

Royal Commission for the Exhibition of 1851

Annual Report and Accounts

For the year ended 31 December 2020



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:

Great Exhibition Scholarships
Enterprise Fellowships

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

The total number of individuals being supported in 2020 was 148

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Chairman's Report

Bernard Taylor, Chairman of the Board of Management

In common with the rest of the world in 2020 the 1851 Royal Commission saw significant impact from the Covid 19 pandemic: a year which started with great plans, not least for a second Great Exhibition Road Festival even better than the first, came to a crashing halt in March with the commencement of the first lock down. An early casualty was the Fellows' Reception with The Princess Royal, cancelled at three days' notice, and the 1851 'family' has not gathered since, thereby depriving our award holders of one of their greatest benefits: the opportunity to meet and exchange ideas. However our setbacks are a mere inconvenience compared to the devastating impact on the institutions on our legacy estate, particularly the museums and the Royal Albert Hall; we can only admire their irrepressible spirit and determination to make the best of a truly terrible situation, absorbing the blows of one setback after another and continuing to provide inspiration to all through online content. Prince Albert would surely have been proud.

Notwithstanding the above, there is plenty of positive news to report. Prescient action by the Finance Committee in February in liquidating sufficient assets to cover three years of costs, meant we were well prepared to weather any storm without having to cut back on programmes. The Committee also started, and maintained up until the autumn, three-weekly management meetings with our investment managers to actively manage the risk as markets and economies around the world responded to the imposition of the various pandemic management measures. This close attention and the skilful work of our investment managers led us to finish the year on another record high – I thank the Finance Committee and their advisers for all their work to achieve this remarkable result.

Our fellowship committees quickly adjusted to virtual meetings and we were able to achieve a full complement of awards. At the same time we reassured current award holders who were impacted by the pandemic that we would look favourably on requests for extensions and, to date, 25 have been granted at a cost of £266,000. Our programmes have continued to grow, with our Graduate Enterprise Fellowships, in partnership with the Royal Academy of Engineering, set to increase to six by next year. This year also saw completion of the first Technical Teaching Fellowships, a two-year programme in partnership with the Education and Training Foundation, aimed at improved teaching standards in the Further Education sector. The scheme shows much promise and the Board has agreed to extend the pilot phase until at least 2022 to allow a fuller evaluation of its impact.

2020 also saw us take on the administration of the Sir Misha Black Medal and Awards. The Medal honours those who have given distinguished services to design education: it was the first, and is the only, international award to do so. The Award for Innovation in Design Education salutes innovation in design education in the United Kingdom. The Awards commemorate the work and life of the designer and architect, Professor Sir Misha Black, whose pioneering work played a crucial role in the development of design in Britain. They are a close fit with the 1851 objectives and we are delighted to give them our support.

While the Great Exhibition Road Festival could not go ahead as planned, we were still able to stage the fifth of our annual series *The Engineers* with the BBC World Service, albeit on a virtual platform rather than at the Festival site. This was the first time the BBC had brought together a 'live' audience on Zoom: drawn from every continent, it was a mix of members of the public and engineers from the Royal Academy of Engineering's global network who were able to participate in a united audio loop specially created for the programme. The planned theme was changed from 'Climate Engineering' to 'Re-engineering the Future' and four engineers engaged in combating coronavirus – including the British CPAP success story represented by Professor Rebecca Shipley – took part in a panel discussion chaired by Kevin Fong. We were proud to be one of the pioneers of this audio format, now commonplace, which attracted a maximum capacity global audience on the night. It was broadcast a week later to the BBC World Service English audience, which now tops 97 million listeners per week, and attracted very positive reviews. At our request, the BBC also produced a video of the programme which was put up on the Great Exhibition Road Festival website and is currently available on the Royal Commission website.

It has been customary to run a schools' competition in conjunction with *The Engineers* with virtual school visits by the panellists as part of the prizes. The intention this year was to expand this in conjunction with the Festival and the 'Great Exhibition in Schools' challenge was on the verge of launching when the pandemic struck. Our partners, the Big Ideas Company swiftly transformed it into the 'Great Exhibition at Home' which was picked up by major media outlets, including Sky News, the Sunday Times and Forbes Magazine, and recommended as an excellent initiative for home schooling. There were over 6,000 downloads of the free resources and some truly innovative entries at the end of the twelve-week run. In the course of the year the Commission has also supported other home schooling initiatives including a Fun Kids radio project and a series of videos to assist physics teachers, as part of the effort to overcome some of the immense challenges posed by the closure of schools.

We have long had an ambition to see improvements to the public realm around the Royal Albert Hall to place it in a more appropriate setting and better connect it to the Albert Memorial to the north. Architect Deborah Saunt, an 1851 Built Environment Fellow in 2009, laid the groundwork and urgency was injected by the need to improve security arrangements following the terrorist attacks in London in 2019 and 2020. Westminster City Council and Transport for London have now agreed to fund elements of the road improvements and the Commission will support the scheme with a substantial Special Award. Work is due to start early next year and the result will be a significantly more elegant, as well as a safer, approach to this iconic building.

I have touched on some of the highlights of this extraordinary year but of course that is not the whole story. As the reports that follow show, our Fellows and our alumni continue to do exceptional work and it is supporting our current award holders that, quite rightly, absorbs the bulk of our expenditure each year. Helping the brightest and the best to achieve great things and extending the influence of science and art on productive industry remains our focus and this report shows that our work continues undiminished in this respect. This could not happen without the hard work of our loyal staff and the Commissioners and committee members who are so generous with their time. I am very grateful to them all for helping us so successfully through a uniquely difficult year; I hope to be able to report on a more normal one in twelve months' time.

Bernard Taylor CBE DL FRSC

Secretary's Report

We had barely had time to welcome our two new members of staff, Helen Harris, Fellowship Programme Manager and Kat O'Dea, Office Manager and Executive Assistant, before the office closed in mid-March and we have been working from home ever since. On the whole this has gone very well but we are all looking forward to returning to South Kensington at the earliest opportunity. Despite the fact that they have spent more time working in isolation at home than together in the office, our new recruits have had a great impact. The additional resource has enabled us to do more to promote our awards, particularly Industrial Fellowships and allowed us to strengthen our relationship with our media consultants AprilSix. Much effort has gone into a new website, with improved utility and a fresh look, which launched in early 2021. Engagement with award holders, who have been denied our usual run of social events, has suffered as a result of the pandemic but increasing activity on social media and efforts to feature work on the website have gone some way to alleviate this. We are poised to restart a live programme as soon as restrictions are lifted.

Notwithstanding the shortcomings of living in a two-dimensional world much has been achieved by our award holders and our alumni: a clear demonstration of the continuing reach of the '1851'. I hope you enjoy reading about the impact they are making across an extraordinary breadth in the pages that follow.

Nigel Williams CEng

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 also 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 6 million visitors, it also made a substantial profit.

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

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

The Commission continues its work to this day, both managing its freehold estate and awarding over £4m 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 Royal Commission ensures that its work is for the public benefit and takes full account of the published Charity Commission guidance. The Royal Commission's 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. Around eight to ten awards 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 is being increased to six a year by 2021.

Great Exhibition Scholarships

The Commission's 5-year commitment to this scheme ended in 2018 when ten scholarships were awarded. These scholars will graduate in 2022. Awarded through The Institution of Engineering and Technology (IET), these scholarships were open to UK residents who achieved 3 A grades or above at 'A' level or equivalent joining an IET accredited undergraduate degree. Up to ten scholarships a year were available. Scholars receive an annual stipend. Similar scholarships continue to be available through the IET.

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.

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 2020

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 18.

The true impact of the Commission's award holders will only emerge over time, but many show ample indications of their future promise during their Fellowships. To take some examples at random:

- 2018 Research Fellow Emilio Martínez-Pañeda was awarded the Simó Prize by the Spanish Society for Numerical Methods in Engineering and the Prestige Award for Risk Reduction in Mechanical Engineering by the Institution of Mechanical Engineers
- 2018 Industrial Fellow Maristefania De Vido was awarded the MacFarlane Prize by Heriot-Watt University and has been selected to be part of The Foundation for Science and Technology "Future Leaders 2021" programme

- 2018 Industrial Fellow Adam McKenzie was awarded a Postgraduate Prize by the Institute of Engineering and Technology
- 2019 Industrial Fellow Alex O'Neill was awarded the Young Scientist of the Year prize at the Tire Technology Expo

More 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 19 to 33. Many completing Fellows comment quite explicitly on the importance of their Fellowship to their success:

As a young CEO who moved to the UK in 2017, the Fellowship's support provided me with much needed access to a network of like-minded entrepreneurs and experienced professionals to learn from. Learning from other's success, and more importantly, their challenges, has enabled me to rapidly expand the leadership and management skills that are required to build an ambitious and close-knit team to build impactful products.

Ben Lakey, Enterprise Fellow 2019

The support provided by the Industrial Fellowship has significantly increased the potential of my DPhil by enabling generation of high-quality experimental data. As I am based in the department of statistics, it was difficult for me to obtain my own biological data. The resources provided by the Industrial Fellowship have enabled me to build a strong collaboration with a research group in Zürich, Switzerland. I visited them to use their state-of-the-art experimental setups to generate my own biological data as well as to exchange scientific expertise. This data is currently being actively studied in preparation for multiple peer-review article submissions.

The Industrial Fellowship has had a notable impact on my career prospects. The Fellowship provided a truly unique and exceptional opportunity which made me a highly skilled interdisciplinary researcher. The CEO of a London based biotech company (and my future employer), LabGenius, directly headhunted me to join their company more than one year before the official end of my DPhil.

Aleksandr Kovaltsuk, Industrial Fellow 2018

For some, it is clear that without the award from the Commission, their project would not have gone ahead:

I originally proposed my project to my employer 12 months prior to applying to the 1851 before I knew it existed and although my manager told me he liked it and it was a good idea he said we could not allocate any time or resources to work on it. I can say that without the support of the Commission this project would not have gone ahead. I am grateful that it did as this project has allowed me to develop a process and product from the initial concept through to lab scale testing, something I don't believe I would have been able to do at this stage in my career without the support of the Commission. Doing this has allowed me to gain a wide range of engineering skills I would have never developed as a chemist on my previous career trajectory. I have learned how to weld as well as how to code, I have become a qualified refrigeration and ATEX engineer and I have been awarded membership of the Institute of Chemical Engineers. This has positioned me within the company as the go between for the chemical and engineering departments. The support from the Commission I believe has been very valuable, especially to a small company. To be able to train a PhD in the company's core subject matter is something that most SMEs would not be able to do without external support.

Andrew Anderson, Industrial Fellow 2017

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

In my opinion, the support provided by the Royal Commission through their Industrial Fellowships is fantastic. It provides a fantastic platform for bright young individuals to develop their independent careers. I am very grateful for the support offered to Iestyn and our research and as such make it

a point to ensure that I continually promote the scheme to my network, not only the Industrial Fellowship but all of the generous awards offered by the Commission. I have found the process of being a supervisor of an Industrial Fellow most fulfilling. As an academic engineer, and Whitworth Scholar, I think it is so essential that schemes such as this fellowship continue to facilitate the engagement of academia and industry and it is only through schemes such as this that creativity and innovation in British industry will continue to propagate.

Professor Karl Dearn, University of Birmingham

The Fellowship allowed a small start-up (3 people when the Fellowship first started) to give the Fellow the potential to develop a completely new product range from scratch and increase his knowledge and future capability. This would not have been possible without the support of the Fellowship during the period.

Dr Alex Reip, Oxford nanoSystems

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 34-35. Many of our alumni tell us that their Fellowship has made a decisive difference to their career:

The 1851 Fellowship gave me an invaluable platform and recognition as an independent researcher. It was a fantastic opportunity to do cutting-edge research, meet new colleagues and friends and build networks for a lifetime.

Dr Apala Majumdar, Research Fellow 2006

I had the great fortune of being granted an 1851 award that I used to support my first post-doctoral position at the Plant Breeding Institute in 1984. Subsequently I spent the next 35 years in research at CSIRO and then the Australian National University where I am currently a professor in the Plant Science Division of the Research School of Biology. The 1851 gave me the chance to develop independent research in the UK and was a wonderful opportunity at the start of my career. I have spent my career investigating photosynthesis and most recently have been trying to apply this towards increasing crop yield. I was elected fellow of the Australian Academy of Science in 2013 and last year was recognised with a Highly Cited Researcher in Plant and Animal Sciences award by Web of Science.

Professor John Evans, Overseas Scholar 1984

Getting the Rome Scholarship in Painting from the Royal Commission of 1851 changed my life. It sent me to the British School at Rome in 1979, where I had a year to paint with total support and during that year my professional future opened up and I was awarded a Fulbright fellowship to the USA. I've never looked back. I'm represented by a NY gallery and my paintings are in major collections including The Metropolitan Museum of Art and the V&A Museum London.

Carole Robb, Rome Scholar 1979

It's 28 years since I first visited Imperial College London (ICL) for my Royal Commission for the Exhibition of 1851 Industrial Fellowship interview at the Sherfield building and was ecstatic to be told that I had been successful! The award enabled me to travel around the UK (and the World) to visit eminent academics, engineers and industrialists, who gave me their time, experience and advice willingly. This was invaluable in my formative engineering development and has provided life-long career contacts.

So, in 2017, it was with great pride that I took on the role of Royal Academy of Engineering (RAEng) Visiting Professor of Robotic Systems Architectures at ICL. This scheme aims to get senior industrialists to contribute to undergraduate teaching and was my opportunity to 'give back' to academia and engineering. Primarily, my approach was to link the students' academic taught work to the Dyson 360Heurist, a robotic vacuum cleaner for which I was the Product Technical Lead.

