



Imperial ENGINEER



SEISMIC 2020

BOULDERING IN BOLIVIA

MANAGING BLACK SWANS

RETURN TO VATNAJÖKULL

CGCA IMPACT PHOTO COMPETITION

For members of City & Guilds College Association
and The Royal School of Mines Association

ISSUE 33 *AUTUMN 2020*

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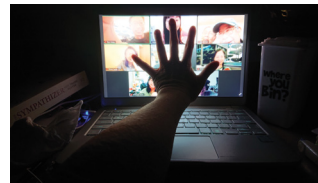
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Cover Image

"Just a Call Away"
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Winner of IMPACT
Photographic Contest
(see page 30)

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EDITORIAL BOARD

Peter Buck (Editor)
David Bishop, Eilidh Campbell,
Tim Cotton, Paul Holmes,
Bill McAuley (Emeritus Editor)

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CORRESPONDENCE and ENQUIRIES

Eilidh Campbell
Alumni Relations Office
Level 1 Faculty Building, Imperial College London,
South Kensington Campus, Exhibition Road
London SW7 2AZ
Tel: +44 (0)20 7594 9238
Email: rsma@imperial.ac.uk for RSMA queries
Email: cgca@imperial.ac.uk for CGCA queries
Website: www.imperial.ac.uk/engineering/alumni/
CGCA website: www.cgca.org.uk
RSMA website: www.rsm-association.org

URLs at the end of items indicate more details online.
Where appropriate we use bit.ly short-links for readability and useability.
Faculty news items may be derived from Imperial News where full attribution details can be found.



I would like to offer our thanks again to Prof Dick Kitney (immediate Past President). He came to the role at short notice, when Dame Judith Hackitt had to step down to lead efforts in the independent review of regulations and fire safety following the Grenfell Tower tragedy. Professor Kitney went on to serve as the President for three successful years. I am delighted and humbled to be carrying the baton as President of the City & Guilds College Association.

We had a successful virtual AGM in June. In my inaugural presentation at the AGM, I shared my thoughts on 'managing black swans' and highlighted how governments across the world will benefit from an 'engineering' mindset to solve issues arising from the current pandemic (see page 23).

It has been an extraordinary year. The pandemic has posed several challenges to the College. The Faculty has prioritised a safe environment and wellbeing, while continuing to provide a world-leading hybrid education. As you know, the College, and in particular the Engineering Faculty, has been at the forefront of research for a vaccine and providing world-class design for ventilators. We owe a great deal of gratitude to those alumni, staff and students who are directly involved in helping with the current crisis.

An important item on my agenda as the President is to explore how we can extend support for student and alumni welfare during this uncertain period. I also want to build on the achievements made in the last three years by increasing participation with our younger members. We will continue to develop career mentoring programmes and publicising CGCA's activities in the current and wider communities.

This Association has always benefitted from a loyal, dedicated and hard working committee. I personally would like to express my appreciation to the leadership provided by Nigel Creswell as Secretary and Peter Chase as Treasurer. Peter and Alison Buck have done outstanding work in producing Imperial ENGINEER, a crucial link to our CGCA community. Under extremely difficult circumstances, Colin Kerr and his colleagues are taking on the challenging task of planning for our 2021 Annual Dinner. Tim Munday and Milia Hasbani have played a vital leadership role with our younger members. I would also like to thank Chris Lumb and the other board members of OC Trust for their work during this period in supporting students and student activity.

As I look forward to this new chapter, I want to give you and your families my best wishes in these challenging times. I look forward to seeing some of you at a CGCA event – whether physical or virtual – in the near future.



**Atula
Abeyssekera**

PRESIDENTS REPORT



**Tim
Cotton**

Unbelievably, I find myself once again writing to you all in the capacity of RSMA President embarrassingly entering a fifth year in office. We are struggling to recruit new Committee members and as such, the Committee and I felt that for consistency I should stay another year. This motion was taken to the AGM in August this year and approved by the members present. Whilst the Committee has a reasonable level of membership, time commitments of the members mean that filling the Executive roles in the Committee is becoming harder. If you do have time, please do consider joining the RSMA Committee, it is truly worth it as you can see first hand the tremendous impact that giving back has on the current student body.

As a volunteer organisation, we will always do our best to respond as quickly as we can to your requests and comments, so please do bear with us if we are a bit slow at getting back to you. We rely heavily on the College Alumni Relations team in managing the communication channels with members as they have the systems and people to do this type of work. The Committee has a good working relationship with these departments which are a great help in running the administration side of the Association and getting any feedback from Members out to the Committee.

I am very happy to report that due to the success in 2019 the RSMA once again launched the RSMA Final Year Student Bursary Prize in June 2020. This award is open to students who are beginning their final year in September 2020. In a change in 2020, the Committee is planning to award a minimum of three prizes across ESE and Materials and, depending on applicants, may consider more. As we go to press, there are 16 applicants being considered which is the largest number of applications we have seen so far. The scheme was created to reward students who show the

true RSM Spirit and act as an ambassador for the RSM. Successful candidates must be able to show commitment, achievement and excellence above that of their peers in areas such as academic excellence, community & RSM Union involvement, sporting prowess, or contribution to a sport or club within the RSM. Financial hardship will also be considered as a criterion. Working with Department Directors of Undergraduate Studies at ESE, Materials and the Faculty of Engineering we have had 16 applicants and will be short listing and awarding the bursaries shortly. Remember, the funds have been raised by YOU through your kind generosity at events and specifically by those members who have supported the 100 Club. This is an amazing achievement and is a concrete example of former students of the RSM who want to give back to the current student body. Lastly, the 100 Club continues to slowly grow and I would encourage you, if you are able, to sign up and support the RSMA via the 100 Club or by a one-off donation. If you are already signed up then a huge thank you and please double check your banking details so that you are continuing to pay yearly. Your support is truly appreciated! Read on for a more detailed review of the 100 Club.

Due to the COVID-19 Pandemic and the restrictions on social gatherings, the 2020 Annual General Meeting of the Association was held virtually on the 19th August 2020 via video conference. Tragically, this meant the final year Bar-B-Q had to be cancelled, as the College and associated faculty was closed. See the AGM report on page 4 for a full update.

The ongoing challenges of the pandemic have led the Committee to reluctantly cancel the 136th annual dinner that was due to be held on Friday 27th November 2020 at the Rembrandt Hotel in Knightsbridge. Only World War II has stopped the dinner in the past but, given the difficulty of trying to plan a meaningful event within the continually changing Government guidance, the Committee felt that this is the right thing to do. The Association is not out of pocket in relation to the booking of the dinner as the Rembrandt Hotel has been extremely flexible in regard to the booking conditions.

The Committee continues to maintain a very active relationship with the RSMU and for the 2020/21 academic year, the new RSMU representatives are Jasmine Crocker and Teigan Collins, respectively President and Honorary Secretary. Between us, we are looking to continue to engage with students on careers evenings and to support the students and associated societies throughout this challenging time.

I hope you find this issue informative and I look forward to seeing some of you in the RSM and /or at an RSMA event when it is safe and prudent to do so.

DIARY

As a result of the ongoing worldwide COVID-19 pandemic, events in most locations have been cancelled or converted to virtual events. Local restrictions are varied, therefore before considering attending any event, please contact the organisers to check whether the event is still taking place.

RSMA Toronto, Canada

Informal RSM meeting, noon, Last Friday of every month.
Jason George Pub, 100 Front Street East, Toronto
Contact: rsm.1851@gmail.com

RSMA Perth, Australia

Monthly Sundowner, First Friday of every month.
The Celtic Club, 48 Ord St, West Perth, WA, 6005
Contact:
Alan Dickson – alan@dickson.com.au
John Sykes – johnpsykes@gmail.com

Imperial Alumni, Houston, USA

Alumni social, 6pm, Third Thursday of every month.
Capital Grille, 840 West Sam Houston Pkwy N, Houston, TX 77024
Contact: Matt Bell – matt@in2oilandgas.com

Imperial Engineering Alumni, Johannesburg, South Africa

Quarterly Johannesburg Lunch (18 Nov, 17 Feb 21, 19 May 21)
Baron & Quail, Woodmead, Johannesburg, South Africa
Contact: Richard Gundersen – Gundersen@yebo.co.za

5&10 Reunion Lunch Saturday 21st November 12 noon GMT

Due to Covid, this year's "5&10 Reunion lunch" will be on Zoom. All C&G/FoE alumni welcome; let's create a worldwide gathering! Starts noon GMT on Saturday 21st November (so, evening in east Asia and breakfast in America!) for 2 hours. Drop in when you like. Bring your own fare. Go to zoom.us/join and join with id 984 0894 0946. There'll be separate areas inside Zoom for each decade, where peers can meet and chat, followed by a combined session with speakers from today's students and yesteryear. All on the one call! Spread the word. Don't miss it.

An up-to-date calendar of events of interest to CGCA and RSMA members is always available on the CGCA and RSMA websites. Imperial College maintains a calendar of college events at bit.ly/IE-WhatsOn and the Friends of Imperial College regularly organise events of interest to alumni (see bit.ly/IE-FOI)

Please note that while many of these events are open to all and often free, they usually require registration in advance. Please follow the links in the entry to get more information including if and how to register and whether there is any cost.

For more information follow links, or see page 2 for contact details

2020 RSMA AGM Report

Two dozen or so RSMA members and Committee members connected via a video conference link on August 19th 2020 for the Annual AGM of the RSMA. All papers for the meeting were placed online on the front page of the RSMA Website and can still be accessed by going to the RSMA website at: <http://www.rsm-association.org>

The members heard various reports from the President, Treasurer and Chair of the RSMA Trust and salient points are noted below.

