the above figures.

16. INVESTMENTS

	2023 £	2022 £
(a) <i>Movements in listed investments</i>		
Market value 1 January	112,318,792	133,023,295
Acquisitions at cost	23,917,759	15,283,538
Disposals at cost	(20,252,654)	(16,517,911)
Net (losses) / gains on revaluation	13,031,928	(19,470,130)
	<u>129,015,825</u>	<u>112,318,792</u>
Market value 31 December	129,015,825	112,318,792
Value at cost 31 December	96,844,702	93,179,598

(b) *Geographic breakdown*

	2023 £	2023 £	2022 £	2022 £
	Listed investments	Cash	Listed investments	Cash
In the UK	54,650,993	1,114,072	52,328,177	3,516,273
Outside the UK	74,364,832	88	59,990,615	155,879
	<u>129,015,825</u>	<u>1,114,160</u>	<u>112,318,792</u>	<u>3,672,152</u>

All investments are listed on a recognised stock exchange.

There were no individual holdings the market value of which is considered to be material in the context of the portfolio as a whole.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

17. DEBTORS

	2023	2022
	£	£
Rents receivable		
– in hands of surveyors	132,886	48,647
– in arrears	126,391	299,016
	<u>259,277</u>	<u>347,663</u>
Other debtors	28,244	338
Prepayments	31,395	29,918
Accrued income	-	-
	<u>318,916</u>	<u>377,919</u>

18. CREDITORS

	2023	2022
	£	£
Amounts falling due within one year		
Grants payable	3,866,077	4,379,636
Other creditors	212,825	215,726
	<u>4,078,902</u>	<u>4,595,362</u>

	2023	2022
	£	£
Analysis of other creditors		
Investment management fees	145,301	134,891
Property management fees	24,398	8,400
Audit fees	15,000	13,800
Other legal and professional fees	12,478	17,588
Others	15,648	41,047
	<u>212,825</u>	<u>215,726</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

18. CREDITORS (continued)

	2023 £	2022 £
Amounts falling due after more than one year		
Grants payable	3,206,557	3,106,492
Due in one to two years	2,195,140	2,188,881
Due within two to five years	1,011,417	917,611
	<u>3,206,557</u>	<u>3,106,492</u>

The analysis of grants payable by award is as follows

Award	Period of commitment	2023 £	2022 £
Fellowships and studentships			
– Research Fellowships	3 years	3,321,439	3,099,479
– Industrial Fellowships	3 years	2,286,548	1,595,090
– Industrial Design Studentships	2 years	286,942	339,645
– Built Environment Fellowships	2 years	80,000	58,402
– Design Fellowships	2 years	55,000	142,500
– Regenerative Design Fellowships	2 years	132,500	-
– Enterprise Fellowships	1 year	62,500	187,500
– Sir Misha Black Award Bursaries	1 year	1,000	-
STEM education and outreach	1 year	196,250	342,932
Support for legacy estate	3 years	640,455	1,410,050
Archives and alumni relations	1 year	-	26,500
		<u>7,072,634</u>	<u>7,486,128</u>

19. FINANCIAL INSTRUMENTS

	2023 £	2022 £
Carrying amount of financial assets		
Debt instruments measured at amortised cost (debtors excluding prepayments)	287,520	348,001
	<u>287,520</u>	<u>348,001</u>
Carrying amount of financial liabilities		
Measured at amortised cost	7,285,459	7,701,854
	<u>7,285,459</u>	<u>7,701,854</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2023

20. FUNDS

	At 1 January £	Income £	Expenditure £	Gains / (losses) £	Transfers £	At 31 December £
Unrestricted General	127,957,079	2,565,941	(5,723,796)	16,621,009	(691,549)	140,728,684
Designated – Special Projects	2,418,658	-	-	-	691,549	3,110,207
	<u>130,375,737</u>	<u>2,565,941</u>	<u>(5,723,796)</u>	<u>16,621,009</u>	<u>-</u>	<u>143,838,891</u>

In 2021, the Commissioners set up a designated Special Projects Fund. It is anticipated that this will be used to fund activities in connection with the 175th Anniversary of the Great Exhibition in 2026 and perhaps also to fund activities around the transition to net zero, although Commissioners retain the discretion to direct alternative uses and remain mindful of the desirability of maintaining disbursements through periods of inferior market return. The designated fund comprises listed investments. It is administered as part of the unrestricted fund.

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, architecture 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 76 to 78. Details of the Commission's professional advisers are provided on page 79.

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 are therefore eligible to receive a 15% employer pension contribution to the pension scheme established for auto-enrolment purposes or a personal pension of their choice. All employees also benefit from a Group Income Protection policy that will cover basic salary and pension contributions if they are unable to work due to long-term illness. At their absolute discretion,

Commissioners may pay a nominated beneficiary a lump sum equivalent to 18 months' salary if an employee dies while employed by the Commission. All employees are also entitled to an interest free season ticket loan. All of the above benefits are available to all employees, including key management personnel. 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 role 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 are summarised below.