With the support of Dyson, I was able to extend the aim of the scheme and provide teaching at other institutions. Over the three-year tenure of the award I supported 18 Universities, 34 unique cohorts, and engaged with 1136 students covering England, Wales, Ireland and Scotland. In addition, with the help of the teaching staff at ICL I achieved Fellowship of the Higher Education Academy (FHEA). I have now joined the RAEng Visiting Professor Management group to assist with the strategy, development and running of the scheme. Further, I will continue to provide Industrial Teaching to help the development of the next generation of engineers.

Dr Robert Deaves, Industrial Fellow 1994-1997

For some, a Fellowship does much more than just enable a successful career:

As a recipient of an 1851 Royal Commission Fellowship I can say that this set me on the path to becoming a successful academic, and, importantly for me, also to having a family. For anyone wanting to be a professional scientist/academic, i.e. continuing after the PhD, your career requires you to move, branch out and fight hardest to stay in the game typically in your late 20's to 30's and this is exactly the same time, especially for women, that the 'biological clock ticks loud'. The freedom provided by the two year-fellowship comes at a crucial time and is invaluable because it provides:

- (i) endorsement to me and the world that you are on-track to becoming an independent scientist (what employers are looking for)*
- (ii) flexibility to control where you are in a critical phase of your life: staying with a partner / moving away from a partner can be make-or-break for women continuing their careers and I think this is a big reason why we lose so many good female scientists from the PhD to postdoc and higher rank phases – they don't necessarily want to relocate where a partner cannot follow (or does not want to) at that stage in their lives (if they want a family).*

My fellowship allowed me to find a solution that allowed my partner and I to be in a place where we both had fulfilling work in the same town. Always a challenge for ambitious couples.

After my Royal Commission Fellowship came a second success – my good start resulted in me obtaining a 5-year Royal Society University Research Fellowship, which allowed me to continue the independence and flexibility.

20 years later, I am now doing really well as a Senior Lecturer at Stockholm University working in the field of palaeoclimate research, AND have a teenage family, in part because of the great start my Royal Commission fellowship gave me. Thank you, Royal Commission, for investing in me! Plus I will never forget the incredible dinner and evening at the Royal Armoury when I was sitting opposite HRH Prince Philip, Duke of Edinburgh, with the Director of the Natural History Museum on my side (inspiring conversation), and on occasions, experiencing wonderful performances of music and dance at the Royal Albert Hall. What a package of privileges!

Dr Helen Coxall, Research Fellow 2000

The work of our alumni also has tremendous real-world impact. To take one topical example, the intelligent cameras for better transport planning developed by 2016 Enterprise Fellow Yang Lu and his company Vivacity Labs have really come into their own during the pandemic. The company now has more than 1,000 sensors installed across the UK, in cities including London, Manchester, Oxford, Cambridge and Nottingham, the data from which is fed back to Government to inform Covid policy. In addition, Vivacity Labs' technology has been adopted by more than 30 UK councils, following the recent £250m government funding awarded for regions to develop 'Active Travel' schemes, which encourage people to avoid public transport or their cars and instead walk or cycle to get around. The company has also recently secured a partnership with Transport for Greater Manchester to control traffic across 25% of the central Manchester area.

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. They include awards to Physics Partners, to produce a series of videos for teachers giving tips on how to

teach key topics; to Fun Kids Radio, for a series of audio programmes on great British inventors; to Primary Engineer, for a series of podcasts aimed at young people, featuring engaging engineers; to SmartSTEMs, for development of an online platform and event package kit to facilitate STEM outreach events aimed at young people from disadvantaged backgrounds; and to In2ScienceUK to provide information, mentoring and skills workshops to help young people from low income and underrepresented backgrounds move into STEM careers.

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. Feedback from grant recipients suggests the programme is largely achieving its aims. To take a couple of recent examples:

In 2016, The South Downs National Park became the world's latest International Dark Sky Reserve, with 66% of the Park having Bronze Level Skies. The South Downs Dark Night Skies Festival was launched to celebrate this designation and help people experience the joy of witnessing and understanding dark night skies.

The Commission's support enabled the introduction of Virtual Reality technology that furnished those attending the event on a cloudy night or in areas suffering from light pollution with the opportunity to virtually experience a true dark night sky, inspiring them to go out and seek the real thing. The VR experience has since been used at school science events and other outreach programmes, where it has proved universally popular.

To take another example, Kids Invent Stuff is an initiative by two former Young Engineers of the Year to establish a YouTube channel to get primary school children inventing things – which are then built by real engineers. They do this to give more primary school kids the chance to engage with real engineering projects. The Commission first supported their Big Inventor, Little Inventor Challenge in which the presenters, Ruth Amos and Shawn Brown, brought to life a different kid's invention every month, with often hilarious consequences. Inventions brought to life so far include a robot shopping trolley and the world's first sneeze-activated flamethrower. Their work has been featured on Tomorrow's World Live, BBC News Online as well as major US TV news outlets. More recently, the Commission supported their Giant Rube Goldberg Machine Challenge which saw them build a giant chain reaction machine from 60 kids' invention ideas, setting a new world record and securing a live invention demo on BBC's *The One Show*. Together it is estimated that these projects have reached over 6 million people through national media, views and mail outs.

Needless to say, not all Special Awards proceed completely smoothly, and many recent awards are suffering significant delays in implementation as a result of the pandemic. 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.

In recent years, the Special Awards Programme has been complemented by an increasing focus on the Commission's own educational initiatives, including, in 2020, the Great Exhibition at Home, which challenged schoolchildren to produce a video at home showing their ideas for addressing the impact of climate change. This was enthusiastically received and achieved excellent press coverage. It is estimated that around 10,000 children engaged directly or indirectly with the programme and the quality of the final entries was excellent. The programme won many plaudits for providing a constructive way for parents to entertain children stuck at home while their schools were closed.

As well as promoting STEM outreach, the Commission also makes Special Awards focused on continuing to develop South Kensington as the premier destination for those interested in science, engineering, art and design. This year, as mentioned in the Chairman's report, they included a major award to improve the public realm around the Royal Albert Hall.

Finally, the Commission sometimes makes Special Awards to facilitate access to its own archives and in 2020 gave a grant to the University of Oxford to support the work of Dr Andrew Cusworth, who is seeking to enhance access to and understanding of material relating to Prince Albert's legacy, including the Great Exhibition.

COVID-19

As made clear in the Chairman's Report, the Commission, like every other organisation, has been impacted by the pandemic; many events had to be cancelled and some programmes moved on-line. In terms of its core grant-making activity, however, the Commission has largely been able to continue as planned and Commissioners do not believe that any adjustments to the accounts are required.

As soon as the possibility of a pandemic became clear, the Finance Committee acted to ensure that there were sufficient cash or near cash assets in place to fund at least three years' expenditure in full. This gave confidence that the Commission would be able to ride out the immediate disruption and need not curtail any of its programmes. The Committee also met regularly with the investment managers to monitor the position. Investment markets have to be sure 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 value of the Commission's portfolio has risen over the year.

Similarly, while some of the Commission's tenants have asked for and received temporary support with deferred rent demands and the like, there is not considered to be any risk to the long-term value of the estate. That is not to say of course that some of our legacy institutions have not been severely impacted.

The Commission had robust business continuity plans in place and Commissioners, Committee members and staff have adapted relatively straightforwardly to the need for remote working. The 2020 and 2021 award rounds for all the Commission's Fellowships and Studentships have gone ahead as planned with a full complement of awards made. A majority of existing award holders have been able to adapt their workflow patterns to fit the unusual circumstances imposed by lockdowns etc. Where this has not been possible, the Commission has granted extensions and provided the necessary financial support. Commissioners have also been pleased to provide 'paid sabbaticals' where award holders' specialist skills have enabled them to support the fight against COVID-19, whether through testing, modelling or other means.

All in all, Commissioners are confident that whatever the short-term disruptions, the pandemic should not have any material, long-term impact on the Commission's work.

Post balance sheet event – Brexit

The Commission does not import or export significant goods or services from the EU and does not currently employ any staff from the EU; to date there has been relatively little direct impact from Brexit therefore.

The Commission's alumni system is hosted in the EU and the Commission may therefore be impacted by changes to data protection regulations arising from Brexit, particularly if an adequacy decision is not forthcoming. However, the Commission has taken relevant legal advice and remains confident that it should be possible to meet any new requirements through proper contractual arrangements.

Although none of the eligibility criteria for the Commission's various awards have changed as a result of Brexit, Commissioners accept that there may nonetheless be some impact on the number of Fellowship applications the Commission receives from EU citizens and this will be monitored over time. So far, however, application numbers appear to be holding up well.

Future Plans

The Commission has long recognised the need to ensure a future pipeline of applicants for its awards by raising awareness amongst the young of the excitement and importance of STEM, something it does primarily through its Special Awards programme. Over the past 15 years the Commission has awarded grants totalling £2m to a variety of organisations adopting a wide spectrum of different approaches. Commissioners would like to develop a strategy for STEM interventions more clearly focused on long term impact with hard to reach groups and will be examining how this might be possible. Commissioners will also be exploring how to move beyond raising awareness to facilitating access to STEM careers, building on Special Awards such as that to In2ScienceUK mentioned earlier in this report and the Technical Teaching Fellowship programme mentioned by the Chairman.

In recent years the Commission's Special Awards programme has been complemented by its own educational initiatives, including in particular the inaugural Great Exhibition Road Festival and 2020's Great Exhibition at Home. The enforced closure of the Albertopolis institutions in response to the pandemic makes it difficult to say with certainty when large scale public events in South Kensington will be possible again, but the Commission stands ready to play its part in helping Albertopolis to thrive again as the premier destination for those interested in science, engineering, art and design.

Another ongoing priority for the Commission is to increase awareness of its award programmes and the opportunities they provide to the brightest and the best. The pandemic has restricted opportunities to implement marketing campaigns and ambassadorial networks, but the Commission remains committed to moving forward with new initiatives as soon as possible. The Commission is particularly keen to raise awareness amongst the UK's black and minority ethnic populations and amongst young female scientists, engineers and designers. The Commission is looking at how it best works with its alumni, universities and others to increase the diversity and inclusivity of its awards.

As well as raising awareness of its awards, and their impact, the Commission will as always be reviewing the value they add and ways in which they can be improved and made more attractive to potential applicants. Commissioners will also be looking at new ways in which the Commission's objects can be promoted beyond its award holders. With the incorporation of the Sir Misha Black Awards into the Commission's portfolio, Commissioners are particularly focused on exploring ways in which the Commission can positively influence design education in the UK and extend its support beyond those fortunate enough to win its Industrial Design Studentships.

Awards Granted in 2020

Research Fellows

Dr Claudia Bonfio

Subject: Exchange of chemical messages between primitive cells *University of Cambridge*
Drawing upon the principles of supramolecular chemistry, lipid self-assembly and peptide biochemistry, this project aims to build functionalised primitive cells capable of molecular transport and signalling, ultimately leading to cell-to-cell communication. The research will thus provide a more complete picture of the transition from prebiotic chemistry to early life.

Dr Matthew Gleeson

Subject: Decoding the crystal record of volcanic eruptions *Cardiff University*
It is now becoming clear that magmatic systems beneath volcanoes are vertically extensive and predominantly crystal rich. These crystals preserve an important, but understudied, record of pre-eruptive magma system dynamics. This project will explore this record using state-of-the-art geochemical techniques to identify the primary process of melt transport within crystal-rich magma reservoirs.

Dr Xianxin Guo

Subject: End-to-end optical training of neural networks *University of Oxford*
This project aims to realize the first optically trained neural network with an end-to-end optical backpropagation scheme. Constructed with simple linear optical elements and atomic vapor cells, such an optical neural network can offer significant computation speedup and remarkable power reduction as compared to its electronic counterparts.

Dr Harry Miller

Subject: Geometric approach to optimisation in quantum thermodynamics *University of Manchester*
One crucial obstacle for designing reliable quantum devices stems from the influence of unwanted fluctuations that can damage thermodynamic performance. This project will devise powerful methods for optimising the control of realistic quantum systems using techniques from differential geometry, with an aim to guide the development of improved quantum technologies.

Dr Alex Plajer

Subject: Mechanistic catalyst control in CO₂/epoxide copolymerization *University of Oxford*
This project will explore mechanistically guided ligand design for CO₂/epoxide copolymerization to target the co-catalyst copolymerization and free block-copolymerization and challenging epoxide monomers such as propyleneoxide and limonenoxide.

Dr Adam Smith

Subject: Understanding strongly correlated matter using quantum computers *University of Nottingham*
This project offers new approaches to further our understanding of currently perplexing strongly correlated quantum materials and address fundamental open questions in condensed matter physics. It will develop new quantum algorithms to tackle these questions that are tailored for the new quantum computing technology that has emerged in recent years.

Dr Patrick Stowell

Subject: Cosmic ray neutron detectors for smart agriculture / civil engineering monitors *Durham University*
This project will develop novel, low cost, soil sensors that use background radiation to map soil moisture with enhanced resolution over existing measurement techniques. These sensors will enable new methods to autonomously monitor moisture variation over time to extract valuable information on the hydrological properties of large areas of land.

Dr Hannah Wauchope

Subject: Understanding the biodiversity of the past to predict the future

University of Exeter

As the Earth's climate emergency worsens, understanding how species' distributions will shift is key to effective conservation. Using the past 17,000 years of climate change as a natural experiment, this project will identify what traits helped species track suitable habitat, to help predict the distribution of biodiversity on a future Earth.

Dr Niclas Westerberg

Subject: Reshaping the quantum vacuum for photon sources

University of Glasgow

As photon sources get smaller, their shape and the nature of their surroundings increasingly affect the quantum fields inside them. This project will bridge the theory gap between photon generation and quantum vacuum effects at these scales, which will enable nano-optic devices, and advance fundamental studies of the quantum vacuum.