President

The President, Tim Cotton, highlighted that once again, due to limited success in recruiting new Committee members, the succession planning for the Association Executive was behind schedule. Furthermore, the challenges of handing over in the midst of a pandemic were seen as too great. Accordingly, it was proposed that Tim should stay in the role for another year, all members present concurred. At the meeting, one Committee member was elected and the existing members and officers (as listed in the yellow box below) were voted in.

Treasurer

The Treasurer reported that the RSMA and Trust are in good financial health and have the necessary funds available to continue to support

100 Club	2019	2018	2017	2016	2015
Donations	£6583	£4550	£7170	£4552	£0



Tim Cotton remains as RSMA President for another year

the RSM. The year was marked by a generous and unexpected legacy of £16,220 from the Illing Trust, at the wishes of a former student. With this unexpected endowment and a growing "100 Club", the Trust anticipates being able to give more bursaries in 2020. These will be awarded in the Autumn 2020 Term to final year students who show the true RSM spirit and act as an RSM ambassador. There have been 16 applicants and names are currently being shortlisted.

Since the 100 Club was started in 2016, there have been 41 members; as of today, only 37 remain active. The original idea was sound but

unfortunately, the take up has not been what was originally envisaged but through the generosity of the 100 Club members almost £23,000 has been raised since 2016. See table above.

The drop in members is due to:

- 1 member thought it was a one off £200 payment and not a yearly £200 payment.
- 3 members have been unresponsive to further communications and have only made one payment.
- 7 members are in arrears for 2019 and the Association is in correspondence to remind them to continue to pay.

2018 saw the first three £1000 Bursaries awarded and a further three £1000 Bursaries awarded in 2019. In 2020 it likely that at least a further three bursaries will be awarded.

Chair of the RSMA Trust

The Chair of the Trust reported that in terms of the Trust's Trust Deed, the President, Honorary Treasurer and Honorary Secretary of the Association and the President of the RSMU are appointed as trustees ex-officio. The following offered themselves for election as trustees: Professors Rees Rawlings and John Monhemius, Fiona Cassidy, Coen Louwars, John O'Reilly and Glynne Lloyd-Davis and were duly voted in by a show of virtual hands.

In other Trust matters, the following awards were made and presentations will be made at some point during the 2020/2021 academic year:

- *Peter Harding Memorial Award* went to Fiona Cassidy
- *Rees Rawlings Young Member Award* will not be awarded.

Finally, the trust reported that a number of the Trustees would be changing roles. The first was Professor Rees Rawlings, who stepped down at the meeting as the Trust Chair and was succeeded by Fiona Cassidy. Second, Hannah Bungey was announced as a successor to Glynne Lloyd-Davis as the Trust Honorary Secretary.

100 Club draw

After the video conference, the draw for the 100 Club £250 raffle prize was once again won by Martin Levy who won the draw at the last Final Year Bar-B-Q.

Election of officers and committee for 2020/21

President: **Tim Cotton**
Senior Vice-President: **Vacant**
Junior Vice-President: **Vacant**
Past-President: **John O'Reilly**
Hon. Secretary: **Hannah Bungey**
Hon. Treasurer: **David Bishop**
VP International: **Vacant**
Membership Secretary: **Vacant**

Members: **Lorraine Craig**
John Monhemius
Rees Rawlings
Daniel Hill
Sam Argyle
Eleanor Jay
Ben Moorhouse
Seb Turner
Richard Griffiths
Aisling Dunn – new member
Jasmine Crocker (President RSMU)
Teigan Collins (Hon Sec RSMU)
Alfie Baines (GeologicalSoc President)
Arinjay Jadeja (MatSoc President)
Rory Bardner (GeoPhys President)

Overseas: **Celia Hayes** (Australia)
Harry Fisher (Australia)

CGCA ANNUAL DINNER 2021

In normal times, we would usually start planning for the annual dinner in the early summer, June or July, to be ready for the event to be held in late February or early March of the following year. This allows us time to book a venue and identify our main speakers, ready for an announcement in the autumn issue of Imperial ENGINEER, along with a booking form. As you know, these are not normal times, so we have had to make some slightly different arrangements. At the time of the last dinner, February 2020, the Covid-19 pandemic was making its way across Europe but had not really had a significant impact on the UK. But by the end of March 2020, the UK was in lockdown. By April the pandemic had gripped the country, there was talk of a second spike of infections in the autumn or winter and the future seemed very uncertain.

Against this background, it seemed particularly risky to try to

hold our event at the usual time, so after some discussion, we agreed to go for the later date of Friday 14 May 2021, in the hope that the situation with the pandemic will have clarified somewhat by then, and I am pleased to say that we now have a venue and a guest speaker. We will gather once again at the Ironmongers' Hall in the company of our new President, Professor Atula Abeysekera, and our main guest, the President of the Royal Academy of Engineering, Professor Sir Jim McDonald FREng FRSE.

In view of the continuing uncertainty, we have also decided to defer the start of the booking period until January, which is why you do not have the usual booking form with this copy of IE. Instead, assuming that all still seems well with our May date, we will contact all members with full details of booking early in January, using the e-mail and postal addresses currently held in

membership records. At the same time, we will also contact those other friends of the Association who have been regular attendees of the dinner in recent years, so that they also have full details.

We very much hope that this delay gives us a better chance of

holding our dinner in the first half of 2021 and that we will be able to meet friends, members and guests at a convivial occasion next May. Who knows, we may even be able to celebrate the success of the Imperial College Covid-19 vaccine which is currently undergoing clinical trials.



Photo: Ziyuan Mao

We last held the Annual Dinner at the Ironmongers' Hall in 2018

CGCA 2020 AGM – COVID Style

2020 has forced many changes on all areas of our lives, and the CGCA AGM/President's Evening was not immune. It was due to be held on Monday, 8th June but even though the UK was easing the lockdown restrictions, it was still not possible to have a physical meeting and certainly not a social event following it. So, it was decided to hold a virtual meeting, using the ZOOM platform.

On the day, the whole meeting went surprisingly smoothly, and was very well attended, with people far away from London taking advantage of being able to participate while sitting in their homes.

Professor Kitney opened the meeting and gave an overview of the last year for CGCA. He highlighted the contributions to CGCA of many people, including: Colin Kerr, for the Annual Dinner; the Imperial Alumni team, for their support of our operations; Peter and Alison Buck, for Imperial ENGINEER; and the Committee, for supporting his presidency. He also thanked Judith Hackitt, as she stood down from her role as Immediate Past President.

Following his review, Professor Kitney ended his record-breaking three years Presidency, and handed over to Professor Atula Abeysekera.

One limitation of a virtual meeting was that Richard was unable to physically hand over the medal of office to Atula! (Maybe we need to invest in a 3D copier?)

The accounts for 2019 were approved and a largely unchanged Board and Committee were elected. New faces include Professor Anil



As you can see above, Atula was delighted when he was finally able to retrieve the medal of office from Richard

Bharath who joins us as Senior Vice President.

On a legal point, UK Companies House had made a statement to allow organisations to hold virtual or hybrid AGMs even if their Articles of Association strictly did not accommodate meetings of that style. This includes CGCA and one of the decisions taken at the meeting was to update our Articles to allow virtual and hybrid meetings in future.

At the end of the AGM, Atula gave a very well received talk entitled *Managing Black Swans*, a transcript of which you can read on pages 23-25 of this magazine. This was especially timely, given the current pandemic and the widespread criticism received by various governments of their handling of the crisis and their appetite for acting on expert advice.

Sadly, there was no way of replacing the President's Evening that traditionally follows the AGM, so virtual attendees had to provide their own refreshments! But we hope that 2021 will see this special evening able to be held again.

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

Covid-19 responses across Imperial

As has been apparent from national media coverage, Imperial's medical researchers and academics have been at the forefront of advising the UK government on the scientific aspects of Covid-19 and how best to deal with it, as well as developing vaccines. Imperial's research and expertise has been invaluable to many communities around the world. But, less widely reported, has been research and development across Imperial's Departments, spin-out companies and research partners in White City. We have collected together some of that work below. More information can be readily found on the Imperial News website.

Early in the pandemic, various of the Imperial White City Incubator companies started to adapt their technology and skillsets to help the fight against the pandemic.

MediSieve are developing a magnetic filtration system as a precision tool for doctors to extract harmful substances from blood. The company moved into the Incubator in 2018 and last year received funding from Innovate UK to develop their platform to treat sepsis through the removal of pathogens and damaging cytokines from the blood. As the pandemic progressed, data showed that one concerning symptom in COVID-19 patients was the high level of the inflammatory cytokine interleukin 6 (IL-6) in the blood. Although part of the immune system's response to the virus, high levels of cytokines – commonly known as cytokine storms – can cause organ failure or death. MediSieve decided to pivot their technology as a potential way to remove IL-6 from the blood of COVID-19 patients. "The current treatment for excess levels of IL-6 in COVID-19 patients involves drugs that suppress or block the immune system. But it's not ideal to give someone who is trying to fight an infection a drug that subdues the immune system and remains in the body. We want to use our technology to tune that approach so we can remove IL-6 at the time it is causing harm but then stop this process as soon as cytokine levels are manageable so the patient's immune system can continue to function." MediSieve quickly refocused their work on treating this aspect of COVID-19. As well as adapting their technology, MediSieve have also helped in the pandemic by 3D printing components for Personal Protective Equipment, responding to a call to redeploy equipment and facilities for this purpose in which they were joined by other Imperial groups. It is this community spirit that MediSieve cite as an important attribute of the White City campus, along with access to expertise, facilities, opportunities for collaboration and being able to expand into the space they need.