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)

The Rt Hon Professor Lord Kakkar KBE PC FMedSci
Chairman, Board of Management

Professor Jim Al-Khalili CBE FRS FInstP
The Rt Hon Lord Burnett of Maldon PC
Professor Dame Ann Dowling OM DBE FREng FRS
Mr Jim Eyre OBE
Professor Sir Andrew Hopper CBE FRS FREng FIET
Professor Lord Mair CBE HonDSc FREng FICE FRS
Dame Alison Nimmo DBE MRTPI FRICS HonFRIBA FICE
Ms Sandra Robertson
Professor Dame Carol Robinson DBE FRS FRSC FMedSci
Professor Eleanor Stride OBE FREng HonFIET
Professor Chris Wise RDI FREng FICE MStructE HonFRIBA FRSA

The Rt Hon Lord Burnett of Maldon was appointed to the Board on 8 September 2023

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 Science, Innovation and Technology
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

Ms Sandra Robertson *Chairman*
Ms Sarah Arkle
The Rt Hon Lord Burnett of Maldon PC
Professor Sir Andrew Hopper CBE FRS FREng FIET
Dame Alison Nimmo DBE MRTPI FRICS HonFRIBA FICE
Mr Thomas Seaman
Mr Fabian Thehos CFA

The Rt Hon Lord Burnett of Maldon was appointed to the Committee on 7 December 2023
Mr Thomas Seaman was appointed to the Committee on 14 September 2023

Science and Engineering Fellowships Committee

Professor Dame Carol Robinson DBE FRS FRSC FMedSci *Chairman*
Professor Jim Al-Khalili CBE FRS FInstP
Professor Gillian Bates FRS FMedSci
Professor Mike Benton FRS FRSE
Professor Martin Bridson FRS
Professor Andrew Briggs
Professor Neil Champness FRSC FLSW
Professor Anne Dell CBE FRS FMedSci
Professor John Dewey FRS
Professor Cyril Hilsum CBE FREng FRS
Professor Patrick Keogh FREng
Dr Sandra Knapp OBE FRS
Professor Rachel O'Reilly FRS FRSC
Professor Sheena Radford OBE FRS FMedSci
Dr Dame Frances Saunders DBE CB FREng FInstP
Professor Christopher Tout
Professor Stuart West
Professor John Wood CBE FREng

Professor Trevor Stuart retired from the Committee on 1 January 2023
Dr Sandra Knapp was appointed to the Committee on 6 February 2023
Professor Stephen Muggleton retired from the Committee on 14 February 2023

Brunel Fellowships Sub-Committee

Professor Dame Carol Robinson DBE FRS FRSC FMedSci *Chairman*
Professor Dame Anne Dowling OM DBE FREng FRS
Professor William Powrie FREng FICE
Professor John Wood CBE FREng

Professor David Ewins retired from the Committee on 1 January 2023

Industry and Engineering Committee

Professor Dame Ann Dowling OM DBE FRS FREng *Chairman*
Professor Cees de Bont
Professor John Clarkson FREng
Dr Nicholas de León
Professor Andrew Lewis FREng FRSC FAPS FIMMM CChem CSI
Professor Lord Mair CBE HonDSc FREng FICE FRS
Professor Ron Pethig
Dr Malcolm Skingle CBE DSc
Professor Dame Sarah Springman DBE FREng
Professor Adam Stokes
Professor Eleanor Stride OBE FREng

Professor Cees de Bont was appointed to the Committee on 17 September 2023
Professor Adam Stokes was appointed to the Committee on 18 September 2023

Built Environment and Design Fellowships Committee

Mr Jim Eyre OBE *Chairman*

Professor Rachel Cooper OBE

Ms Kat Scott

Dr Andrea Siodmok EMPP FRSA HonDCL

Professor Chris Wise RDI FEng FICE MStructE HonFRIBA FRSA

Dame Alison Nimmo retired from the Committee on 1 January 2023

Sir Misha Black Awards Committee

Ms Mary Mullin *Chairman*

Professor Chris Wise RDI FEng FICE MStructE HonFRIBA FRSA

Professor Peter Childs

Dr Nicholas de León

Professor Malcolm Garrett MBE RDI FISTD

Professor Geoff Kirk RDI FEng

Professor Sir Christopher Frayling retired from the Committee on 1 January 2023

Staff

Mr John Lavery MVO

Mr Amahl Smith ACA

Mrs Helen Harris

Mrs Angela Kenny RMARA

Ms Kat O’Dea

Secretary

Finance Director

Fellowship Programme Manager

Archivist and Alumni Relations

Office Manager / Executive Assistant

Professional Advisers

Bankers

The Royal Bank of Scotland plc
London Drummonds (B) Branch
49 Charing Cross
London SW1A 2DX

Investment Consultant

Stanhope Consulting
35 Portman Square
London W1H 6LR

Surveyors

Daniel Watney LLP
165 Fleet Street
London EC4A 2DW

Investment Managers

Schroder & Co. Limited
1 London Wall Place
London
EC2Y 5AU

Auditor

Moore Kingston Smith LLP
9 Appold Street
London EC2A 2AP

Charles Stanley & Co. Ltd
55 Bishopsgate
London EC2N 3AS

Actuaries

XPS Pensions
Albion
Fishponds Road
Wokingham RG41 2QE

JP Morgan Asset Management (UK) Ltd
60 Victoria Embankment
London EC4Y 0JP

Legal Advisers

Farrer & Co LLP
66 Lincoln's Inn Fields
London WC2A 3LH

Insurance Brokers

Howden
3rd Floor
Quadrant House
Croydon Road
Caterham CR3 6TR

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