Brunel Fellow

Dr Edward Hart

Subject: Advancing main bearing science for wind and tidal turbines

University of Strathclyde

Wind turbine main bearings are failing with much greater frequency than expected, with associated costs running into the hundreds of millions. This project looks to significantly reduce these costs and the failure risks associated with main bearings in wind and tidal turbines by establishing a detailed scientific understanding of this component.

Industrial Fellows

Maral Bayarra

Subject: Satellite-enabled early warning system for geotechnical structures

Sponsor: Satellite Applications Catapult

University of Oxford

Interferometric Synthetic-Aperture Radar analysis allow the detection of mm-precision ground motion from space. This enables large-scale monitoring of geotechnical structures such as tailings dams which have an unacceptably high failure rate. This project will develop AI-embedded remote monitoring tools with early warning capabilities.

Sam Bourne

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

Sponsor: LifeArc

University of Kent

This project will address the poor clinical translation of pain therapies, which are urgently required. Genetic variants within ion channels linked to pain will be interrogated and characterised. Novel therapeutic candidates identified at LifeArc will then be screened to improve the translation of first-in-class therapies and stratify patient populations.

Daniella Cheang

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

Sponsor: AstraZeneca

University of Oxford

Hydrogen borrowing provides an elegant alternative to Nature's carbon-carbon bond synthesis. This proposal outlines a strategy for developing a sustainable, biomimetic, enantioconvergent method for converting racemic feedstock alcohols into enantiopure biologically relevant molecules. Producing water as the sole by-product, this method has extensive potential for industrial use.

Sophie Duong

Subject: Metal to ceramic interfacial engineering for armour applications

Sponsor: Dstl

University of Surrey

The international defence scene is ever-changing and threat levels are increasing. Armour development is necessary to protect our Armed Forces to ensure they are best equipped to protect us. This project proposes a novel approach to bonding metals with ceramics to better protect soldiers from new and existing ballistic threats.

Jack Kay

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

Sponsor: Ingenza

University of Plymouth

Antimicrobial resistance is a growing global health threat. Antimicrobial peptides have therapeutic value and Ingenza plan to use their knowledge, experience and relationships with academic leaders to discover novel peptides for tackling emerging superbugs. This project will support the development of new and improved methodologies and tools to this effect.

Joseph Lawton

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

Sponsor: Plasma Quest

University of Surrey

Improving windows' energy efficiency and controlling solar infrared radiation heating is crucial for reducing future global energy consumption for cooling buildings. Vanadium dioxide technology promises smart energy-efficient windows but requires high temperature processes. Utilising a novel, scalable technique, a visibly transparent, infrared radiation-regulating, vanadium dioxide window coating is targeted.

Poppy Oldroyd

Subject: Conducting polymer electrodes for interfacing with the brain

Sponsor: Johnson Matthey

University of Cambridge

Conducting polymer-based electrodes are being used for recording and stimulating the central and peripheral nervous system in order to understand and treat neurological disease. The aim of this project is to understand how the fundamental properties of these electrodes determine recording / stimulation efficiency and device lifetime.

Euan Rodgers

Subject: Development of a permanently installed monitoring system using guided waves for safety critical nuclear components

Sponsor: Rolls-Royce

Imperial College London

The inspection of safety-critical nuclear components is essential but is often difficult and costly. This project will develop a novel permanently installed monitoring system using guided waves, allowing the inspection of large geometries from a single position with increased sensitivity and reduced cost when compared with currently used ultrasonic methods.

Thomas Waddell

Subject: Causal modelling of type 2 diabetes and multi-organ dysfunction through quantitative magnetic resonance imaging: applying Bayesian networks

Sponsor: Perspectum Diagnostics

University of Oxford

Obesity is associated with multi-organ dysfunction and poor health outcomes. This project aims to develop a computational model of obesity utilising Bayesian-network methodology that incorporates quantitative MRI metrics of multiple organs and bioinformatics. This model will allow the prediction of future patient health outcomes and the provision of targeted interventions.

Declan Williams

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

Sponsor: QinetiQ

University of Birmingham

Flow chemistry methods offer adaptable, greener processes with a higher level of control compared to traditional batch reactions. This project will investigate the synthesis of both qualified and unqualified military explosives through the use of microreactors, and how their chemical and physical properties vary when compared to batch processing.

Enterprise Fellows

Lewis Hornby

Company: Jelly Drops

Many people with dementia are no longer aware of thirst, do not equate drinking with quenching thirst and do not recognise cups for what they are. Eating is often easier than drinking, even still, it's difficult to encourage them to eat. One way to overcome this is to offer a treat! This format excites people with dementia, they instantly recognise it and know how to interact with it. Jelly Drops are hydrating treats that enable people with dementia to hydrate more often and independently.

Alex Murdock

Company: Thermulon

Thermulon has designed a novel continuous chemical process to synthesise complex nanoporous insulation materials at scale by combining new techniques coming out of academia with scalable industrial production. The process comes from discussions with over 40 players in the construction space (Mace, ARUP, Kingspan etc.) to define their insulation problem, combined with discussions with over 30 world leading academics in nanoporous materials. In combination with reading over 130 research papers, multiple product iterations were devised to develop a building material that could be processed in a way to directly match the industry defined criteria of energy-efficiency, fire-safety, sustainability and price.

Matt Escott

Company: Protolaunch

Protolaunch reduces the cost of access-to-space for small payloads by enabling a small launch vehicle that can disrupt ridesharing services by facilitating dedicated launch for small payloads. A bottom-up design approach to propulsion enables an engine specifically designed for <100kg payloads from the outset rather than miniaturising technology from larger vehicles. Protolaunch's engine implements a novel thermodynamic cycle utilising phase changes of cryogenic nitrogen within the engine cooling jacket to provide performance and cost advantages. Such a vehicle can deploy satellites exactly where and when required, extending their onboard fuel supplies so customer satellites can generate revenue sooner and for longer.

Bella-Trang Ngo

Company: Brarista

Brarista is a B2B2C software that replicates fully the process of professional bra-fitting. It makes it possible for women to shop and get fitted properly and accurately from home, using any digital camera. Via their favourite retailers, by wearing a tight vest top and taking several photos of their upper body, consumers can use the software to work out exactly what bra size to buy in the right bra styles that work for their breast shapes and fashion needs. To achieve the highest level of accuracy, Brarista's unique computer-vision algorithm is trained on an ever-expanding proprietary data set of real-life women.

Varun Sarwal

Company: Hammer

Hammer is the world's first *adaptive* flight automation software for unmanned aerial vehicles. It is highly versatile in that it supports many different types of flight automation, and yet extremely simple to use. Using artificial intelligence and modular software architecture, the software morphs itself based on the task at hand. This allows operators to use the same software for a number of different flights, eliminating the need to learn new software all the time. Moreover, with features such as Terrain-follow, 3D Views, in-built simulator and multi-mission automation, it can be used to automate flights even in the most complex environments.

Joseph Sherwood

Company: Flit [Financially supported by the ERA Foundation]

Flit's e-bike uses a novel fold with the battery and other electrical components built into the top tube, and the motor built into the rear hub. By using a new design, we are able to select lightweight electrical and mechanical components to minimise the weight of the bike. This allows for a clean looking e-bike that is specifically designed to be easy to carry and, at 14 kg, is 30% lighter than a typical folding e-bike. This is not possible with existing designs which have evolved to work with a specific subset of components.

Design Fellow

Aran Dasan

Subject: "Enki" – Technology for Resilient Biodiverse Oceans

Mentor: Professor Michel Kaiser, Heriot-Watt University

The ocean is under intense environmental and societal pressure from the twin effects of climate change and human fishing activity, forcing humanity to rethink our relationship with marine ecosystems. In the meantime, we struggle to source healthy protein for a growing population (currently, around 20% of the global population relies on ocean protein). The ocean can be a source of this sustainable 'blue' protein, but fishing fleets require smarter tools to fish better.

Enki is a new technology for 'Precision Fishing', a concept analogous to movements in Precision Agriculture and Internet of Things. It is an idea for highly targeted fishing that is based on frequent and spatially dense observation and measurement of the oceans, in response to impending scarcity of marine resources. Enki exploits the ubiquitous nature of global fishing operations: aiming to turn fishing gears into ocean sensors and fishing vessels into scientific platforms, to measure the ocean densely and cheaply on a similarly massive scale, returning benefits to fishermen and their stakeholders in fisheries management, as well as scientific and policy communities.

Enki is a toolkit of devices that attaches to and converts fishing nets into these ocean sensors. By measuring key oceanographic variables (temperature, salinity) at-depth, at the same time as measuring fishing outcomes (fishing type, catch amounts, location, duration), Enki aims to create a rich dataset to support dynamic fisheries management decision-making, on-the-spot fishing sustainable decisions by skippers, and enhanced climate change modelling and weather prediction.

Sir Misha Black Medal for Distinguished Services to Design Education

Professor Birgit Mager

Professor of Service Design

University of Applied Sciences, Cologne, Germany

Since her appointment in 1995, Professor Mager has developed the theory, methodology and practice of Service Design. Her lectures, projects and publications have led to a new understanding of the economical, ecological and social function of design in the provision of public and private services.

Sir Misha Black Awards for Innovation in Design Education

Professor Oliver Broadbent

Founder and Director

Constructivist Ltd

Professor Broadbent has dedicated his career to injecting creativity into university-based engineering design education. In the last decade he has led the way in ensuring that the climate emergency is a central driver in engineering design and in advocating that the creative response of engineers must be central to ensuring positive change in the built environment.

Professor Daniel Charny

Ms Dee Halligan

Founders

FixEd

Professor Charny and Ms Halligan founded FixEd as a ‘think and do tank’ working with schools, colleges and universities to foster design skills for a changing world. Their aim is to put social and environmental matters at the heart of practice across disciplines under the banner of ‘applied creativity’.

Industrial Design Students

Alex Dallman-Porter	Innovation Design Engineering	Royal College of Art and Imperial College London
Daniel Ellis	Industrial Design	Central Saint Martins
Sean Fisher	Contextual Design	Design Academy Eindhoven
David Harris	Global Innovation Design	Royal College of Art and Imperial College London
Ella Hetherington	Bio-integrated Design	University College London
Daniel Karaj	Global Innovation Design	Royal College of Art and Imperial College London
Roumyana Kotopanova	Manufacture and Commercialisation of Stem Cell and Gene Therapies	University College London
Tahira Resalat	Innovation Design Engineering	Royal College of Art and Imperial College London
James Stirrat	Innovation Design Engineering	Royal College of Art and Imperial College London
Joy Zhang	Innovation Design Engineering	Royal College of Art and Imperial College London

Special Awards Granted

STEM education and outreach

Smart STEMs – Digital portal

Ruth Mountford – They Made It podcasts

Fun Kids Radio – How's that Made?

Physics Partners – Physics videos

Primary Engineer – Leaders Award podcasts

In2ScienceUK – Alumni programme

RedR UK – Engineering in emergencies

London Transport Museum – Engineering your neighbourhood

Cranfield University – National flying laboratory centre

Support for legacy estate

Science Museum Group – National Railway Museum's Great Machine

Royal Albert Hall – Public realm project

Exhibition Road Cultural Group – Covid Culture Shock event

Archives and Alumni Relations

University of Oxford – Digitizing Albert Research Fellowship

Royal Collection Trust – Queen's Bindery Apprenticeship Scheme

Awards completed in 2020

Research Fellows

Dr Claire McIlroy

Project: Semi-crystalline materials in additive manufacturing

University of Nottingham

Additive manufacturing is a disruptive polymer processing technology, offering mass customization and personalization that is unavailable via traditional manufacturing techniques. Compared to other methods, filament-extrusion 3D printing is considerably cheaper and has the ability to process durable high-performance thermoplastics for high-end applications. However, weakness along the welds that join the extruded filaments is a crucial factor limiting advanced application. Recently, the use of semi-crystalline polymers in 3D printing has sparked much interest for numerous reasons, including increased mechanical strength and biodegradability, which is particularly important for tissue-engineering applications. During her fellowship, Claire developed the first molecularly aware model of the printing process that couples flow, rheology and crystallization kinetics under typical non-isothermal conditions. Using this model, she was able to gain a fundamental understanding of how semi-crystalline polymers behave during printing, and how different conditions may affect the final properties of a printed part.

By collaborating with experimental teams at the University of Nottingham, NIST, University of Bradford, and the University of Genoa (funded by a Royal Society Exchange Scheme), she was able to validate the model predictions: flow through the nozzle can align the polymer molecules and subsequent rapid solidification can 'freeze-in' this molecular structure leading to the notorious weak spots along the welds. On the other hand, this flow-induced polymer alignment can alter the crystallization kinetics leading to smaller, stronger crystal structures localised to the weld region. Thus, this research fellowship has opened new avenues for controlling printed properties via molecular design.

In September 2020, Claire transitioned to a Lecturer position in the School of Mathematics and Physics at the University of Lincoln, where she will continue her research in polymers used for additive manufacturing applications; in particular with her collaborators at Lincoln she will investigate 3D printed personalised pharmaceutical tablets via multi-scale computational modelling. Claire has recently been appointed as the Secretary for the British Society of Rheology and as an Associate Editor for the *Additive Manufacturing* journal.

Dr Guillaume Nataf

Project: Colossal barocaloric effects in liquid crystals

University of Cambridge

Cooling is essential for perishable food, medicine, buildings and electronics. Current cooling technologies exploit large thermal changes that occur in fluids when driving liquid to gas phase transitions with pressure. However, these vapour-compression technologies are harmful to the environment and display low energy efficiencies. By contrast, cooling based on pressure-driven thermal changes in solids, i.e. barocaloric effects, promise novel environmentally friendly cooling technologies with high energy efficiencies. While several major breakthroughs have been recently reported, solid barocaloric materials are still in their infancy, and they all operate at solid-solid phase transitions.