FreshCheck produce an innovative spray that provides a cheap and rapid method to identify and prevent bacterial and chemical contamination by simply changing colour when applied to a surface. Originally targeted at the food industry, the FreshCheck spray is now receiving interest from a broader range of industries who are looking to ensure hygiene during the pandemic. Although the FreshCheck spray doesn't directly detect COVID-19, it does verify that a surface is clean and without contamination which, by proxy, is a good indication that it is virus-free. It is also much cheaper and easier to implement than current tests to directly detect the presence of COVID-19. "Our mission has always been to make a hygiene test that is more affordable. Allowing more people to access a scientific gold standard to demonstrate cleanliness. With the arrival of COVID-19, the issue of surface contamination became a priority for everyone making accessibility and affordability

even more important." With the wider range of customers approaching FreshCheck, the team are now iterating their product for more functionality in the non-food industry. By reducing its sensitivity to chemicals, whilst maintaining its ability to detect bacteria the spray avoids needlessly flagging high levels of chemical cleaning products, something that would be a concern in food preparation but is not in office or transport locations. The FreshCheck team is also planning to accelerate the development of their handwipes which they believe will have universal appeal as a means to check cleanliness and hygiene. FreshCheck believes that their sense of agility has been built into their company from an early stage. All three co-founders have studied for PhDs in the Chemical Biology of Health and Disease at Imperial and were encouraged to take up opportunities for entrepreneurship and innovation during their degrees. The company took part in the Enterprise Lab Venture Catalyst Challenge in 2015, received support from the Imperial Advanced Hackspace and since then has gone from strength to strength, moving into the Incubator at the beginning of 2018.

Affinity Biomarker Labs are experts in qualifying, validating and testing blood-based proteins that can be used as indicators of a disease or condition to aid clinical decision making. Based at the Imperial White City Incubator since 2018, the company's mission is to assist in the discovery, verification, validation and analysis of novel biomarkers, particularly in areas of high unmet need. With the outbreak of COVID-19, they have directed this mission towards testing for antibodies in the blood that are produced as part of the immune response following COVID-19 infection. At the end of February, the company launched the SARS-CoV-2 serology testing which uses fully automated platforms to test for the levels of two antibodies - IgM and IgG - in whole blood, serum or plasma. Unlike methods that directly detect the presence of the virus, antibody tests help determine whether the individual being tested was ever infected, even if that person never showed symptoms. As such, these serological tests for COVID-19 antibodies play an important role in understanding the virus's epidemiology in the general population and identifying groups at higher risk for infection.

Other Imperial spinout companies have been playing significant roles in the response to the pandemic:

Visibion Ltd, whose chairman is Professor Richard Kitney, Professor of Biomedical Systems Engineering in the Department of Bioengineering (and immediate Past President of CGCA), has deployed their Image Cube product to the NHS Nightingale Hospitals, to securely manage imaging data ensuring there is no delay in providing scanning images to specialists, crucial for the timely diagnosis and treatment of patients in the current pandemic.

DnaNudge, founded and run by Regius

Professor Chris Toumazou, developed their lab-in-a-cartridge technology to create CovidNudge, a rapid COVID-19 test that does not require a lab and can be performed in cartridges smaller than a mobile phone with results in 90 minutes. "The DnaNudge test was developed as a lab-free, on-the-spot consumer service that can be delivered at scale, so we clearly believe it offers very significant potential in terms of mass population testing during the COVID-19 pandemic. The platform is well suited to testing in primary care and community settings with potential for use in non-healthcare settings such as care homes, schools, transport hubs, offices, and, to help bring the arts back, in theatres and venues." This transformative, single-chip multiplex test not only enables a comparison of a sample against both the WHO and CDC assays, but could also test for FluA, FluB and RSV. In addition, the chip includes a control assay for human RNA, which eliminates 'false negative' results by testing for inadequate swabbing. The test is authorised by the Medicines and Healthcare products Regulatory Agency (MHRA) for clinical use and has subsequently obtained its CE mark. An average sensitivity – compared against numerous NHS lab-based tests – is around 95% and specificity around 100%. These results satisfied the MHRA's performance criteria. The government placed a £161 million order for 5.8 million high-speed DnaNudge COVID-19 test kits to be used in NHS hospitals from September. The test is now being rolled-out UK wide in urgent NHS patient care and elective surgery settings, plus out-of-hospital locations.

The London BioFoundry, part of Imperial's National UK Innovation and Knowledge Centre for Synthetic Biology (SynbiCITE), has repurposed robotic technology normally used for synthetic biology research to help with testing for COVID-19. During the early stages of the coronavirus pandemic, the rapid rise in the need for testing led to bottlenecks during peak demand, creating a need for new approaches to boost testing capacity. The Imperial team were able to repurpose an existing high-throughput robotic platform as a way to help NHS diagnostic labs avoid these bottlenecks – cutting their reliance on reagents in high demand from other testing platforms around the country, which were in very limited supply. In addition to helping with COVID-19 testing, they hope this will enable the development of low cost testing platforms for infectious diseases such as HIV, Hepatitis and Influenza. Each machine has the capacity to process up to 1000 samples within 12 hours. But with initial funding from the UK Dementia Research Institute, a team led by Professor Paul Freemont was able to adapt the platform to help with testing for active cases of infection with SARS-CoV-2, the virus that causes COVID-19. The technology is now in use in NHS pathology labs for frontline testing. In order to repurpose the robotic platform, the Imperial team had to create new software and hardware, as well as developing new testing standards to guarantee highly reproducible results. Building on the

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existing antigen testing platforms in clinical use, they applied two new detection methods, based on the gene editing protein CRISPR, and a robust colour change assay called LAMP. Working with clinical colleagues based at the Imperial College NHS Healthcare Trust, they were then able to validate their platform on patient samples to show how the platform compared.

In another project, Imperial researchers will look for potential new treatments for COVID-19 using the computing power of people's smartphones. Working with Vodafone Foundation, the 'Corona-AI' project will use the free DreamLab app, which crunches calculations using a smartphone's computing power while its user sleeps. The app has already helped find potential new cancer drugs and is now aiming to help in the fight against the coronavirus pandemic. Data generated from the calculations will help Imperial scientists identify existing drugs and food-based molecules with antiviral properties. Ultimately, they hope to enable tailored treatments to be developed for patients with COVID-19. The app works by creating a network of smartphones to power a virtual supercomputer, capable of processing billions of calculations, without collecting or disclosing users' location data. No personal data is downloaded to or processed from the user's device. Researchers believe that in the long run this work could speed up access to effective drugs and enable tailored treatments against this infectious disease. While traditional experimental research and standard research methods could take years to develop, the mobile cloud-based processing approach of DreamLab can drastically reduce the time taken to analyse the huge amount of data that exists. A desktop computer with an eight-core processor running 24 hours a day would take decades to process the data, but a network of 100,000 smartphones running six hours a night could do the job in just a couple of months. Instead of looking for brand new drug molecules, the project will search through a database of thousands of existing drugs that could be repurposed to fight COVID-19. As these drugs are already known to be safe, they could be used much sooner than new drugs. In addition, the project will comb through a database of food molecules that could potentially boost the drugs' ability to fight COVID-19 in the body. Coronaviruses need their hosts – us – to survive and replicate. They do this by 'hijacking' cellular processes, using our own proteins to help them survive. The complex interactions between the virus' proteins and our own are called 'virus-host interactome networks'. Traditional antiviral drugs only target one of the proteins involved, but this leaves the possibility of the virus mutating to get around the roadblock created by the drug. Instead, any treatment needs to be able to tackle multiple parts of the virus-host interactome network. This is where the supercomputing power of the nation's smartphones comes in. DreamLab uses machine learning, on a mobile supercomputing network, to analyse billions of combinations of existing drug, food-based molecules and genetic interactions, fundamentally reducing the time needed to make discoveries. The best treatment could include existing drugs and supportive molecules found in foods. However, mapping how combinations of molecules interact with the virus-host interactome network is very

complicated, and combinations of three, four, or even more compounds would be impossible to test in the lab. A member of the DreamLab collaboration, Professor Michael Bronstein from the Department of Computing at Imperial, said: "We are using network-based AI methods to identify antiviral compounds amongst a dataset of thousands of molecules, by modelling the network effects of the interactions between these molecules and biomolecules in our body. We have previously successfully used these methods to find 'hyperfoods' containing anti-cancer drug-like compounds, are now retooling them for the new disease." Eventually, the team hopes that multi-drug therapies with supportive diets could be prescribed to help COVID-19 patients recover.

SynSapien is a startup founded by Manolya Adan and Basil Mahfouz, both alumni from Imperial's MSc in Environmental Technology, to develop an open innovation platform to bring together scientists, researchers and innovators from around the world to share data and collaboratively solve global challenges. The inspiration for their platform came from the response of the scientific community to the SARS epidemic in 2003: 84 scientists from 13 labs across 11 countries collaborated to respond to the epidemic, achieving in one month what each lab would have needed over a year to do. The platform currently has several live projects being worked on by an interdisciplinary community of over 500 scientists, researchers, and students across the world, representing universities such as Imperial College London, the University of Oxford, University of Cambridge, University of Birmingham, University College London, Georgetown University, and Sorbonne University. This includes a project to design a low-cost emergency ventilator to help lower income communities respond to COVID-19. According to the World Economic Forum, ventilators cost around \$30,000 each, making them unaffordable to many healthcare systems in low income countries. SynSapien is inviting scientists and innovators worldwide to design a low-cost ventilator that can be locally produced at a value of less than \$99. Compared to other crowdsourcing platforms which run on a competitive model, SynSapien's system is a collaborative tool that enables large groups of users to innovate together to solve global problems quickly. The SynSapien team is supported by the Enterprise Lab, which works to support enterprising activity across the College by providing access to state of the art facilities, training, mentoring and a range of programmes to help Imperial's student innovators develop new business ideas, hone their pitching skills and raise their entrepreneurial aspirations.