During his fellowship, Guillaume investigated (baro)caloric effects in liquid crystals. Liquid crystals have properties between those of conventional liquids and those of solid crystals. For instance, a liquid crystal may flow like a liquid, but its molecules may be oriented in a crystal-like way. Guillaume demonstrated that both lyotropic and thermotropic liquid crystals exhibit outstanding barocaloric responses due to their large thermally driven changes in entropy, small thermal hystereses and extremely large shifts of their transition temperatures with pressure.

During the project, Guillaume established strong national and international collaborations (e.g. with the University of Luxembourg, the University of Barcelona and the University of Ljubljana), published six articles in international peer-reviewed journals (e.g. Nature Reviews Physics) and was awarded a Junior Research Fellowship by Wolfson College Cambridge. At the end of the second year of his fellowship, Guillaume was appointed Researcher at the French National Centre for Scientific Research (CNRS). Based in the laboratory GREMAN, in Tours, he is now investigating how ferroic oxides can be used to obtain dynamic heat flow controls in large temperature ranges.

Dr Mark Puttick

Project: Biodiversity and the sixth mass extinction: lessons from the past *University of Bath*

Mass extinctions are large-scale events in which a huge proportion of standing life goes extinct in a short space of time. Probably the most famous mass extinction is the Cretaceous-Palaeogene crisis 66 million years ago that wiped out the non-avian dinosaurs. Mass extinctions are fascinating in their own right: by destroying swathes of diversity (diversity is the number of species that exist at a point in time) these mass extinctions have altered the course of evolution. Large scale loss of lineages allows surviving clades to prosper and radiate.

During his fellowship, Mark addressed major questions related to mass extinctions: (1) how did these mass extinction events alter major patterns of trait evolution? (2) and what methodological approaches are available to study these events? To answer these questions it is vital to turn to the fossil record, as well as develop approaches and models to clarify the impacts of extinctions.

Mark used a simulation approach to understand patterns of evolution of continuous measures of biology, such as body size, through mass extinction events. He found that in response to mass extinctions changes in body size are inherently variable even under simple patterns of change and understanding the ‘selectivity’ of these events is difficult with current statistical approaches. Furthermore, even extinction events in deep time can leave ‘traces’ of the mass extinction in the distribution of body traits in living species.

Mark also wrote new approaches for studying mass extinctions in the R package *motmot* that contains extensive code to examine trait evolution and mass extinction selectivity. Using this code (<https://cran.r-project.org/web/packages/motmot/index.html>), he found that the mass extinction 66 million years ago was followed by 10 million years of rapid evolution in body size of mammals as they exploited available ecological space vacated by the extinction of dinosaurs.

In addition to these main studies, Mark has written code and published a paper for preparing and analysing molecular clock studies to date events in the history of life, including mass extinctions. He also published a Masters project for which he was the main supervisor on the selectivity of extinction during a major extinction, the Triassic-Jurassic extinction around 200 million years ago. He has also contributed novel R code incorporated on the CRAN database in the package *disparity* (<https://cran.r-project.org/web/packages/disparity/index.html>).

Following the fellowship, Mark is now a Senior Analyst at the Office for Students.

Dr Andy Kah Ping Tay

Project: Magneto-mechanical biomedicine for pain modulation and immune engineering *Imperial College London*

Andy’s research focuses on delivery of DNA into immune ‘soldier’ cells to engineer them into ‘super-soldiers’ to eliminate cancer. As a result of the pandemic, Andy has decided to cut short his fellowship after only a year and relocate to be closer to his family, accepting a position as Assistant Professor at the National University of Singapore.

Despite his limited tenure, Andy’s research made significant progress and he hopes to file a patent in the next year. Andy has also received a number of prestigious awards including: BrightSpark Top 30 Young Engineers in the UK; Imperial College London President’s Award for Research Excellence: Outstanding Early Career Researcher (one of only four); World Economic Forum Young Scientist (one of only 25 selected globally in 2020); Alessandro Chiabrera Award for Excellence in Bioelectromagnetics.

Andy writes: “I am extremely grateful to the Commission for nurturing me and providing me with financial and administrative support. It was only through the support of the Commission that I was able to accomplish so much during this short period. As a beneficiary of the Commission, I hope to represent the organisation as an alumnus, sharing my fellowship experiences and enhancing research ties between Singapore and the UK.”

Dr Matthew Wallace

Project: Elucidation of carbohydrate dissolution and gelation using NMR imaging techniques

University of East Anglia

The ability to measure the properties of molecules quickly and accurately is fundamental to modern science. Whether it is a new drug, a material or a cosmetic ingredient it will have faced a battery of analytical tests throughout its development. Nuclear magnetic resonance (NMR) can provide the 3D structures of molecules with unparalleled efficiency and is one of the most important analytical techniques in the chemical and biological sciences. However, two serious drawbacks of conventional NMR are the slow speed of analysis and the high cost of the equipment. An NMR spectrometer, which costs more than £500k, is only able to process one sample at a time with analysis taking anything from a few minutes to several hours. In this project, Matthew has developed a fundamentally new approach to NMR that enables multiple analyses to be condensed into just a single NMR experiment, thereby providing substantial savings in time, labour and cost. Using controlled chemical concentration gradients, Matthew's methods enable molecular systems to be analysed under a range of conditions without the requirement to prepare and analyse a large number of separate samples. For example, the pH-dependent properties of a drug molecule can now be measured in 20 minutes rather than the several hours of tedious sample preparation and analysis required by the conventional procedure. Matthew's methods also provide greater insight into the processing of next-generation sustainable ingredients for personal care and medical products. Matthew has published eight papers during the fellowship, three as first author, and has recently been awarded a UKRI Future Leaders Fellowship to continue his research in NMR method development at the University of East Anglia.

Industrial Fellows

Andrew Anderson

Project: Manufacturing enhanced heat transfer surfaces on commercial heat exchangers

Sponsor: Oxford nanoSystems

University College London

Over the course of the fellowship Andrew developed a novel coating process which allows for the rapid, large-scale micromachining of non-flat surfaces over the range of 50-500µm+ which can be integrated into the current product offering at Oxford nanoSystems and increases the range of applications for the technology. Andrew also designed, built and heavily modified a heat transfer test rig which is capable of performing experiments with every refrigerant available on the market including CO₂, propane and ammonia, over a wide heat flux range, something which hadn't been previously achieved in any company or academic institution. This will allow the technology to be tested in the widest range of possible applications even on refrigerants which aren't on the market yet to keep the company at the forefront of technology and allowing the company to create quick proof of concepts in each area which would normally require a new rig for each application. This allows the company to significantly reduce development and process optimisation timescales. Now that the fellowship has ended, Andrew is continuing work at Oxford nanoSystems on the new coating process as well as building a database of the different factors which affect heat transfer and a model which will accelerate the company's development time further.

Timur Avkiran

Project: Discovery of novel small molecule drugs for the treatment of tuberculosis

Sponsor: LifeArc

University of Warwick

Timur's project targeted antibiotic resistance in the hope of developing novel cures for some of the world's toughest diseases. During his fellowship, he was able to progress a number of drug targets from early stage screening hits to the point of in vivo testing. All of the compounds he produced were tested in a biochemical assay to test for potency against the isolated target protein. Compounds of interest were then selected for more thorough ADME (absorption, distribution, metabolism and excretion) testing, to test the compounds solubility, stability and permeability. Compounds with a promising profile were subsequently tested for antimicrobial activity against Mycobacterium Tuberculosis and Mycobacterium Bovis and showed evidence of antimicrobial activity. It is hoped that these compounds may yet lead to novel therapeutics for targeting TB. Timur's work was greatly assisted by the travel budget associated with the fellowship which allowed him to attend relevant international conferences and have meetings with leading academics in the TB field. The feedback and ideas gained from these opportunities were then used to help guide his research further. Timur is continuing his research at LifeArc and is delighted that a fellow LifeArc employee has been appointed an Industrial Fellow this year.

David Dearlove

Project: The regulatory and downstream effects of supplemental ketosis

Sponsor: TdeltaS Ltd

University of Oxford

Ketones are molecules produced by our body during starvation that have profound effects on metabolism (that is, the way our body uses and stores energy). TdeltaS Ltd. Has developed a ketone-containing drink, which may be used to enhance human physical performance and potentially as an adjunctive treatment for some diseases. Across three studies recruiting 39 healthy participants, David's work has provided novel insights into the effects of this drink on human physiology, metabolism and physical capacity. This includes understanding: the optimal dosing of the ketone drink; determining ketone oxidation rates (that is, how much of the ketone ingested is "burnt" to create energy) and how this is affected by energy demand (that is, the rate at which the body must "burn" fuels to create energy); which individuals may benefit most from consuming the drink (based on the molecular characteristics of their skeletal muscle fibres); and determining the effects of repeated dosing (three times daily for 10 days) of the drink on carbohydrate and fat metabolism. As the company expands its global operations (<https://www.tdeltas.global>) this basic science is essential to determine how to most effectively utilise the ketone drink to enhance human performance and health. To date, David's work has led to 4 publications in peer-reviewed journals with more expected and, of course, a doctoral degree. David will continue this work as a post-doctoral researcher at the University of Oxford with TdeltaS Ltd., building upon the learning and experience he gained during his DPhil.

Carlos Julià

Project: Development of an automated bioreactor for suspension and adherent cell expansion for cell therapy manufacture

Sponsor: Aglaris Ltd

University College London

This project focused on developing a better bioreactor for cell therapy manufacture. Significant progress was made, particularly in respect of the process control system.

Carlos is now a Process Development Scientist at GammaDelta Therapeutics.

Aleksandr Kovaltsuk

Project: Using antibody next generation sequencing data to aid antibody engineering

Sponsor: UCB Pharma

University of Oxford

Aleksandr's project was conducted in collaboration with UCB Pharma, a biopharmaceutical company based in Slough. During his fellowship, Aleksandr studied the human adaptive immune system and how it can be leveraged in therapeutic antibody engineering. More specifically, he interrogated snapshots of natural human antibody repertoire diversities generated by next-generation sequencing (NGS) technologies. He developed multiple open-source software packages to enable scientists to interrogate the entirety of antibody repertoires using structural information for the first time. These tools were published in peer-review journals. UCB Pharma actively uses these software packages in their antibody discovery pipelines.

A significant number of studies have made their antibody repertoire data publicly available. However, these outputs are fragmented across repositories and tend to be presented as raw nucleotide reads, which means non-trivial effort is required to reuse the data for analysis. To address this issue, Aleksandr developed the first database that curates more than 1.9 billion sequences from 85 studies. This knowledge is of high significance in guiding therapeutic antibody development by referencing to the sequence space accessible to naturally observed human antibodies. This database was also made open-access and published in a peer-review journal.

Lastly, Aleksandr helped the scientific community in the global COVID-19 research effort. He co-authored the development of the first database that collates all known antibody binders against SARS-CoV-2. Each of these binders holds a valuable piece of molecular descriptor information about SARS-CoV-2 complementarity. One of the immediate applications of this database is the assessment of the adaptive immune response elicited by COVID-19 vaccine candidates and natural infections. A unified enrichment of the known neutralising sequences in antibody repertoires across all post-vaccinated human donors would be indicative of an effective and protective immune response.

Following his fellowship, Aleksandr will be joining a London based biotech company, LabGenius, as a Data Scientist.

Iestyn Stead

Project: Reduction of parasitic losses in zero emissions liquid air engines

Sponsor: Dearman

University of Birmingham

Iestyn's research focussed on reducing losses found in a zero-emission cryogenic engine – the Dearman Engine – operating in conditions that allow for the introduction of innovative technologies: the introduction of polymers, biomimetic lubricants and improved analysis methods.

The first area analysed identified the potential for frictional reduction that replacing metal engine components with polymers can provide: increasing the efficiency of the engine, reducing the mass and the cost of manufacture. The second investigation developed novel lubricants based on natural sources. These lubricants have the potential to drastically change the nature of the Dearman Engine, reducing the need for auxiliary components and the number of fluids within the engine. The key to the efficiency of the engine and what separates it from other cryogenic engines is the presence of a heat exchange fluid (HEF); the fluids that were developed will lubricate and have the potential to also operate as a HEF.

The final area of research was based on how the collection and analysis of frictional data are done. Polymers and biological compounds have mechanical properties that are dependent on the frequency and time of loading; Iestyn's work exposed the impact of this on the friction and wear properties and the benefit of using high sample rate monitoring in the determination of these.

Following the completion of his fellowship, Iestyn will be remaining at the University of Birmingham as a Research Fellow researching other environmentally focussed technologies.

Chris Towell

Project: Smart mixing – artificial intelligence in live music mixing systems

Sponsor: Allen & Heath Ltd

University of Plymouth

Allen & Heath is seeking to develop intelligent automatic mixing systems both to aid experienced audio engineers and to enable inexperienced users to improve audio quality in live events.

As a tool for automatic music mixing, Chris has developed a neural network based musical instrument recognition model that is on a par with the state of the art in academia and industry. This has saved the company a considerable sum of money as the company was previously in talks to purchase such a model for circa \$150,000. This model is due to be incorporated into an upcoming product which is expected to be the first in a line of intelligent mixing consoles.

Chris has also developed a novel technique for automatic mixing using information theory that together with techniques developed to overcome the lack of training data will form the basis for the company's future work on automatic mixing, enabling the company to maintain a competitive edge over its international competitors.

Following the completion of his fellowship, Chris will remain at Allen & Heath, working to continue integrating machine learning models into their products and engaging in further collaborations with the University of Plymouth. Having been awarded the fellowship through an unusual route, Chris has only partially completed his PhD and hopes to resume studies in August 2021.

Ed Williamson

Project: New ceramic coatings for small modular reactors

Sponsor: Rolls-Royce plc

University of Surrey

Ed's Fellowship focused on the development of new coating materials for components in small modular reactors (SMRs), a type of factory-built fission reactor, currently revolutionising the nuclear industry. Components in nuclear environments have to withstand high levels of irradiation, wear and corrosion so coatings are vital for component longevity.