Meanwhile, the Department of Aeronautics has been employing their 10x5 wind tunnel to support various research projects. For one project, early in the pandemic, the department teamed up with the Formula One team Mercedes-AMG Petronas and the Imperial College Healthcare NHS Trust ENT surgical team to test shielding devices designed to minimise the spread of patient-generated aerosols during surgery such as airway intervention, tracheostomies and examinations of the upper airway using flexible video scopes through the nose. As these procedures lead to patients coughing and sneezing, the need for protective devices is acute. Shield configurations

were designed using computational fluid dynamics and prototypes were then produced by Mercedes for testing in the wind tunnel. More recently, the wind tunnel has been used to assess the risk of transmitting COVID-19 during various forms of exercise, such as walking, jogging, running and cycling. Human volunteers exercise on fixed equipment like exercise bikes and treadmills under conditions which accurately simulate the relative motion through the air of an exercising person. Particles of CO₂ from exhaled breath are measured within the air currents behind the person exercising. CO₂ is used as a surrogate for virus-carrying aerosol, and is measured using new sampling probes, AirSniffers from AirPortal Ltd.

Three Design Engineering students have developed a range of antimicrobial face coverings, soon to be available across College outlets. This initiative – developed by Shafae Ali, Jemima Bradley and Alfie Mcmeeking – marks the launch of the DreamTeam, a concept created with Dr. Nick Munro, Visiting Professor at the Dyson School of Engineering and Imperial Consultants to provide students with experience on 'real world' projects. The three-layered face coverings feature technology by Swiss company HeiQ, with each layer individually helping to keep the user safe and comfortable. The inner layer uses a SmartTemp coating to provide dynamic cooling, whilst the outer layer is coated with Eco Dry and Pure water repellent technology. The middle layer features Viroblock technology, utilising silver ions and cosmetic grade liposomes allowing for antimicrobial protection. Alongside the custom branded designs, the intention is for the masks to represent a face covering that is both state-of-the-art and immediately recognisable. The students oversaw the entire process, from branding, development, sourcing, supply chain development, marketing and the creation of point of sale displays. In collaboration with Campus Services, the range will shortly be on sale across a variety of College outlets and venues, as well as being available on the Dill app. Jemima Bradley, Commercial Lead on the project, said: "We knew from the start that the technology was especially important, as I don't think that Imperial students should expect any less than the best that we can provide."

Important research is being conducted not just into the virus itself, but also how to manage the response to it. The UKRI is funding over £100K towards an Imperial-led project designing new exit strategies for COVID-19 lockdowns. Co-investigator Professor Thomas Parisini of Imperial's Department of Electrical and Electronic Engineering said: "The difficulty with intermittent lockdowns until a vaccine's found is timing: lockdown too early, and the peak of infections shifts to a later date; too late and it won't limit the peak." To circumvent this, the team, led by Professor Robert Shorten at Imperial's Dyson School of Design Engineering, with the University of Glasgow, will develop periodic short-term lockdown strategies to suppress cases while encouraging social and economic activity. They will also develop network-based infection models to protect vulnerable communities. The four-month project is a worldwide effort also involving universities in Italy, Israel, Ireland, Australia, Canada, Scotland, and France.

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

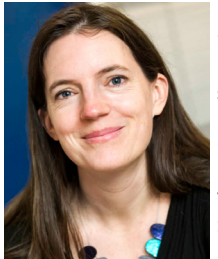
New RAEng Chairs

The Royal Academy of Engineering recently appointed two Imperial engineers as Chairs in Emerging Technologies. Professors Emile Greenhalgh and Molly Stevens have been awarded the highly prestigious ten-year funding – given to global visionaries pioneering technologies that could have global benefits. The appointments bring the total number of Chairs at Imperial to six – the most Chairs of any UK university.



Professor Emile Greenhalgh of the Department of Aeronautics has received the Chair for his project 'Structural power and multifunctional structural materials'. The Chair will enable Professor Greenhalgh

to focus on developing structural power composites – mechanically load-bearing materials that can store and deliver electrical energy. These multifunctional composites are a completely new way of using structural materials, heralding an emerging technology that could revolutionise sectors such as portable electronics, vehicles, aerospace, and infrastructure. If successful, such 'massless energy' could ultimately consign conventional batteries to history.



Professor Molly Stevens of the Departments of Materials and Bioengineering has received the Chair for her project 'Multidimensional Target-Agnostic Sensing (MTAS): the next generation of biosensors'. The Chair will enable Professor Stevens to focus on developing a range of new bioengineering technologies for strategies in biosensing. Professor Stevens and her group aim to develop the next generation of technology platforms on which to achieve these goals, including a new MTAS platform which will enable longitudinal monitoring of patients and biotech processes over time. Working closely with clinical and industrial partners, her multidisciplinary research will enable applications in diagnostics in point of care settings, profiling of diseases such as cancer and monitoring of biotech processes like gene therapy.

Earlier this year, **Professor Joao Cabral** of the Department of Chemical Engineering was appointed Procter & Gamble / RAEng Research Chair in Soft Matter Microflow Engineering. His work involves creating processes which can encourage soft materials to spontaneously assemble into complex structures. This could involve the use of flow, light, or heat. One of his aims is to address current challenges with water scarcity and sustainability and achieve a step-change in predictive research and engineering to enable the use of greener chemistry and lower energy processes.



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New RAEng Fellows

Five Imperial researchers are among 53 top engineers to be elected to the Fellowship of the Royal Academy of Engineering. The new elections take the number of Imperial Fellows of the RAEng to 97. Becoming a Fellow is one of the highest honours an engineer can receive in the UK and Fellowship is awarded in recognition of outstanding and continuing contributions to the profession.



Leroy Gardner is Professor of Structural Engineering and Director of Research in the Department of Civil and Environmental Engineering. His research into steel structures, advanced analysis and design, high performance structural materials and additive manufacturing has underpinned design code developments around the world and verification of the world's first metal 3D printed bridge.



Philippa Gardner is Professor of Theoretical Computer Science and Director of the Research Institute on Verified Trustworthy Software Systems (VeTSS) in the Department of Computing. Her research focuses on program specification and verification, exploring ways to describe mathematically what programs will and will not do. With her group, she has introduced compositional reasoning about complex concurrent programs, developed trusted mechanised specifications of programming languages such as JavaScript and Web Assembly, and built a platform to develop compositional analysis tools for programming languages such as JavaScript and C.



Sandro Macchietto is Professor of Process Systems Engineering in the Department of Chemical Engineering and a leader in enterprise and promoting interfaces between academia and industry. His research

focuses on the development of methods for the modelling, simulation, control, optimisation and design of processes using an integrated systems approach, and their practical use in a variety of applications like sustainable energy systems.



Esther Rodriguez-Villegas is Professor of Low Power Electronics in the Department of Electrical and Electronic Engineering and leader of the Wearable Technologies Lab at Imperial. Her research focuses on wearable medical devices and low-power integrated circuits with a focus on healthcare applications like brain, heart and lung conditions.



Omar Matar is Professor of Fluid Mechanics in the Department of Chemical Engineering, and Vice-Dean (Education) of the Faculty of Engineering. His research focuses on fluid mechanics and data-centric engineering with energy and manufacturing applications. He is working to develop the next generation of data-driven, physics-constrained, multi-fidelity predictive tools for improving design and decision-making under uncertainty, safety management, and for reducing carbon emissions.

RAEng Research Fellowships

Of 16 research fellowships awarded this year, two have been won by Imperial researchers. The Academy's Research Fellowships are designed to advance excellence in engineering by enabling early-career researchers to concentrate on basic research in any field of engineering. Each awardee receives five years' worth of funding to advance their research careers. They also receive mentoring from experienced Academy Fellows, providing valuable advice and industry links that will enable the researchers to establish themselves as future leaders in their fields.



Dr Timothy Runcorn from the Department of Physics – Advanced biomedical imaging. Diseases like cancer are usually diagnosed by biopsy, where a sample of the tissue is taken and examined in a lab. This can be a very invasive procedure for diseases like bowel cancer. Instead, biomedical imaging can assess the tissue during an exploratory operation without removing any. Currently, this requires highly complex and

expensive lasers, preventing its widespread use in hospitals. Dr Runcorn will engineer new fibre laser technology to develop cost-effective clinical endoscopes that use these imaging techniques.



Dr James Ewen from the Department of Mechanical Engineering, – Developing new lubricants. Lubricants help engines and other components run more efficiently by reducing friction between moving parts.

This enables vehicles to use less fuel and produce fewer emissions. Improved lubricants could reduce the energy consumption and pollution from the transportation sector by up to a quarter. Through a combination of molecular science and engineering, Dr Ewen is developing methods to design new lubricants using computational approaches. The flexible tools he develops will also be used to optimise fluids required for the moving parts in electric vehicles. Dr Ewen will collaborate closely with researchers at Shell (via the University Technology Centre for Fuels and Lubricants) and Afton Chemical, as well as university researchers across Europe.

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

Imperial engineers win ERC Grants.

Academics from Bioengineering, Computing, and Materials, were rewarded in the latest wave of European Research Council Starting Grants. The ERC grants recognise talented early-career scientists who show potential to be research leaders and have a scientific track record showing great promise. This year the ERC awarded more than 466 grants – including 62 to UK-based researchers – worth a total of €677 million.