Current components in reactors are typically coated in hard chrome plating using electrodeposition, but this process creates carcinogens. Around the world, governments are creating regulations to curb the levels of chemical pollution from industrial processes. The new coatings developed have provided alternatives with reduced environmental impact.

From the coatings identified and tested, the Cr_2O_3 thermal spray coating had the best overall performance in irradiation and wear testing but there were concerns over its corrosion performance. The Cr_3C_2 -NiCr coating was shown to offer comparable irradiation and corrosion performance to Hexagonal Close Packed structure (HCP) and could be considered for use in applications where wear performance is not as critical. The study also highlighted key factors for future testing in this field, such as the importance of using borated water in wear testing and the benefit of X-ray photon electron spectroscopy in providing additional wear performance information.

Ed's Industrial Fellowship funding allowed additional coatings to be tested, which was highly beneficial. Dissemination to the wider nuclear industry and ceramics sector was achieved at international conferences in Japan, Singapore and the USA. A scientific journal paper was also published in the *Wear* journal.

Ed is now employed by MBDA as a Senior Materials Engineer.

Enterprise Fellows

Surakat Kudehinbu

Technology: Microfluidic lab-on-a-chip

RAB-Microfluidics

RAB-Microfluidics have developed cutting-edge microfluidic technology to provide automated real-time continuous testing and analysis of lubricating oil in valuable machinery. This technology has the advantage of combining the depth and robustness of conventional laboratory analysis with onsite delivery. It improves efficiency, reduces operating expenditure and increases the uptime of heavy rotating machinery. This technological innovation enables RAB-Microfluidics to solve the hard-to-reach and hard-to-sense challenges of many businesses across various industries such as processing and manufacturing, power generation, offshore wind, transport and the maritime industry.

Surakat comments that the Enterprise Fellowship has been of immense value both to him personally and RAB-Microfluidics. The Fellowship granted the company access to fellows and mentors with tremendous business experience and insightful industrial knowledge that has helped bring the company closer to commercialisation. During Surakat's Fellowship, RAB-Microfluidics began generating revenue from paid pilot trials of their technology in the maritime and energy sectors, expanded their team and closed a £1.24 million investment round.

As RAB-Microfluidics enters into its next phase of growth, the company plans to further strengthen their team and develop their product roadmap, with the aim of a full product launch in the maritime sector in the first quarter of 2022.

Ben Lakey

Technology: Affordable prostheses

mitt Wearables

Since Ben was awarded the Fellowship, Mitt Wearables has raised angel investment, hired its first five employees, received CE Marking approval and launched its first product. Mitt won an Innovate UK Global Challenges Research Fund Grant in 2019 and was awarded 'Disruptor of the Year' at the 2020 London Business Awards.

In the last few months, Ben has started a new digital health company, Syndi Health, within the London 15 cohort of Entrepreneur First, with the aim of supporting the surge of people in need of urgent mental health support. Syndi's first two digital products are medically approved and ready to support patients through continuous and passive monitoring using the most valuable and accessible window into their behaviour and health – their smartphones.

Syndi has secured initial pre-seed investment from Entrepreneur First and will start pilot trials with several NHS Mental Health Trusts and University Student Wellness Support Teams around the UK during 2021.

Rowan Minkley

Technology: Sustainable bioplastics

Chip[s] Board

Chip[s] Board is developing an eco-friendly wood substitute manufactured from industrial potato waste. Unlike MDF, Chip[s] Board is biodegradable post-use, its production is carbon negative and contains no added formaldehyde or other toxic resins or chemicals. The company has secured a steady supply of raw materials through a partnership with McCain's Foods Ltd. During the Fellowship, Chip[s] Board relocated to a warehouse in Leyton and established a 100-litre production line. The company received a Business of Fashion, Textiles and Technology SME grant and a Knowledge Transfer Network Spark Award.

Rowan says: "The Enterprise Fellowship was a huge turning point in our development. Having bootstrapped the company for the first year while working part-time to keep food on the table, we suddenly had access to some capital to keep the company running and access to high-quality mentorship to accelerate our progress.

Over the past few years, we have grown from a humble team of three to a dynamic team of seven, with industry specialists in each research and development department – and we will shortly be expanding to a team of twelve.

The support programme helped push me with pitch practice and public speaking (something I have never been too fond of), allowing me to articulate our vision and entice investors. Paired with a deep dive into operations and accounting, the programme has shaped my understanding of raising investment and managing a small company.

Since participating, we have secured over one million pounds in equity investment and over three hundred thousand pounds in grants. The most recent investment was secured to relocate from London to Leeds and begin commercialising our technology in a pilot plant."

Lewis Hornby

Technology: Hydrating sweets

Jelly Drops

Jelly Drops make hydrating sweets for people with dementia. Since being accepted onto the Enterprise Fellowship Jelly Drops has made fantastic progress despite an otherwise challenging year. The company has grown from four to 14 staff, built a production facility, successfully launched its product and has now supplied over 1.5 million Jelly Drops. During the last 12 months Lewis and the team have secured a further two rounds of investment putting them in a strong position to expand staff numbers and production capacity and start shipping to the US.

Since launch the product has received a great response and Lewis comments that it's been incredible to hear the stories shared by people in their community about how Jelly Drops are improving lives. The team have used this feedback to develop the product further – launching a new and improved version in March 2021.

Given the pressure the care sector has been under to protect their residents during the pandemic, roll-out in care homes has understandably been delayed. But in the limited trials the team have conducted they have received great feedback and insights and are now in a great position to launch across the sector with their updated product. This was recognised at the National Dementia Care Awards where Jelly Drops were awarded the Innovation Prize.

Lewis says: "The support offered through the Enterprise Fellowship has been invaluable in helping us successfully scale, for this we are very grateful to the Royal Commission for the Exhibition of 1851 and the Royal Academy of Engineering. This support has given us a great foundation going into 2021 and beyond. We look forward to our continued expansion and getting Jelly Drops in the hands of people that need them the most!"

Built Environment Fellows

**Ms Ellen Hadden, Ms Astrid Bois d'Enghien, Ms Roberta Marcaccio
and Mr Tom Greenall, DSDHA**

Subject: Cycling and the Built Environment – Sharing the Beautiful Everyday Journey

Mentor: Mr Alan Baxter, Alan Baxter Ltd

The focus of this project was 'Can cycling infrastructure help improve London's public realm?' This question immediately raised further questions; what is London's cycling network and why is it different from other cities? And what do we mean by an improved public realm for London?

The team's research into the nature of London's cycling network supported the notion that the scale and morphology of London means that it is often impossible to replicate the ordered infrastructure of European cities such as Copenhagen and Amsterdam. Cycle journeys in London are on the whole much longer and often pass through a much more varied range of street typologies – many of which are narrow and non-orthogonal. The lack of space available on the street network, particularity in central London, means that cyclists, and their infrastructures, are often excluded from the key nodes and landmarks which might help them navigate through this megacity.

The question of what an improved public realm for London means has been difficult to define; architects and urban designers are overwhelmed with a plethora of guidance, design checklists, movement simulation software and technical information that helps shape the design of cities. But this guidance often ignores the aesthetic, temporal and psychological aspects of movement which is integral to the diverse experience, good or bad, of individuals on our streets.

The recent political rhetoric is positive; we want to create healthy, inclusive streets which encourage more walking, cycling and use of low-carbon public transport. But how do we achieve this in ever-changing, crowded, central London where demands on space are such that some form of sharing is required but where conflicts over behaviour and users' priority are most likely to arise?

The debate over cycling and the public realm, falls too easily into the polarised camps of segregated or shared, but the team see the role of the urban designer as one that can challenge this oversimplification. Our urban environment is impacted by multiple mutable factors including policy, weather conditions, diverse behaviour and activity. Our city requires designs that accommodate this movement and change. Yet we lack a consistent method to visually represent and test the range of factors affecting a space when designing for movement. The team's research seeks to provide this method.

The team sought to develop a visual or drawn methodology for designing cycling (or other movement) infrastructures that could help improve the experience of London's public realm for all users. They have developed a nine-criteria design toolkit, which can be used in tandem with existing guidance such as TfL's Healthy Streets Indicators, that provides a methodology for exploring the spatial, temporal and psychological aspects of movement.

The team have tested the design methodology on a series of case studies of different scales and types in London to demonstrate how it might be used; this included testing proposals as an alternative vision for the reconfiguration of Oxford Street. It is the team's hope that designs produced using this methodology will help to make London's streets healthier, more enjoyable and beautiful places in which to be.

Professor Irena Bauman

Subject: Manufacturing an Inhabitable City – Built InCommon

Mentor: Professor Flora Samuels, University of Reading

Irena's fellowship conceptualised and developed a replicable prototype for new neighbourhood-based facilities, an enabling infrastructure to support localised manufacture of residential and commercial buildings. A network of such local workshops would generate a Built InCommon ecology of supply chains, skills training, and users.

Irena conducted a review of the industry, including the policy environment, the range of available Modern Methods of Construction (MMC), the range and types of factories, and the range of the emerging distributed construction systems. This helped her understand the supply side. She also undertook a similar review of the demand side by researching the sector of housing providers that could be interested in the social, economic, and environmental value offered by Built InCommon.

This early research revealed a number of distributed systems that could be fabricated locally by communities themselves, and a number of organizations interested in exploring the potential of setting up a Built InCommon facility.

The regulatory and financial environment were also reviewed. To fully understand the impact of regulations on the distributed systems, she initiated the Build Offsite Property Assurance Scheme process of accreditation for MassBespoke – one of the new construction systems – which provided first-hand experience for the study.

The next focus was the business models for the distributed fabrication of buildings. Irena designed and costed a flying factory, working with two community development trusts in different locations to develop integrated local supply chains with existing workshops and other local stakeholders, including funders and public bodies.

The main outputs of the fellowship have been The Built InCommon Beginners Guide, which includes six case studies of community-led, locally fabricated homes and a five-minute video explaining all the key findings and including testimonies from the community organizations that are pioneering the concept and developing the infrastructure and ecology of Built InCommon. Three Built InCommon build projects have been completed and three other, larger affordable housing projects (50 dwellings in total) are awaiting planning approval. The ecology of Built InCommon is taking roots and growing.

Design Fellow

Ms Jennifer George

Subject: Design and ‘Fake News’ – The Shelter Schema: Designing for Displacement

Mentor: Dr John Orr, University of Cambridge

In response to a call to disrupt ‘fake news’ and false information, Jennifer proposed a system for aggregating existing information in the shelter and settlements sector of humanitarian aid into a digitally accessible format for shelter practitioners on the ground, enabling practitioners to make better informed decisions in humanitarian shelter projects.

Following the completion of a prototype of the system in year one, and a successful collaboration with the International Organisation for Migration in year two, the software is now in place. It allows practitioners to access information, education, and communication (IEC) materials related to shelter. In addition to this, IOM have conducted a rigorous review of the IEC materials in the system, utilising their extensive networks of shelter practitioners. This means that field practitioners can also view the review comments on the documents made by technical experts, making informed choices on best practice. As a result of this collaboration, IOM have issued a thank you to the project, stating that ‘by having the IEC material openly accessible through the software platform, this project will facilitate the rapid development of common messaging in emergency responses’.

Jennifer’s fellowship has also enabled wider thought in the shelter sector, including the publication of a new definition of sheltering, opinion pieces in ‘Shelter Projects’ and Forced Migration Review, book chapters in InterAction’s Roadmap for Research and a Routledge Handbook, and papers in academic journals. The new definition of sheltering in particular could have significant impact on future policy and projects. It has also enabled talks at the Centre for Geopolitics, Cambridge Festival of Ideas, and across academic departments.

Most recently, Jennifer was invited to join the 2021 UN Youth Forum Roundtable on ‘Leveraging Technology to Enable Migrants’ and the 2021 UN Global Forum on Migration and Development to provide insight on the development of this software, and the usefulness of digitally-accessible reviewed information, as best practice for the humanitarian sector going forward. This could have real and valuable impact on the creation of future digital systems by governments, policy makers and humanitarian leaders.

Jennifer has recently been awarded the Royal Charter International Research Award for Young Constructors from BRE and the Worshipful Company of Constructors to continue the research started during her fellowship.

Industrial Design Students

Harry Barber

Course: Innovation Design Engineering

Royal College of Art

Harry's second year projects focused on providing sustainable solutions to contexts where people currently rely on fossil fuel powered machines.

Harry's group project, *Saiga*, was a wearable that changes its user's perception of temperature by cooling specific locations on their neck and giving them the option to breathe cold air when necessary. It was proposed as a way of reducing dependence on air conditioners which are used worldwide despite being highly polluting, inefficient and energy demanding machines. The *Saiga* wearable came out of an extensive experimental design process where Harry and his group discovered methods which allow us to alter our perception of temperature rather than changing the temperature of the environment around us.

Harry's solo project, *Sycamore*, was a portable wind power harvester designed as a sustainable alternative to diesel generators. It produces power using an inflatable kite that flies crosswind through the sky tethered 100m above a base on the ground. The whole system can be packed down into a small box for transportation and it is able to generate substantial amounts of power autonomously and entirely renewably.

Due to its unique portability, *Sycamore* is the first renewable energy technology that has the potential to bring power to contexts without a power grid or where the power grid is broken, where people currently depend on diesel generators for power. This project was awarded first prize in the KI Award in 2020.

Since graduating, Harry has been working as a Future Product Researcher at Brompton Bicycle in London. His role involves researching what cities of the future will look like, and designing, prototyping and testing ways that we could be moving through them.

Nadia Bassiri

Course: Innovation Design Engineering

Royal College of Art

During her studentship Nadia focused on projects exploring the intersection between technology and the future of healthcare.