In Bioengineering, **Dr Juan Alvaro Gallego's** IntuitiveBCI project is looking at improving brain-computer interfaces (BCIs) – devices that analyse brain signals to interpret the user's intended action, such as moving their hand to pick up an object. Dr Gallego says that BCIs have been used in research labs to control robotic limbs or stimulate paralysed limbs to move as the person intends. However, current state-of-the-art BCIs are much slower and less precise than natural movements. Once the team have a better understanding of how the brain executes skilled movements, they will develop and test a new type of BCI. "BCIs hold great promise to change the lives of many people, by restoring movement to hundreds of thousands of people with paralysis or very debilitating movement disorders. We hope to further the knowledge of what parts of the brain to look at and how to combine their information, so our findings could be broadly adopted in future BCIs. BCIs are still under development, but the field is advancing rapidly. So, a sci-fi future with people controlling things with their mind may come to fruition during our lifetime."



Also in Bioengineering, **Dr Rodrigo Ledesma-Amaro's** DEUSBIO project is engineering microbes to provide them with new functionalities that allow them to sustainably produce fuels, chemicals, materials or food. Microbial biomanufacturing has the potential to enable the transition to a green bio-based economy where our commodities and speciality chemicals do not depend on petroleum. "In this project, we will explore novel ways of engineering microorganisms by looking at how individual cells organise themselves within the population and how we can coordinate their behaviours by applying design principles. This project has the potential to enable the creation of robust microbial cell factories that can synthesise the chemicals of the future in a sustainable manner."



In Materials, **Dr Florian Bouville's** SSTEEL project is trying to find a way to mitigate or even remove brittle behaviour in material of any composition. "We experience brittle fracture in our everyday life, think about our

kitchenware or, now, cell phone screen and casing. But it has more dramatic consequences in place where brittle materials have to be used, at high temperature, in contact with the human body, or because they present unique functionalities. Some materials, for instance metals or polymers, can deal easily with brittle fracture with naturally occurring reinforcing mechanisms. But the goal of this project is to program reinforcements in any material that could delay or stop a crack by shaping the part into very small individual bricks that can interlock." Dr Bouville is aiming to develop a new process capable of precisely shaping these tiny elements to control how efficiently they will interlock when a crack wants to start, independently of the material composition used. The project could potentially benefit structural ceramics used for biomedical implants or in aeronautics. It could also make some components of energy storage or generation devices safer and more durable, and could even lead to more resistant mobile phones.



In Computing, **Dr Mario Berta's** QENTROPY research project is in quantum information science, a dynamic interdisciplinary field at the intersection of quantum physics, mathematics, theoretical computer science, and engineering. In recent years, there has been tremendous progress in the design and control of quantum devices, promising revolutionary applications in information processing – such as the prospect of physically secure quantum communication over the envisioned quantum internet. "In my project, we will develop novel mathematical methods in matrix analysis and optimisation theory that will build the basis of a computational framework of approximation algorithms revealing the ultimate, physical limits of quantum information science. This includes schemes for cryptography and communication, as well as algorithms for the description of strongly interacting many-body systems."

New AIAA Associate Fellow

Dr Paul Bruce, in the Department of Aeronautics, has been named as an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA).

The AIAA is the world's largest aerospace technical society. With nearly 30,000 individual members from over 91 countries, AIAA brings together industry, academia, and government to advance engineering and science in aviation, space, and defence. By selecting Associate Fellows, AIAA recognises individuals who have made outstanding contributions in aeronautics or astronautics. Previously, Dr Bruce has attended and helped organise various technical committees at many AIAA conferences. He has been a member of the Fluid Dynamics Technical Committee for three years, and is now on the Aerodynamic Measurement Technology Committee. Dr Bruce joins both Professor Rafael Palacios and Dr Matthew Santer as AIAA Associate Fellows in the Department of Aeronautics.

RAEng Special Award

The President's Special Awards for Pandemic Service are awarded by the Royal Academy of Engineering to recognise exceptional examples of engineering in the service of society during the pandemic. Nineteen individuals and teams of engineers from across the UK will receive specially commissioned silver medals for their contribution. **Regius Professor of Engineering Chris Toumazou** has received one of the awards for the CovidNudge lab-free COVID-19 test (see page 6).

The Queen's Birthday Honours



Professor Nilay Shah, Head of the Department of Chemical Engineering, has been awarded an OBE for services to the decarbonisation of the UK economy. His work aims to optimise the way we design and operate processes in industrial and energy systems. Some of his most important work has been in designing and analysing energy production systems – modelling and optimising technologies like carbon capture and storage systems, and minimising the cost of bio-ethanol production.



Senior Strategic Fellow, **Dr Deesha Chadha**, from the same Department, has been awarded an OBE for services to faith communities in her voluntary role as co-chair of the Faiths Forum for London. She was elected co-chair in 2019 and has served as a member of the National Executive Committee of the Hindu Forum of Britain for over 10 years. At Imperial, Dr Chadha is involved in the curriculum review process in her Department. She is also an active researcher in this area and teaches some of the technical content of the programme.

Visiting Professor Charlotte Williams, from the Department of Chemistry, has been awarded an OBE for services to Chemistry.

Also recognised is Imperial alumnus **Professor Graham Medley**, who receives an OBE for his services to the COVID-19 response. He is Professor of Infectious Disease Modelling at the London School of Hygiene and Tropical Medicine.

Alumna **Sheridan Ash**, Imperial MBA, was awarded an MBE for services to women and girls through technology.

Presidential professor

Professor Thomas Parisini, of the Department of Electrical and Electronic Engineering, has been elected President of the IEEE Control Systems Society (CSS) for 2021-2022. The Society, part of the Institute of Electrical and Electronics Engineers (IEEE) in the USA, is dedicated to the advancement of the theory and practice of systems and control. Professor Parisini said: "I am thrilled to be elected as President and am excited to begin serving the IEEE Control Systems Society for two years."

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

Women of the Future



Dr Nuria Oliva-Jorge of the Department of Bioengineering has been shortlisted as a finalist for the Aviva Women of the Future Awards in the Science category.

The Awards are intended to provide a platform for remarkable female talent in the UK. The Science category recognises a group of truly exceptional female scientists who are forging new ground in research and scientific achievement. Dr Oliva-Jorge is currently working on designing smart materials for biomedical applications, like nanoparticles for cancer treatment and biomaterials to treat inflammation and help regenerate tissue.

Dr Emma Chapman of the Department of Physics has also been shortlisted in the Science category. She is researching the first stars; how they formed and how they contributed to the Universe we see today. Imperial College London itself is also nominated in the 'Corporate' category.

New Materials Chair

The Department of Materials has announced the creation of the Armourers & Brasiers' Chair in Materials Science, a new professorial post that will have significant impact on research and teaching in the Department. The post secures additional academic leadership in materials science, enabling existing research themes to be strengthened and new challenges to be taken on. The Department is internationally renowned for its research, which spans biomaterials and tissue engineering; ceramics and glasses; engineering alloys; functional materials; nanotechnology and nanoscale characterisation; and the theory and simulation of materials. The Department has prioritised efforts to inspire the next generation of materials scientists through school outreach initiatives, and the post-holder will strengthen the Department's links with the Armourers and Brasiers' Company, which shares this aim.

The donation, the largest ever in the Department's history, establishes an endowment to fund the Chair indefinitely, with the title passing from post-holder to post-holder in perpetuity. The exceptional generosity of the gift will make it possible to offer the Chair with an enhanced salary and access to funding for the post-holder's research, factors which will make the opportunity attractive to the world's best materials scientists. Attracting and retaining top academic talent is a priority for the Department, and this post will play an important part in realising that goal.

The donation marks the 700th anniversary of the Armourers and Brasiers' Company, which was founded in 1322 to oversee standards in the production of arms and armour. The Company has a longstanding association with Imperial, having been one of the founders of the City & Guilds of London Institute. Promoting materials science is one of the Company's primary purposes and it has generously supported materials research and education at numerous universities, including Imperial.

London Mayor's Entrepreneurial competition

The London Mayor's Entrepreneur Programme aims to find the capital's best student business ideas that will benefit the city. The competition has four awards, three of which were won by Imperial student teams this year, each being awarded a £20,000 prize for their business.

The **health award**, won by **Unhindr**, aims to find innovations that improve physical and/or mental health for Londoners, reduce waste and make the health sector more sustainable. Unhindr is developing a technology to address the issue of inflexible prosthetic limb fitting which leaves amputees in pain and dependent on fitting clinics. Their solution, Roliner, is a sock that understands the body's daily changes and adapts to them automatically using artificial intelligence without needing hospital visits. Unhindr was founded by Ugur Tanriverdi, a PhD candidate in the Department of Bioengineering.

The **environment award** aims to find innovations to reduce carbon emissions and improve the environment in London and was won by **The Tyre Collective**, founded by Innovation Design Engineering students, Siobhan Anderson, Hanson Cheng, M Deepak Mallya, and Hugo Richardson from the Dyson School of Design

Engineering. The team have designed a solution to the growing problem of pollution caused by tyre wear from vehicles. Every time a vehicle brakes, accelerates or turns a corner, the tyres wear down and tiny particles become airborne, producing half a million tonnes of tyre particles annually in Europe alone. Their device captures microplastics from tyres as they are emitted. Once collected, the fragments can be reused in new tyres or other materials such as ink.