For her group project she explored ways to reduce rising chronic illnesses caused by a lack of physical activity. Her group created *ALLYN*, a device that attaches to widely available home exercise bikes, transforming them into immersive exercise machines. *ALLYN* controls the resistance of the exercise bike and facilitates a convenient virtual workout between two or more people in different locations, simulating a tandem bike ride. This novel tandem bike exercise makes connected users indispensable to one another and is built upon the scientifically proven motivational mechanism known as the Köhler Effect, where a sense of indispensability is known to increase effort and adherence during group exercises. *ALLYN* was exhibited at two graduate shows, where an interactive set allowed people to successfully try the tandem bike experience.

For her solo project, Nadia created *TRACE*, a behaviour tracking wearable and app for people with Obsessive Compulsive Disorder (OCD) and collaborated with mental health professionals and people with lived experience of OCD. OCD is an anxiety disorder where obsessive thoughts trap people in a cycle of compulsive behaviours. Compulsions can often manifest as ritualistic interactions with objects and *TRACE* is designed to track these rituals, providing powerful novel behavioural data that can be used by therapists and users to monitor and better understand symptoms, with the aim of improving and recommending treatment via the app.

After graduating, Nadia started a new role as Lead Design Engineer at AMPHIBIO, an InnovationRCA start-up developing bio-inspired materials technology with applications in deep sea diving and sustainable textiles for sportswear.

Jeffrey Chow

Course: Innovation Design Engineering

Royal College of Art

Jeffrey's final year project tackled the global issue of food waste. His approach focused on changing consumer behaviours, households being the largest contributor to food waste in the UK and other countries. Working in collaboration with PhD students from Imperial College Bioengineering, he developed *HoneyBox*, a technology-based behavioural intervention that completely automates food management for consumers. It consists of a smart food container that uses a low-cost, paper-based gas sensor to measure spoilage gases and detect food degradation. *HoneyBox* adds value to fresh ingredients by informing consumers about food quality and extending foods' shelf-life. The product is used with an app that provides detailed information on any food, an overview of the food stored in the fridge, automated reminders before foods expire, and suggested recipes that pair with stored foods. *HoneyBox* provides consumers with never-before-seen real-time information about their food to help them manage their fridge, reduce food waste and guarantee food safety. The project is also built on evidence from scientific literature that successful food waste preventative solutions align consumers' personal goals, such as saving time/money and eating good food, with food waste reduction goals which primarily involve planning or managing food better.

Jeffrey has now joined the PhD team BlakBear to continue developing *HoneyBox*. They have recently secured a government grant from Waste Resources and Action Planning for a one-year consumer trial of *HoneyBox*. Jeffrey is also developing prototypes to pilot BlakBear's technology with food processors and retailers in the hope of tackling food waste across the entire food chain.

Aimee-Elisabeth Kyffin

Course: Innovation Design Engineering

Royal College of Art

With a background in Product Design, Aimee joined the IDE course at the Royal College of Art and Imperial College London to further her education and give her time to discover how to bring together multidisciplinary teams to create positive impact on the world around them, by and through Design, Engineering, Social Sciences and the Commercial disciplines.

For her final group project, Aimee and her course mates Claudia Maw, Daan Leenarts and Melinda Kuei, spent 3 months designing and testing *Heart Restart*. *Heart Restart* is a unique and innovative defibrillator because of its small size, the fact that it is owned by the at-risk patient and that it empowers their friends and family to save their life in case of an emergency. *Heart Restart* gives a second chance at life from a pocket. Aimee and her team are currently working with medical and technical experts to continue the development of *Heart Restart*.

For her final solo project, Aimee worked in partnership with Shafina Vohra, a PhD student at Imperial College, to develop *Clickit*. *Clickit* provides multi-sensory language development opportunities for children, through the use of colour and shape when learning to read and write. Everyone deserves an equal chance at an education, especially those who are dyslexic. *Clickit* is a way of giving these children an education and a future. Extensive testing with students of all ages and abilities has shown the value of teaching all children to learn in this new way. Aimee and Shafina are continuing to work together to further develop *Clickit* with the hope of bringing it to market.

Currently Aimee is working as an Experience Designer for Chemistry Team, a Strategic Design Consultancy with an emphasis on healthcare and public sector projects around the world.

Tom Pais

Course: Innovation Design Engineering

Royal College of Art

Throughout his Master's degree, Tom explored how cyber-physical systems and digital innovations could make an immediate impact on our health, environment, and wellbeing.

For his final project Tom developed *GEIA*, an artificial intelligence platform that makes indoor health measurable and manageable through 30+ real-time proxy variables, giving building managers the data they need to continuously make their building a healthier place. With over 90% of all infections – including COVID-19 – taking place inside buildings, it is clear that pathogens are currently thriving in absence of smart, targeted cleaning and indoor health management. *GEIA* was exhibited at Dutch Design Week 2020 and has garnered interest from the world's largest real estate and building management corporations.

Upon graduating, Tom combined nurturing *GEIA* into trial phase with working as an investment analyst for a sustainable venture capital fund. Currently, Tom is building Gorillas – the fastest growing start-up in Europe – from the ground up in the Netherlands. He aims to unite the operational experience of building a business from 5 to 300 employees with the creative, technical, and human-centred lessons learned during his course in Innovation Design Engineering, in order to continue building impactful ventures.

Ravi Woods

Innovation Design Engineering

Royal College of Art

For his final project, Ravi developed *Eccla*; a modular system of furniture for churches. Currently, most churches have pews; heavy benches that discourage flexible use of the church space. However, in the 21st century, numbers are declining, with church membership having decreased by 8% since 2012. In response, churches are having to use their space more flexibly, with furniture playing a key role. However current solutions, such as stackable chairs, look messy and untraditional within the church space.

Eccla is a furniture system that aims to strike a balance: giving churches the flexibility to use their space in a range of ways, while still keeping a traditional design aesthetic. This is achieved through wood and metal finishing, and iconography inlaid within the piece.

Each *Eccla* bench is made of two pieces – a base and a back – which simply clamp together. This allows for four main setups: as a straight row for traditional services, as curved rows for concerts or lectures, as tables & chairs for Bible studies & dinner events and stacked away for full use of the space.

Thus, *Eccla* can be used for a range of events, while also giving churches the opportunity to rent out their spaces.

During his studentship, Ravi enjoyed working on the design and engineering of the built space and now works at the engineering firm Max Fordham LLP, where he has specialised in the lighting design and energy usage of large-scale cultural buildings.

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 Richard Sibson (1969-1972)

- Awarded R.A.F. Penrose Gold Medal, Society of Economic Geologists

Professor Surya Thakur (1970-1973)

- Published second edition of *Laser Induced Breakdown Spectroscopy*

Research Fellows

Dr Jo Ashbourn (2002-2004)

- Organised conferences on *The Rise of Big Science in Physics*, *The Greatest Physics Discoveries of the 20th Century* and *Physics of the Impossible Revisited* at the St Cross Centre for the History and Philosophy of Physics

Professor Michael Cant (2000-2002)

- Appointed a Fellow at the Institute for Advanced Study, Berlin

Professor Apala Majumdar (2006-2008)

- Awarded British Liquid Crystal Society's Cyril Hilsum Medal
- Awarded Suffrage Science Award in Mathematics

Professor Rachel Oliver (2003-2005)

- Named one of the Top 50 Women in Engineering by the Women's Engineering Society

Professor Hugh Osborn (1966-1968)

- Elected a Fellow of the Royal Society

Dr Richard Preece (1977-1979)

- Awarded Quaternary Research Association's James Croll Medal

Dr Nicole Reindl (2017 – 2019)

- “An in-depth reanalysis of the alleged type Ia supernova progenitor Henize 2–428” published as a highlight article in *Astronomy & Astrophysics*

Professor Edward Tate (1999-2001)

- Awarded Corday-Morgan Prize, Royal Society of Chemistry
- Cofounded Myricx Pharma

Industrial Fellows

Dr James Palles-Dimmock (2013-2016)

- Completed £8m investment round with Quantum Motion Technologies Ltd

Industrial Design Students

Mr Steven Williams (2008-2010)

- Launched ICODice (<https://icodice.co.uk>), a unique learning aid for students and professionals alike, bringing the mundane formula sheet into three dimensions

Enterprise Fellows

Guillem Singla Buxarrais (2017)

- *NeuroBall*, a novel medical device for post-stroke rehabilitation:
 - Secured investment from the o2h Therapeutics and AI Fund
 - Secured support from MedCity and Stroke Association through Collaborate to Innovate
 - Started pilots with leading rehab facilities in the US, following FDA registration

Victoria Hamilton (2017)

- *Recoil Kneepads* picked by ‘Business Insider’ as the best such products available for extended use.

Ming Kong (2016)

- Launched a successful Kickstarter campaign to bring his company TGO’s *etee* button-free VR controller to market
- TGO shortlisted for an E&T Magazine award in Outstanding Innovation in Manufacturing 4.0

Ms Hsin-Hua (Sheana) Yu (2018)

- Commercial launch of *Aergo*, the world’s first automated postural management seating system

Rome Scholars

Mr Hugh Petter (1990)

- Awards from SW RIBA, Civic Trust and National Housing Awards for mixed use urban extension to Newquay at Nansledan

Ms Carole Robb (1979)

- Solo exhibition, Tibaldi Gallery, Rome

Report by the Chairman of the Finance Committee

Executive summary

The net assets of the Commission at 31 December 2020 stood at £138m compared with £128m at 31 December 2019. The total expenditure on charitable activities during 2020 was £5.2m, compared to £4.3m the previous year. For the last nine years a strategic asset allocation biased heavily in favour of real assets has been consistently pursued by the asset managers appointed and regularly reviewed by the Commission. Notwithstanding recent volatility, this policy has aligned itself with the value expansion in equity markets with the result that the nominal value of the Commission's portfolio has grown at an average annual rate of approximately 8.2% after all fees and disbursements.

Organisation

The Board of Management has appointed the Finance Committee as a sub-committee to supervise the Commission's finances and investments; this Committee meets at least twice a year. During 2020 there were two formal meetings and an additional nine teleconferences with the Commission's investment managers to monitor the performance of the portfolio in light of the global pandemic and to take appropriate action. I would like to thank all members of the Committee for their sterling work in overseeing the Commission's finances.

Sources of Funding

The Commission's income and gains derive primarily from its investment portfolio. In 2020, property (the Commission's estate) made up 16%, stock market investments and bonds 83% and cash 1% of the capital assets (for 2019 the corresponding figures were 16%, 83% and 1% respectively).

Reserves Policy

The total funds at the balance sheet date were £138,125,545 (2019: £128,403,095).

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

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

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

Investment Policy

The Commissioners believe that they can best 'make a difference' by maximising the financial return from the investment portfolio and using that return to fund fellowships, studentships and other charitable grants. The Commissioners' investment objective is therefore to achieve sufficient total returns to fund the existing award programmes whilst also protecting the capital value of the portfolio for future beneficiaries. Superior performance will be used to sustainably expand the programme of activities. The Commission reviews its asset allocation and manager selection on a regular basis with these objectives in mind.

Commissioners have determined that a strategic asset allocation biased heavily in favour of ‘real’ assets (equities, properties, commodities, etc.) as opposed to ‘nominal’ assets (cash, bonds etc.) gives it the best chance of meeting its overall investment objective over the long term. In order to ensure sufficient liquidity so that grant commitments should always be able to be met without the need to sell assets at distressed prices, Commissioners have determined that a minimum of £5m should normally be held in ‘nominal’ assets such as cash and bonds; beyond this, it is expected that the portfolio will normally comprise ‘real’ assets.

As at the balance sheet date, the Commission’s portfolio was spread across three investment managers: a global equity fund of approximately £71.2m managed by Schroders (C.I.) Ltd; a portfolio of exchange traded funds of approximately £38.5m actively managed by Charles Stanley & Co. Ltd and an investment of approximately £10.6m in a strategic bond fund managed by JP Morgan Asset Management Ltd. The Commission also owns the freehold of various properties on its legacy estate in South Kensington valued at £23.3m.

The overall portfolio targets an absolute return over the economic cycle of RPI + 4%, after all charges; there is no income target although the composition of the portfolio is such that in a normal year income of around 2 – 3% pa is expected. Each fund manager also compares performance against appropriate market and sector benchmarks.

The Commission recognises 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 recognises 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. As at the balance sheet date, the Commission’s main segregated equity portfolio had scope 1 and 2 carbon emissions that were 81% less than the MSCI World index (2019: 67% less than the MSCI World index). The carbon intensity of the Commission’s combined equity portfolio (direct and indirect holdings), measured in tonnes of CO₂ emissions per million dollars of sales was approximately half that of the MSCI World index.

Disbursement policy

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

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

Comments on the Results for the Year

In 2020, the portfolio generated returns of £15,593,069 (2019: returns of £22,144,755). After allowing for donations and other income of £72,032 (2019: £24,792), total expenditure of £5,919,025 (2019: £4,924,544) and actuarial losses of £23,626 (2019: gains of £76,852) this resulted in a net increase in funds available to finance future grants of £9,722,450 (2019: £17,321,855).

The total return comprises income and gains / losses. The annual income generated in 2020 by the Commission's assets was £2,715,229 or approximately 2% of opening portfolio value, somewhat less than the yield the previous year (2019: £2,728,598, 2.5%) reflecting the impact of the pandemic on corporate dividends. Capital values also experienced greater volatility during the year, but the Commission's investment managers were able to position the portfolio to take advantage of those sectors of the economy able to perform well during the pandemic and as a result the Commission's liquid investment portfolio enjoyed gains of £10,902,758 (2019: £17,229,216). The directly held property portfolio also saw revaluation gains of £1,975,082 (2019: £2,186,940), the majority of the gain relating to one high end residential property which was the subject of negotiations regarding freehold transfer.

Expenditure on raising funds – which primarily comprises investment and property management fees – increased from £658,343 to £740,364. This increase primarily reflects professional fees incurred in respect of the potential freehold transfer referred to above.