The **smart cities award** aims to find technological innovations to make London a better place to live and work, and was won by **Toilets4London**, a mobile app that enables people to find toilets wherever they are in the city. The app with a focus on improving hygiene and accessibility, will provide businesses such as cafes, pubs and restaurants with a way to open their toilets to the public while charging a small fee to cover maintenance and cleaning. Toilets4London was founded by Biomedical Engineering student Nina Rimsky.

The fourth, **creative industries award**, was won by **Art-Z**, a team from the London College of Fashion, UAL.

WE Innovate Programme Final

The WE Innovate programme, run by Imperial's Enterprise Lab, is the College's flagship entrepreneurship education programme designed to support the next generation of women entrepreneurs and help them accelerate their startups. The nine-month programme supports students to develop an early stage business idea and advance their leadership and entrepreneurial skills. WE Innovate includes business coaching, masterclasses and networking, offered remotely for the first time this year, with the overall aim of increasing the number of women in leadership positions, running startups and raising funding. At the final, five finalists will pitch in front of a virtual audience for a chance to win a share of a £30,000 prize fund, sponsored by bp.

- **Microplastics** are tiny pieces of plastic smaller than 5mm that pass through water filtration systems, entering the ocean and contaminating the ecosystem, posing health risks to humans and wildlife. A major source of microplastics is the cosmetics industry, with microbeads being used in exfoliants and scrubs. **Green Beads** aim to provide an alternative to microplastics through biodegradable, non-toxic algae, which they would harvest and shape into beads. The team, led by Chemical Engineering PhD student Lu Ai, say that their beads could be added into paints for sustainable painting, or to extend the shelf life of cosmetic products by incorporating antimicrobial agents into the beads.
- **CalidiScope**, led by medical student Luthfun Nessa, have developed a mattress topper to detect and prevent pressure ulcers. Embedded with sensors, it uses machine learning to help nurses to monitor patient movements, automate documentation and predict the onset of a pressure ulcer before it develops. By alerting nurses when a patient needs moving, CalidiScope say their mattress topper could save patients from unnecessary pain, save nurses time and prevent pressure ulcers developing.

- **Inspire Kids**, led by medical student Ahrabbey Sivananthan, are developing **SpiroLyte**, a pocket-sized collapsible spacer for inhalers used by children with asthma. Asthma spacers are tube-like devices that attach to inhalers, slowing down airflow to optimise drug delivery to the lungs. Inspire Kids' spacer remains attached directly to the inhaler and can be ejected at the click of a button, eliminating a multi-step process. Their spacer, designed like a space rocket, will be linked to an app, **Planet Aeroza**, to encourage children to improve asthma knowledge through a superhero game and interactive videos.
- **AqUasieVe** is a portable water filter designed for sustainable travelling. To avoid drinking contaminated tap water while on holiday, many travellers choose bottled water. However this still poses problems: many bottled water companies simply sell treated tap water, while plastic bottles contribute to waste and are a source of microplastics pollution. AqUasieVe's 5cm filter combines two technologies for water purification: hollow fibre ultrafiltration to mechanically separate water from microplastics, and UV light to break up the DNA of odour-causing and harmful bacteria. Users can attach the filter to a tap wherever they are, to access bacteria-free water. The team is Chemistry students, Giulia Casarano and Virginia Chiarentin.
- The vestibular system, part of the inner ear, is the sensory system that provides the leading contribution to our sense of balance and spatial orientation. **WeAlign** hope to increase accessibility and adherence to rehabilitation for people with balance disorders with an online platform to help them regain confidence, improve mobility and reduce the risk of falls. WeAlign say their at-home therapy, where patients play online interactive games, empowers users to play and track their progress, and receive feedback. WeAlign was founded by Innovation Design Engineering student, WuQing Hipsh.

Return to Vatnajökull

In April 2019, a group of three friends, all postgraduate students, Glen Gowers from Imperial's Bioengineering department along with Oliver Vince and John-Henry Charles from the University of Oxford, set off on an expedition to make a crossing of the Vatnajökull Glacier in Iceland, which was first crossed by a team of Cambridge undergraduates in 1932. Aside from their personal goals, the expedition aimed to conduct environmental surveys that would provide an insight into any long-term changes taking place in this rarely visited landscape. They also aimed to push the boundaries of expedition science by becoming the first team to conduct fully off-grid microbial DNA sequencing. They were supported, in part, by a grant from the OC Trust. This article is derived from their comprehensive expedition report and hopefully provides a flavour of their experience and achievements.

Introduction

Early in 2018, we discovered the diary of the 1932 Cambridge Expedition to Vatnajökull. This diary contains a superbly written and entertaining account of an incredible adventure undertaken by a team of undergraduates during the summer of 1932.

Against the odds, and with no prior polar experience, this team of six completed the first double crossing of Europe's largest icecap unassisted and unguided. Soon after the discovery of the diary, we found their scientific publications, their maps and their photographs from the expedition.

These discoveries sparked an idea that, through a combination of long hours, determination and luck, led to the most formative project that any of us has been a part of.

Due to the inaccessibility and hostile conditions on the Vatnajökull, the area that the 1932 team studied is visited extremely rarely. Our plan was to repeat the 1932 expedition as closely as practically possible in 2019. Among other aims, we planned to follow their route unguided and unsupported, rediscover evidence that they left behind and push the boundaries of expedition science as they did. Retaking their photographs and resurveying their basecamp would also give us an insight into any long-term changes taking place in this unique environment.

We are proud of our expedition results. Our scientific programme represented a step-change in the field of remote DNA sequencing, with our findings published in the scientific journal *MDPI Genes*.

Amongst other successes, our historical programme re-discovered a handwritten note that the 1932 team had left in a cairn at their basecamp on the northern edge of the icecap. Most importantly, we all returned safe and happy.

This expedition was much more than the highs and lows of our time on the ice. The training, fundraising, promotion, logistics and research challenged us in multiple dimensions. These challenges have developed us all as individuals and as a team.



Photos by Oliver Vince

The final sunset of the expedition.
The sun barely dipped below the horizon before rising 20 minutes later.

Aims and objectives

This expedition set out to repeat both the physical route and the scientific expedition spirit of the 1932 Cambridge expedition to the Vatnajökull icecap in Iceland. Our expedition had three key aims.

Historical aims

The 1932 team spent 7 weeks on the icecap, plus several weeks either side on the south coast of Iceland. During their time in Icelandic civilisation, they met with many local people and took a diverse range of photographs that show the livelihoods of the Icelanders in the 1930s. Whilst on the icecap, they took many more photographs and recorded their adventures in their diaries. Our expedition's first aim was to repeat their route as closely as possible and visit the key locations of the 1932 expedition. We aimed to discover any records of their visit that remained both on the south coast and at their basecamp. We also aimed to connect with the environment and retake as many of their photographs as possible.

Scientific aims

A major focus of the 1932 expedition was scientific data collection. At their basecamp

on the northern edge of the icecap, they conducted detailed botanical, ornithological, glaciological and geological surveys. They also drew detailed maps of this unique location. Our expedition aimed to conduct environmental surveys that would provide an insight into any long-term changes taking place in this rarely visited landscape. We also aimed to push the boundaries of expedition science by becoming the first team to conduct fully off-grid microbial DNA sequencing. Developing this technology opens the door to increasing our understanding of the vast range of life forms that exist in the most remote corners of our planet. Over 99% of the microbes that exist on this planet have yet to be discovered. This technology has the potential to change that.

Adventure and personal development aims

Before we began the expedition planning process, our team possessed limited relevant experience for independent polar travel. Our aim was to travel unassisted and unguided in one of the planet's most hostile environments as the 1932 team did before us. This presented enormous personal and team challenges in almost every way.

FEATURES

Location

The Vatnajökull Icecap forms an 8000km² frozen plateau between Iceland's two highest mountain ranges. Due to Iceland's position in the Atlantic Ocean and the icecap's proximity to the coast, the Vatnajökull is associated with unpredictable weather including extremely high winds and heavy snowfall. As we discovered on our expedition, it can also rain heavily, even in the middle of the icecap. The Vatnajökull icecap is situated in the south eastern corner of Iceland.

The Vatnajökull provides an ideal location for expedition teams looking for an affordable place to develop their experience of polar environments. It has many of the environmental characteristics of the polar regions, but it is much cheaper to access. Additionally, the presence of an excellent search and rescue (SAR) service and a lack of polar bears makes travel gaining experience significantly safer than elsewhere.

Findings

Historical findings

Our historical rediscovery began in the town of Höfn on the south eastern corner of the icecap. This was where the 1932 team landed in Iceland – we found records of their visit in the local museum and library, along with the buildings that they stayed in pre-icecap.

Our guide onto the icecap was the grandson of 1932 team's guide. During our expedition, we read their published diary, *An Iceland Adventure*, in real time as we experienced the same locations.

On the northern edge of the icecap, we scaled 'Dome 1', a totem looming over the 1932 basecamp. In a cairn on the summit we found fuel cans and, inside, a sealed tin containing a handwritten note from the 1932 team. This was a historical artefact that had never been seen before (confirmed by the

National Park). We were also able to retake several of their photographs and re-map the glacial lake, Thorbergsvatn.

Scientific findings

Our microbial sequencing effort saw us shrink a DNA sequencing laboratory into a lightweight and small enough form to fit into the back of a sledge. This was designed as a modern twist on the flora and fauna surveys conducted by the 1932 team. We achieved over 24 hours of microbial DNA sequencing on the ice cap, comparable to what would be expected in a full-size laboratory. All power for this was derived from solar energy ensuring this kind of experiment could be run repeatedly during the expedition. This work has resulted in a peer-reviewed publication.

Adventure and personal development

This expedition tasked us with organising a project on a much greater scale than anything we had experienced before. Prior to the expedition, sourcing sufficient funding, adequate training, and logistical arrangements proved a steep but invaluable learning curve. During our time on the icecap, fresh challenges developed minute by minute and forced us to respond accordingly. Having no guide or team member experienced in polar travel meant that this placed a sizeable mental strain on us all. Kudos goes to the whole team for channelling this strain into problem-solving and a constant cheerful, 'can-do' attitude. Protecting the delicate scientific equipment from the elements meant that we developed a conservative approach to progress – keeping ourselves well fed and well rested took priority over distance covered. In the end, this enabled us to achieve every single expedition objective and allowed us to live safely and without mishap for an extended period of time.

Historical discovery

1932 Expedition

In July 1932, 6 undergraduates from the University of Cambridge with no prior polar experience made the first double crossing of the Vatnajökull icecap in the south eastern corner of Iceland. In just over a month, the team used pack ponies, skis and their feet to travel unsupported over 120km on the icecap and then a further 60km into the volcanic desert to the north of the glacier.

Storms, the summer melt and failing equipment made their journey incredibly tough-going and prevented them from achieving all of their original expedition goals. Despite this, they were the first team to spend any length of time in this area and subsequently returned with a wealth of geological, glaciological, ornithological and botanical information along with the first accurate maps of the area and a collection of over 200 stunning photographs. Their published account of the expedition describes their journey in graphic detail.

The 1932 team consisted of explorers who went on to excel in all walks of life. The team was led by Brian Roberts, an explorer and diplomat who played a key role in the conception and development of the Antarctic Treaty. The team also included William Launcelot Scott Fleming, an explorer who went on to be a director of the Scott Polar Research Institute and Chaplain to the Queen. Both men were recipients of the Polar Medal for their roles on the British Graham Land Expedition.

Pre-icecap findings

We met several people in both Höfn (at the Glacier museum and in the library) and Vagnnstadir who knew of the 1932 expedition. Most notably, the team at Glacier Jeeps (Bjarni and Bjarney). Bjarney was, in fact, the grandson of Skarpajeddin, the guide for the 1932 team. We had the pleasure of interviewing Bjarney and looking at old photographs and, incredibly, skis left behind by the 1932 team. We were dropped off on the ice-cap by a living connection to the 1932 team, making for quite a special expedition start.

Icecap

Our main reflection from our time on the Icecap with regards to the 1932 team is that they must have had a much tougher experience than us (and were probably just much tougher people). Their equipment paled in comparison to what we were fortunate enough to bring (notably food, navigation, safety communications, tent, waterproofs).

In addition, satellite imagery and access to accounts from people who have previously visited the icecap allowed us to make better preparations than they ever could have done. Decades of climate measurements advised us to conduct our expedition in April, thus avoiding both the summer melt and the worst of the winter storms. The 1932 team went in July/August during the worst of the summer melt and had to travel by night to avoid falling



Satellite image of Iceland (courtesy of the NASA MODIS Rapid Response team) showing the Vatnajökull Icecap in the south-eastern corner of the country. The icecap occupies almost 10% of the surface area of Iceland.

into pools of meltwater. Nowadays, no-one ventures into the middle Vatnajökull during the summer. We hardly saw any crevasses, whereas they record multiple incidences where they nearly lost either team members or critical equipment into cavernous crevasses.

Cairn

In the 1932 diary, they mention that they left a ‘record of their visit’ in the Cairn on the top of ‘Dome 1’. Before departing, we weren’t sure of the exact location of Dome 1 – it is not apparent in satellite imagery nor is it marked on any subsequent maps of the area. We arrived at the northern side of the ice cap in thick fog and set up camp for the night. When the skies cleared in the following morning, we happened to be camped only 2km from a large dome, unmistakably resembling the photos from 1932.

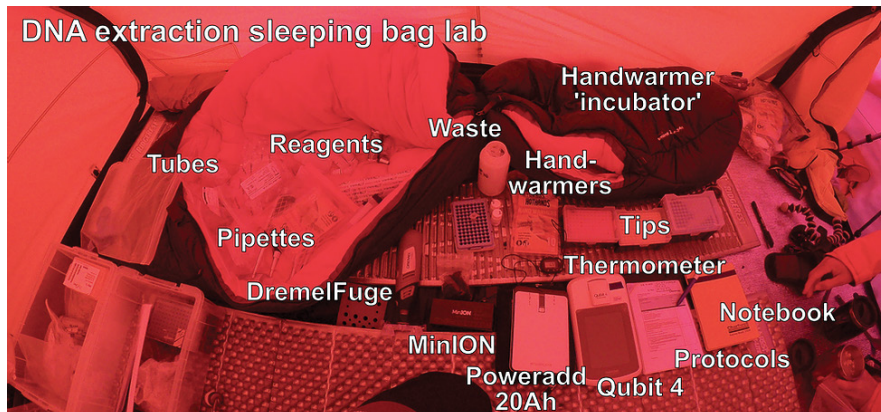
We scouted a route off the ice cap (probing for crevasses as we went) and scaled the dome. To our amazement a noticeable cairn was clearly visible. Moving aside a few of the rocks, we found a pile of weathered fuel cans. Though we were nearly certain this was from the 1932 team we didn’t want to get our hopes up until we had good proof. After some careful excavation, we found a sealed “24-hour ration Horlicks Malted Milk Tab” tin, caked in rust. Gently removing the rubber sealing we found a waxed note inside. This note contained a record of the names, college affiliations, and expedition roles of each of the 1932 members. Fantastically, though, a handwritten sentence survived at the top of the note reading “Camp on lateral moraine below this point from July 14th-28th 1932”.



On the summit of Dome 1, with the cairn in the foreground where the note was found.



Note from 1932 team, found inside a Horlicks tin in the cairn on Dome 1



Microbial research

This work has been published in an open access and peer-reviewed journal, *MDPI Genes* in the ‘Metagenomics in situ’ Special Issue. [Available via the link at the end of this article.]

Background

Travelling to the remote northern edge of the Vatnajökull ice cap in 1932, little was known about the flora and fauna of the region.

“Our object was to study all the forms of life, both floral and faunal, inhabiting a given area”

The Cambridge Expedition to Vatnajökull, 1932, The Geographical Journal Vol 81, 4 (1933)

Their inquisitive and thoughtful characterisation of the life in this remote region was a source of inspiration for our expedition. Where they contributed new insights into the types of visible life found in the remote northern region, we decided to turn our attention to characterising the little known world of life invisible to the naked eye. Microbes (bacteria, and other single-celled organisms) play an enormously influential role in ecosystems. Only recently have we appreciated their abundance and importance in extreme polar environments. Our ability to study these organisms has, thus far, relied upon taking samples back to a laboratory where DNA sequencing can be conducted to identify species. A major drawback to this approach is the propensity for samples to change and degrade over time. As we aim to study more and more remote corners of the earth the time between sample collection and analysis grows, increasing the chance of

sample alteration or degradation significantly. The result of this is well characterised microbial communities in close vicinity to Western research institutions but a lack of data representing the rest of the globe, particularly the most inaccessible regions. Recent developments in DNA sequencing technology have resulted in a handheld device that can be plugged into a laptop. This step change in technology has allowed researchers to take these devices to remote places and demonstrate that DNA can be sequenced in situ, eliminating the need to take samples. To date, however, such endeavours have made use of significant infrastructure, such as generators and vehicles. We saw an opportunity to demonstrate the ability to conduct DNA sequencing entirely off grid, out of a sledge, using solar power alone. In demonstrating this we hoped to create a blueprint that could mean anyone could sequence, and characterise, any microbial community in any remote corner of the planet. And so, in the spirit of the 1932 team, we aimed to meaningfully contribute to the scientific community by developing the field of expedition science.

Sequencing off-grid

With modifications to our lab equipment we were able to fit the entire laboratory (excluding laptop and solar panel) into two 9L boxes that could fit widthways in the back of the sledge. The only pieces of equipment not transported in a sledge were the flowcells, the lab-on-a-chip devices that perform the sequencing. Glen carried these on his person for the whole traverse to keep them from freezing.



All microbial sequencing was conducted within the confines of this tent.

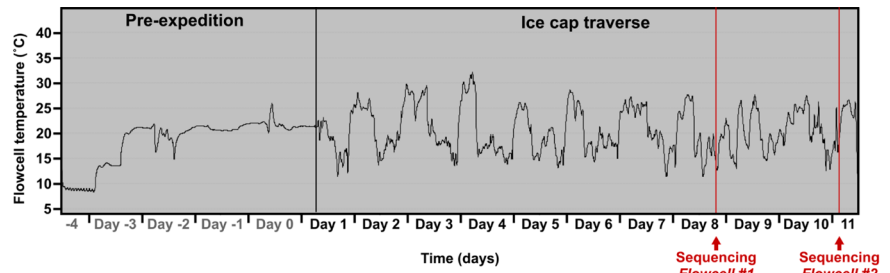
FEATURES

Preventing flowcells from freezing

A critical requirement for sequencing using Oxford Nanopore devices is to use 'active' flowcells. These devices plug into a laptop and are about the size of a smartphone. Flowcells, containing biological material, can rapidly degrade if allowed to freeze and it was therefore imperative to prevent the flowcells from freezing for 11 days while we traversed the ice cap and prepared for the experiments at our base camp.