Total expenditure on charitable activities of £5,178,661 was £912,460 more than the previous year. This primarily reflects an exceptional Special Award of £1.2m for public realm improvements at the northern end of the Commission's estate.

Overview

The Commission manages its assets on a total return basis. Overall, the Commission achieved a total return net of fees of approximately 11%, considerably in excess of the RPI + 4% target for the year of 5.2%. This return was comfortably ahead of peer group indices such as the ARC Equity Risk Charity Index (2.3%), although somewhat below stock market indices such as the MSCI AC World (12.7%) and the IA Global Equity Index (14.8%). In 2019 the Commission achieved a total return of approximately 18%, compared to a target of 6.2%, an MSCI AC World Index return of 21.7%, an IA Global Equity Index return of 22.1% and ARC Equity Risk Charity Index return of 17.4%.

Looking at the last nine years together, since the current investment policy was established, the real return on the portfolio net of fees has averaged 8.6% pa, more than sufficient to fund the target 4% disbursement. Clearly, the financial position and performance of the Commission year to year is sensitive to movements on world stock markets but the outperformance over recent years means the Commission's financial position is extremely strong. Moreover, while volatility will inevitably affect short term performance, the portfolio is well positioned to capture returns over the long term.

Charitable expenditure during the year increased in both absolute and percentage terms, slightly exceeding the target 4% of the trailing three-year average closing capital value of the portfolio (2019: 3.6%). There remains an accumulated underspend from prior years. Commissioners will consider the scope in coming years to award additional fellowships, recognising that some fellows will be so successful they withdraw early; to allow fewer awards in one area to be balanced by additional awards in another; and to make additional Special Awards. Commissioners also remain mindful of the desirability of maintaining disbursements through periods of inferior market return.

The Commission's Auditors

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

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 & 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 39 and 65 to 70 was approved by the Commissioners on 7 July 2021.

Sir William Castell LVO

Independent Auditors' 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 2020 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 2020, 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.

Independent Auditors' Report to the Commissioners of Royal Commission for the Exhibition of 1851 (continued)

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 39, 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.

Independent Auditors' Report to the Commissioners of Royal Commission for the Exhibition of 1851 (continued)

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.

Moore Kingston Smith LLP 11 August 2021

Statutory Auditor

Devonshire House
60 Goswell Road
London
EC1M 7AD

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 2020

	Notes	Unrestricted Funds 2020 £	Unrestricted Funds 2019 £
Income from:			
Donations	4	71,107	20,000
Investments	5	2,715,229	2,728,598
Other	6	925	4,792
Total income		2,787,261	2,753,390
Expenditure on:			
Raising funds	7	740,364	658,343
Charitable activities	8	5,178,661	4,266,201
Total expenditure		5,919,025	4,924,544
Net expenditure before gains and losses on investments		(3,131,764)	(2,171,154)
Net gains on investments			
Gains on property		1,975,082	2,186,941
Gains on investments		10,902,758	17,229,216
Total of net gains on investments		12,877,840	19,416,157
Net income		9,746,076	17,245,003
Other recognised gains and losses			
Actuarial gains / (losses) on defined benefit pension scheme	14	(23,626)	76,852
Net movement in funds		9,722,450	17,321,855
Reconciliation of funds			
Total funds brought forward		128,403,095	111,081,240
Net movement in funds		9,722,450	17,321,855
Total funds carried forward		138,125,545	128,403,095

The notes on pages 47 to 64 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 2020

	Notes	Total Funds 2020 £	Total Funds 2019 £
Fixed asset investments			
Investment properties	15	23,345,382	21,370,300
Listed investments	16	119,307,960	110,771,099
Cash held as part of the investment portfolio		1,017,499	1,656,546
		<u>143,670,841</u>	<u>133,797,945</u>
Current assets			
Debtors	17	1,140,855	272,882
Cash at bank and in hand		1,103,335	950,898
		<u>2,244,190</u>	<u>1,223,780</u>
Liabilities			
Creditors: Amounts falling due within one year	18	(4,580,884)	(3,867,120)
Net current liabilities		<u>(2,336,694)</u>	<u>(2,643,340)</u>
Total assets less current liabilities		141,334,147	131,154,605
Creditors: Amounts falling due after more than one year	18	(2,783,602)	(2,324,510)
Net assets excluding pension liability		<u>138,550,545</u>	<u>128,830,095</u>
Defined benefit pension scheme liability	14	(425,000)	(427,000)
Net assets		<u><u>138,125,545</u></u>	<u><u>128,403,095</u></u>
The funds of the Charity:			
Capital Funds			
Balance as at 1 January		128,403,095	111,081,240
Movement in year		9,722,450	17,321,855
Balance as at 31 December		<u><u>138,125,545</u></u>	<u><u>128,403,095</u></u>

Approved by the Commissioners on 7 July 2021 and signed on their behalf by:

Sir William Castell
Chairman, Finance Committee

NL Williams
Secretary

The notes on pages 47 to 64 form part of these accounts.

Royal Commission for the Exhibition of 1851

Statement of Cash Flows for the Year Ended 31 December 2020

	Total Funds 2020 £	Total Funds 2019 £
Cash flows from operating activities		
Donations received (excluding donations in kind)	71,107	20,000
Grants and award paid	(3,460,087)	(3,775,651)
Payments to suppliers	(885,401)	(914,215)
Payments in respect of employees	(312,540)	(306,959)
Other payments	(22,214)	(25,960)
Cash used in operating activities	(4,609,135)	(5,002,785)
Cash flows from investing activities		
Dividends, interest and rent from investments	1,756,794	2,757,279
Proceeds from sale of investments	60,431,106	31,721,396
Purchase of investments	(58,065,375)	(27,681,469)
Net cash provided by investing activities	4,122,525	6,797,206
Change in cash and cash equivalents in the reporting period	(486,610)	1,794,421
Cash and cash equivalents brought forward	2,607,444	813,023
Cash and cash equivalents carried forward	2,120,834	2,607,444
Disclosed as:		
Cash held as part of the investment portfolio	1,017,499	1,656,546
Cash at bank and in hand	1,103,335	950,898
	2,120,834	2,607,444

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

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; many events had to be cancelled and some programmes moved on-line. In terms of its core grant-making activity, however, the Commission has largely been able to continue as planned.

As soon as the possibility of a pandemic became clear, the Finance Committee acted to ensure that there were sufficient cash or near cash assets in place to fund at least three years’ expenditure in full. This gave confidence that the Commission would be able to ride out the immediate disruption and need not curtail any of its programmes. Investment markets have, to be sure, 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 value of the Commission’s portfolio has risen over the year.

Similarly, while some of the Commission’s tenants have asked for and received temporary support with deferred rent demands and the like, there is not considered to be any risk to the long-term value of the estate. That is not to say of course that some of our legacy institutions have not been severely impacted.

The Commission had robust business continuity plans in place and Commissioners, Committee members and staff have adapted relatively straightforwardly to the need for remote working. The 2020 and 2021 award rounds for all the Commission’s Fellowships and Studentships have gone ahead as planned with a full complement of awards made. A majority of existing award holders have been able to adapt their workflow patterns to fit the unusual circumstances imposed by lockdowns etc. Where this has not been possible, the Commission has granted extensions and provided the necessary financial support.

All in all, Commissioners are confident that whatever the short-term disruptions, the pandemic should not have any material, long-term impact on the Commission’s work.

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

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

2. ACCOUNTING POLICIES (continued)

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.

(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.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

2. ACCOUNTING POLICIES (continued)

(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.

(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.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

2. ACCOUNTING POLICIES (continued)

(j) Financial instruments (continued)

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.

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 2020

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, and given current interest rates and grant periods, 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. The Commission therefore maintains a single unrestricted fund.

4. DONATIONS

The Commission received donations of the majority of their assets from the Sir Misha Black Awards Committee. The donation is for the general charitable purposes of the Commission. The Commission has agreed to provide administrative support to the Sir Misha Black Awards Committee and to meet the costs of their annual Medal and Award ceremonies.

5. INVESTMENT INCOME

	2020	2019
	£	£
Rental income from UK properties	1,300,782	612,194
Income from managed investments	1,379,063	2,111,283
Interest on rent arrears	32,995	–
Interest on cash deposits	2,389	5,121
	<u>2,715,229</u>	<u>2,728,598</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

6. OTHER INCOME

	2020	2019
	£	£
Licence income	925	4,792
	<u>925</u>	<u>4,792</u>

7. COST OF RAISING FUNDS

	2020	2019
	£	£
Investment management fees	507,244	528,878
Property management fees	66,434	63,842
Legal fees	60,255	21,873
Provisions	53,333	–
Allocated support costs (note 11)	53,098	43,750
	<u>740,364</u>	<u>658,343</u>

8. CHARITABLE ACTIVITIES

	Grants (note 9)	Direct costs (note 10)	Allocated support costs (note 11)	2020	2019
	£	£	£	£	£
Fellowships and studentships	3,008,321	89,726	147,469	3,245,516	3,164,652
STEM education and outreach	285,210	67,776	57,804	410,790	636,870
Support for legacy estate	1,332,550	35,193	57,804	1,425,547	328,196
Archives and alumni relations	21,298	17,848	57,662	96,808	136,483
	<u>4,647,379</u>	<u>210,543</u>	<u>320,739</u>	<u>5,178,661</u>	<u>4,266,201</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

9. GRANTS AWARDED

(a) Fellowships and studentships

	2020 No.	2020 £	2019 No.	2019 £
Research Fellowships	10	1,707,647	11	1,743,614
Industrial Fellowships	10	494,982	9	509,607
Industrial Design Studentships	10	412,192	9	354,850
Built Environment Fellowship	–	–	1	100,000
Design Fellowship	1	90,000	–	–
Enterprise Fellowships	5	312,500	3	187,762
Great Exhibition Scholarships	–	(9,000)	–	–
	<hr/>	<hr/>	<hr/>	<hr/>
Total fellowships and studentships	36	3,008,321	33	2,895,833
	<hr/>	<hr/>	<hr/>	<hr/>

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 2020

9. GRANTS AWARDED (continued)

(b) STEM education and outreach

	2020 £	2019 £
SmartSTEMs – Digital portal	14,850	–
Ruth Mountford – They Made It podcasts	5,000	–
Fun Kids Radio – How’s That Made?	10,000	–
Physics Partners – Physics videos	9,800	–
Primary Engineer – Leaders award podcasts	10,160	–
In2ScienceUK – Alumni programme	14,750	–
RedR UK – Engineering in emergencies / Affiliate scheme	5,000	30,000
London Transport Museum – Engineering your neighbourhood	20,602	–
Cranfield University – National flying laboratory centre	197,000	–
Smallpeice Trust – Space Engineering course / Humanitarian Engineering course	–	10,000
Serpentine Trust – Digital knowledge and skills sharing workshops	–	15,000
Armourers’ & Brasiers’ Company – Cambridge Forum	–	1,000
Foundation for Science and Technology – Debate sponsorship	–	1,000
County Upper School – Junior Cospace Robotics Competition	–	1,952
Design Museum – the Great Competition	–	3,000
STEM Learning – ENTHUSE partnership	–	60,000
WISE Campaign – My Skills, My Life	–	60,000
The Common Room – Children of the Revolution	–	40,000
Foundation for Science and Technology – Future Leaders programme	–	9,000
Design and Technology Association – Designing your Future	–	14,625
The PTI – Subject leadership CPD programme	–	14,800
Smallpeice Trust – Arkwright scholarships	–	46,200
British Science Association – CREST Awards for disadvantaged students	–	74,650
UK Electronics Skills Foundation – Electronics Everywhere	–	48,000
Travel bursaries and conference prizes	–	500
	<hr/>	<hr/>
	287,162	429,727
Less: Past awards written back where not utilised in full	(1,952)	–
	<hr/>	<hr/>
	285,210	429,727
	<hr/>	<hr/>

All but one of the STEM education and outreach grants were awarded to institutions (2019: all of the STEM education and outreach grants were awarded to institutions except for one travel bursary and one poster prize).

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

9. GRANTS AWARDED (continued)

(c) *Support for legacy estate*

	2020 £	2019 £
Royal Albert Hall – Public realm project	1,225,000	–
National Railway Museum – The Great Machine	105,050	–
Exhibition Road Culture Group – Covid Culture		
Shock event / Day of Design	2,500	9,500
Victoria and Albert Museum – Raphael Cartoons	–	227,000
	<u>1,332,550</u>	<u>236,500</u>

All of the grants in support of the legacy estate in both 2020 and 2019 were awarded to institutions.

(d) *Archives and alumni relations*

	2020 £	2019 £
University of Oxford – Digitising Albert	26,500	53,000
Royal Collection Trust – Queen’s Bindery Apprenticeship Scheme	1,500	–
English Heritage Trust – Victoria and Albert at Osborne	–	2,500
	<u>28,000</u>	<u>55,500</u>
Less: Past awards written back where not utilised in full	6,702	–
	<u>21,298</u>	<u>55,500</u>

All of the grants in support of archives and alumni relations in both 2020 and 2019 were awarded to institutions.

In total, 13 grants were made to institutions and 37 to individuals (2019: 21 grants to institutions and 35 to individuals).

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

10. DIRECT COSTS

	2020	2019
	£	£
Promotion and selection costs	83,148	76,404
Networking and educational events	6,578	208,322
Estate memberships, projects and advice	–	37,327
Archive supplies and acquisitions	–	6,196
Alumni website and expenses	–	7,080
	<u>89,726</u>	<u>335,329</u>
Fellowships and studentships	83,148	76,404
STEM education and outreach	67,776	208,322
Support for legacy estate	35,193	37,327
Archives and alumni relations	7,487	6,196
	<u>210,543</u>	<u>7,080</u>
	<u>210,543</u>	<u>335,329</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

11. SUPPORT COSTS

	Cost of raising funds £	Fellowships and studentships £	STEM education and outreach £	Support for legacy estate £	Archives and alumni relations £	2020 £	2019 £	Basis of allocation
Governance costs (note 12)	11,880	11,880	9,504	9,504	4,751	47,519	15,076	Board time
Staff costs (note 13)	34,426	113,245	40,341	40,341	44,190	272,543	266,315	Staff time
Retired staff pension costs	1,036	3,408	1,214	1,214	1,330	8,202	13,758	Staff time
Facility costs	1,556	5,120	1,824	1,824	1,998	12,322	12,322	Staff time
Office refurbishment	-	-	-	-	-	-	5,888	Staff time
Office costs	2,553	8,397	2,991	2,991	3,278	20,210	30,684	Staff time
Legal and professional fees	1,439	4,734	1,686	1,686	1,848	11,393	4,009	Staff time
Travel and entertaining	208	685	244	244	267	1,648	9,010	Staff time
	<u>53,098</u>	<u>147,469</u>	<u>57,804</u>	<u>57,804</u>	<u>57,662</u>	<u>373,837</u>	<u>357,062</u>	

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

12. GOVERNANCE COSTS

	2020 £	2019 £
Audit fees (including VAT)		
– Current year	10,200	10,000
– Prior year overaccrual	(100)	(1,400)
Actuarial fees	1,900	1,680
Annual report	769	1,923
Meeting costs	190	2,873
Commissioner recruitment costs	34,560	–
	<u>47,519</u>	<u>15,076</u>

13. STAFF COSTS AND RELATED PARTY TRANSACTIONS

	2020 £	2019 £
Salaries (including benefits in kind)	221,203	185,082
Employers NI	20,330	17,311
Pension contributions	30,148	60,124
Staff recruitment	–	1,171
Training and development	862	2,627
	<u>272,543</u>	<u>266,315</u>

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

	2020 No.	As restated 2019 No.
Support and administration	4.0	3.5
Archive	1.0	1.0
	<u>5.0</u>	<u>4.5</u>

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

	2020 No.	As restated 2019 No.
Support and administration	2.8	2.7
Archive	0.4	0.4
	<u>3.2</u>	<u>3.1</u>

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

13. STAFF COSTS AND RELATED PARTY TRANSACTIONS (continued)

The 2019 average number of employees has been restated to more accurately reflect the split between Support and administration and Archive. The 2019 full-time equivalent number of Support and administration employees has been increased by 0.2 to more accurately reflect the balance across the year.

One employee earned between £90,000 and £100,000 (2019: one employee earned between £90,000 and £100,000). No pension contributions were paid in respect of this employee (2019: no pension contributions were paid in respect of this employee).

Commissioners do not receive remuneration. During the year re-imbursements were made to two Commissioners in respect of travelling and other expenses totalling £601 (2019: to four Commissioners totalling £1,600).

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 £175,003 (2019: £164,373).

There were no other related party transactions during the year (2019: 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 (2019: 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 £30,148 (2019: £60,124) were made in the year. There were no contributions outstanding at the year-end (2019: £3,201 contributions were outstanding at the year-end). There were no prepaid contributions at the year-end (2019: £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.

The Scheme was closed to new members on 14 July 2004. As at 31 December 2020, all six 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 £8,202 (2019: £13,758) which is fully in respect of net interest on the net liability.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

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

As regards the unfunded, defined benefit pension scheme:

The principal assumptions used by the actuary were:

	FRS102 Valuation 2020 (% p.a.)	FRS102 Valuation 2019 (% 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	1.4%	2.0%
Pensionable earnings increases	N/A	N/A
Price inflation	3.0%	3.0%
Pension increases	3.0%	3.0%
Allowance for administration expenses	0.0%	0.0%
<i>Demographic assumptions</i>		
Mortality		
Pre-retirement	N/A	N/A
Post-retirement	S3PA	S3PA
	CMI 2019 1%	CMI 2018 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:

	2020 £	2019 £
Market value of Scheme assets	–	–
Present value of Scheme liabilities	(425,000)	(427,000)
	<hr/>	<hr/>
Scheme deficit	(425,000)	(427,000)
Related deferred tax asset	–	–
	<hr/>	<hr/>
Net liability	(425,000)	(427,000)

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

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

Movements in the year:

	2020 £	2019 £
Scheme deficit at beginning of year	(427,000)	(529,000)
Current service cost	–	–
Interest on obligation	(8,202)	(13,758)
Actuarial gain / (loss) on liabilities	(23,626)	76,852
Benefits paid directly by employer	33,828	38,906
	<u> </u>	<u> </u>
Scheme deficit at end of year	<u>(425,000)</u>	<u>(427,000)</u>

The interest on obligation of £8,202 (2019: £13,758) is disclosed within Support costs (note 11) while the actuarial loss on liabilities of £23,626 (2019: gain of £76,852) is disclosed within Other recognised gains and losses on the face of the SOFA.

15. INVESTMENT PROPERTIES AND OPERATING LEASES

	2020 £	2019 £
(a) Movements in value of investment properties		
Balance at 1 January	21,370,300	19,903,865
Sales during the year	–	(301,630)
Unrealised gain on year-end revaluation	1,975,082	1,768,065
	<u> </u>	<u> </u>
Valuation at 31 December	<u>23,345,382</u>	<u>21,370,300</u>

The valuation as at 31 December 2020 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 2020 valuation, the value at 31 December 2019 has been adjusted, based on further advice from Cluttons, 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 2020

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:

	2020 £	2019 £
Not later than one year	175,788	82,500
Later than one year and not later than five years	–	52,242
Later than five years	9,996,587	12,381,934
	<u>10,172,375</u>	<u>12,516,676</u>

The Commission's investment properties are let for periods ranging up to 999 years. All leases are on full repairing and insuring terms. One lease has a break clause which has been taken into account in calculating minimum lease payments. Leases of residential property are potentially subject to leasehold enfranchisement; this has been ignored in arriving at the above figures.

16. INVESTMENTS

	2020 £	2019 £
(a) Movements in listed investments		
Market value 1 January	110,771,099	96,856,625
Acquisitions at cost	58,063,652	27,685,327
Disposals at carrying value	(52,976,767)	(24,392,681)
Net gains on revaluation	3,449,976	10,621,828
	<u>119,307,960</u>	<u>110,771,099</u>
Market value 31 December		
Value at cost 31 December	89,589,653	84,502,769

(b) Geographic breakdown

	2020 £	2020 £	2019 £	As restated 2019 £
	Listed investments	Cash	Listed investments	Cash
In the UK	61,560,772	902,632	55,437,509	1,656,516
Outside the UK	57,747,188	114,867	55,333,590	30
	<u>119,307,960</u>	<u>1,017,499</u>	<u>110,771,099</u>	<u>1,656,546</u>

The 2019 figure for cash held in the UK has been restated to only disclose cash held as part of the investment portfolio.

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

16. INVESTMENTS (continued)

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.

17. DEBTORS

	2020 £	2019 £
Rents receivable		
– in hands of surveyors	250,079	160,010
– in arrears	822,536	80,498
	<hr/> 1,072,615	<hr/> 240,508
Lease enfranchisement costs (accrued)	–	5,450
Other debtors	8,585	280
Prepayments	26,655	26,594
Accrued income	33,000	50
	<hr/> <hr/> 1,140,855	<hr/> <hr/> 272,882

18. CREDITORS

	2020 £	2019 £
Amounts falling due within one year		
Grants payable	4,418,496	3,686,938
Other creditors	162,388	180,182
	<hr/> 4,580,884	<hr/> 3,867,120

	2020 £	2019 £
Analysis of other creditors		
Investment management fees	131,814	130,456
Property management fees	5,700	10,200
Audit fees	10,200	10,000
Other legal and professional fees	3,400	3,300
Others	11,274	26,226
	<hr/> 162,388	<hr/> 180,182

Royal Commission for the Exhibition of 1851

Notes to the Financial Statements for the Year Ended 31 December 2020

18. CREDITORS (continued)

	2020 £	2019 £
Amounts falling due after more than one year		
Grants payable	2,783,602	2,324,510
Due in one to two years	1,821,110	1,601,535
Due within two to five years	962,492	722,975
	<u>2,783,602</u>	<u>2,324,510</u>

The analysis of grants payable by award is as follows

Award	Period of commitment	2020 £	2019 £
Fellowships and studentships			
– Research Fellowships	3 years	3,099,479	2,815,066
– Industrial Fellowships	3 years	1,595,090	1,655,656
– Industrial Design Studentships	2 years	339,645	355,550
– Built Environment Fellowships	2 years	58,402	95,604
– Design Fellowships	2 years	142,500	120,000
– Enterprise Fellowships	1 year	187,500	375,000
STEM education and outreach	1 year	342,932	281,932
Support for legacy estate	3 years	1,410,050	205,000
Archives and alumni relations	1 year	26,500	107,640
		<u>7,202,098</u>	<u>6,011,448</u>

19. FINANCIAL INSTRUMENTS

	2020 £	2019 £
Carrying amount of financial assets		
Debt instruments measured at amortised cost (debtors excluding prepayments)	1,114,200	246,288
	<u>1,114,200</u>	<u>246,288</u>
Carrying amount of financial liabilities		
Measured at amortised cost	7,364,486	6,191,630
	<u>7,364,486</u>	<u>6,191,630</u>

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 67 to 69. Details of the Commission's professional advisers are provided on page 70.

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. Actions taken to mitigate the impact of COVID-19 are described on page 10 above.

Investments: security, performance, liquidity

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

Grant making: applications, assessment, administration

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

Legacy estate: character, experience, relevance

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

Commissioners and Committee Members

President

HRH The Princess Royal

Commissioners (and Board of Management)

Mr Bernard Taylor CBE DL FRSC *Chairman, Board of Management*

Sir William Castell LVO

Mr Stuart Corbyn FRICS

Professor Dame Kay Davies DBE FRS FMedSci

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

Sir John O'Reilly DSc FREng FLSW

Ms Sandra Robertson

Professor Chris Wise RDI FREng FICE MIStructE HonFRIBA FRSA

Professor Dame Ann Dowling was appointed to the Board on 3 February 2020

Dame Alison Nimmo was appointed to the Board on 11 November 2020

Ms Sandra Robertson was appointed to the Board on 11 November 2020

Professor Sir Christopher Frayling retired from the Board on 1 January 2020

Professor Dame Lynn Gladden retired from the Board on 9 December 2020

Ex Officio Commissioners

The Lord President of the Council

The First Lord of the Treasury

The Chancellor of the Exchequer

The Secretary of State for Business, Energy and Industrial Strategy

The Secretary of State for the Environment, Food and Rural Affairs

The President of the Institution of Civil Engineers

The President of the Geological Society

Finance Committee

Sir William Castell LVO *Chairman*

Ms Sarah Arkle

Mr Stuart Corbyn FRICS

Professor Sir Andrew Hopper CBE FRS FREng FIET

Mr Nicholas Moakes CFA

Dame Alison Nimmo DBE MRTPI FRICS HonFRIBA FICE

Ms Sandra Robertson

Dame Alison Nimmo was appointed to the Committee on 12 November 2020

Ms Sandra Robertson was appointed to the Committee on 12 November 2020

Mr Adam Taylor-Smith retired from the Committee on 12 November 2020

Science and Engineering Fellowships Committee

Professor Dame Kay Davies DBE FRS FMedSci *Chairman*
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 David Ewins DSc FEng FRS
Professor James Feast CBE FRS FRSC
Professor Douglas Gough FRS
Professor Cyril Hilsum CBE FEng FRS
Professor Jane Langdale CBE FRS
Professor Stephen Muggleton FEng
Professor Rachel O'Reilly FRSC
Professor Sheena Radford OBE FRS FMedSci
Professor Maurice Skolnick FRS
Professor Trevor Stuart FIC FRS
Professor John Wood CBE FEng

Professor Mike Benton was appointed to the Committee on 10 June 2020
Professor Martin Bridson was appointed to the Committee on 2 July 2020
Professor Sir Charles Godfray retired from the Committee on 5 June 2020

Brunel Fellowships Sub-Committee

Professor Dame Kay Davies DBE FRS FMedSci *Chairman*
Professor Dame Anne Dowling OM DBE FEng FRS
Professor David Ewins DSc FEng FRS
Professor William Powrie FEng FICE
Professor John Wood CBE FEng

Professor Dame Ann Dowling was appointed to the Sub-Committee on 3 February 2020
Professor William Powrie was appointed to the Sub-Committee on 8 October 2020

Industry and Engineering Committee

Sir John O'Reilly DSc FEng FLSW *Chairman*
Professor John Clarkson FEng
Ms Naomi Climer CBE FEng FIET
Dr Nicholas de Leon
Professor Dame Ann Dowling OM DBE FRS FEng
Professor Lord Mair CBE HonDSc FEng FICE FRS
Professor Ron Pethig
Dr Malcolm Skingle CBE DSc
Professor Eleanor Stride OBE

Professor Dame Ann Dowling was appointed to the Committee on 3 February 2020

Built Environment and Design Fellowships Committee

Mr Jim Eyre OBE *Chairman*

Professor Rachel Cooper OBE

Mr Robin Levien RDI+

Dame Alison Nimmo DBE MRTPI FRICS HonFRIBA FICE*

Dr Andrea Siodmok OBE EMPP FRSA HonDCL

Professor Chris Wise RDI FREng FICE MIStructE HonFRIBA FRSA

Mr Robin Levien was appointed to the Committee on 23 June 2020

Dame Alison Nimmo was appointed to the Committee on 11 November 2020

Dr Andrea Siodmok was appointed to the Committee on 26 June 2020

Professor Sir Christopher Frayling retired from the Committee on 1 January 2020

+Design Fellowship years only

*Built Environment Fellowship years only

Staff

Mr Nigel Williams CEng

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
South Kensington Branch
29 Old Brompton Road
London SW7 3JE

Investment Managers

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

Surveyors

Cluttons LLP
Portman House
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