During the outbound flight, the flowcells were kept in a polystyrene box. This maintained a consistent temperature of 9°C during transit. During the ski traverse, warm temperatures were achieved by placing the flowcells in a tupperware box and stringing this around Glen's neck. The temperature was monitored continuously using an aquarium thermometer with the probe attached to the outer edge of the tupperware box. Temperature could be regulated by moving the box between layers of clothing and layering more clothing on top. Interestingly, the wind direction and strength were more significant factors than ambient temperature, and windproof clothing layers were essential. At night, the flowcells were kept inside the sleeping bag attempting to keep them upright as much as possible.

Above right, is the temperature graph for the entire expedition showing that the temperature never dipped below 9°C, thus validating this method for keeping them warm. Ambient outside temperatures reached a minimum of -16°C during the expedition. Interestingly, at night the flowcells got too hot and at one point exceeded 30°C, the limit recommended by Oxford Nanopore, thus validating the impressive thermal retention properties of the Mountain Equipment Lamina Z - 30/34 sleeping bag and making for an uncomfortable nights sleep for both Glen and his flowcells.



The temperature of the flowcells was monitored for the entire expedition

Conducting solar-powered sequencing (solar-seq)

The final challenge, once we could extract and prepare enough DNA, was to maintain laptop power long enough to collect a meaningful amount of data. Oxford Nanopore sequencing runs a computationally intensive programme. This poses a problem where a normal laptop battery may only last a few hours in cold conditions. Ideally, sequencing runs should continue for 24-48 hrs to obtain sufficiently large datasets. We opted for solar power to generate enough power to achieve this. We pre-charged three 20,000 mAh power banks using a Mobile Solar Chargers 90W solar panel which packs down to the size of a thin briefcase. This solar panel could easily achieve 21V, 3A (-60W) during the long days, even in cloudy conditions. During the sequencing run, the PowerAdd battery was plugged into the solar panel continuously and simultaneously connected to the laptop when required to maintain laptop charge between 60-80%.

Results

We extracted DNA from a soil sample collected from the Hveragil hot spring gorge just north of the ice cap. Our DNA extraction protocol yielded 6.5µg of DNA in total, a

high enough quantity to perform Nanopore sequencing. We first ran a proof-of-principle sequencing run which aimed to use only the laptop battery power. This allowed us to determine if the run was generating useful and meaningful data rather than just 'junk'. Following this successful run, we used a fresh flowcell to perform data collection for as many hours as possible. Using the solar set up described above provided power from 8am-6pm. We continued our sequencing effort using the remaining power banks for a further 9.5 hours (until 3.30am). Combined, these two runs achieved over 24 hours of sequencing, comparable to that expected in a normal laboratory.

Blueprint for future expeditions

We hope that the work here lays the foundations for future expeditions to add DNA sequencing to their scientific toolkit. We anticipate that, in the future, performing DNA sequencing should be as easy as taking anemometer readings and amateur expeditions provide a vital resource for scientists to obtain passive data from the most remote corners of the world. We encourage any upcoming expedition with a scientific programme that could accommodate DNA sequencing to contact Glen (glgowers@gmail.com).

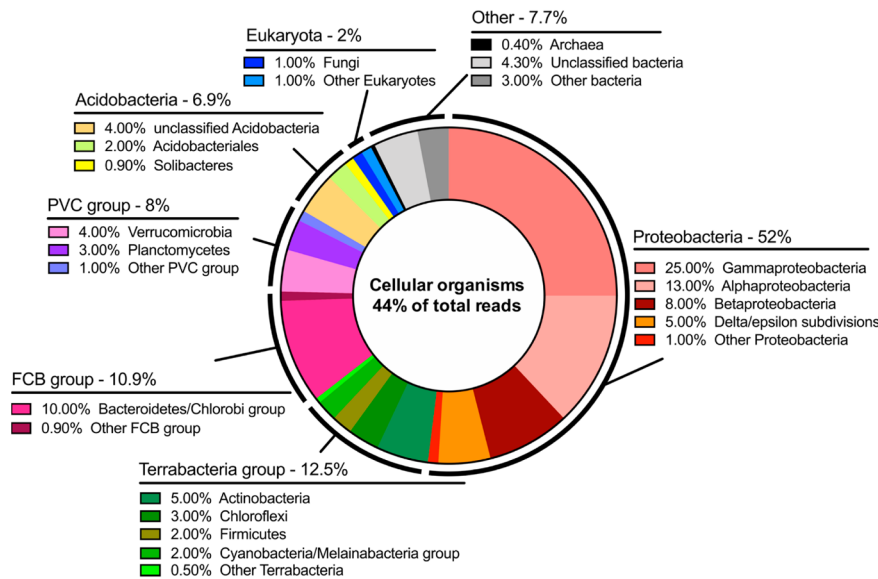
Other scientific contributions

Drone mapping

As a modern take on the basecamp surveys completed by the 1932 team, we were able to create 3D maps of several of the key locations around the basecamp; most notably Dome 1 and the Hveragil gorge. We believe that these maps are the first of their kind to be created of the area.

Whilst commercial software is available that can automate the path of drone flights, we preferred to maintain manual control to keep battery usage to a minimum and cope with any sudden changes in the weather. For Dome 1, an orbital flight was flown around the summit with a camera angle of 45° to the horizon. For Hveragil, the drone was flown in a line down the gorge (from above), with the camera pointing straight down. During both flights, the drone filmed continuously in 4K. Filming requires much less battery usage than stopping and taking photos at intervals and still achieved admirable results.

When back in the UK, sequential images (every 5 frames or so) were taken from the videos using Adobe Premiere Pro. These were then loaded into the Pix4d online software



Metagenomic protein-level taxonomic identification from both sequencing runs combined. Kaiju output is shown for 44% of reads that successfully aligned to the NCBI reference database and assigned to "cellular organisms". The relative percentage of reads assigned to "cellular organisms" of each group of organism is shown. PVC group, superphylum named after three important members: Planctomycetes, Verrucomicrobia, and Chlamydiae. FCB group superphylum named after three important members: Fibrobacteres, Chlorobi, Bacteroidetes.

which created high resolution 2D, 3D and topological maps of the locations. These 3D maps provide an exciting visualisation of the dramatic locations that we visited and allow an accurate depiction of the site of soil sample collection. As an added bonus, it allows a small model of the locations to be 3D printed.

Psychological surveys

As part of the scientific output of this expedition, we took part in a wider study into psychology on expeditions run as a collaboration between the University of Aberdeen, the University of Manchester, the University of Lancaster and NASA. This entailed each team member filling out a short psychological survey each morning and night of the expedition, along with a longer pre and post expedition survey. We are awaiting the aggregated survey results. To find out more, please follow this link:

<http://bit.ly/IE33-EPP>

Mountaineering

Kverkfjöll

In their 1932 book, the team end a chapter suggesting they are going to climb Kverkfjöll and begin the next chapter by saying they've got other plans. Our 2019 experience was not too dissimilar. Kverkfjöll looks beautiful and majestic from its eastern side but given our lack of experience at serious winter ascents, we decided it would be a challenge too far.

All routes up Kverkfjöll from the east appear to entail either engagement with quite heavy crevasses and steep glaciers (e.g. Skarphedinsjokull), or loose and crumbly basalt. That said, its natural beauty and isolation would provide an ideal challenge to more experienced mixed and winter mountaineers.

Svörtutírdar

From our camp, the clearest mountaineering objective in sight and within a reasonable distance (other than Kverkfjöll) was Svörtutírdar, a feature that the 1932 team named 'The Teeth'.

We spent a morning skiing to the base of the teeth, before John-Henry and Glen ascended to the highest point in two pitches whilst Oli flew the drone. The rock was crumbly and basaltic. We made an ascent up the most obvious line, following a chimney in the central section of the teeth up to the ridgeline, before following the ridge up to the summit.

Lava domes

We made an effort to ski up many of the lava domes in the area. The results of our ascents and descents were spectacular falls on nordic skis, in addition to 360° photographs of the summits of some of the domes. The 360° photographs of the dome summits have been uploaded onto Google Maps.

Further reading

Read the full expedition report and paper at:

<https://www.sledgereport.com/>

Team

Our team consisted of three friends with a passion for the outdoors who met whilst studying together at Oxford University. The complementary strengths and good-humoured, competent nature of the team was the bedrock upon which this expedition's successes were built.



Oliver Vince – Expedition Leader

Oliver's aims were to travel and live safely and comfortably in the harsh environment of an icecap. Before starting the expedition, Oliver had experience leading climbing and mountaineering expeditions in the UK and the Alps, as well as expedition experience in the Atlas Mountains and the Malaysian Rainforest. More broadly, Oliver had led a wide range of projects, experience that became invaluable during the organisation and fundraising parts of this project.

Oliver was primarily responsible for the overall logistics and fundraising of the expedition, along with the historical research elements and the 3D aerial mapping. As adventure filmmaking is a personal passion, Oliver also took primary responsibility for the film and photography aspects of the expedition. Oliver graduated with a degree in Engineering Science in 2016 and is currently finishing his PhD in cancer research.



John-Henry Charles – Technical Lead

John-Henry's primary aim for the expedition was to develop his polar experience, to build a platform for further expeditions in the future. John-Henry is also interested in guiding and wanted to continue to develop some of the technical skills for this profession. John-Henry took responsibility for route-planning, cooking, and safety – basically trying to ensure there were no major worries to distract Glen from his science and Oli from his filming.

Having previously completed an unsupported ski crossing of the Hardangervidda, with time spent on two Arctic expeditions (to Svalbard and the Canadian High Arctic), John-Henry had the most polar travel experience of the team. He also has extensive climbing and mountaineering experience across Europe, the Middle East and North Africa, leading up to E1 Trad and IV Scottish Winter. He had also completed long-distance cycles (including UK to Istanbul, and the length of Norway). He completed his Earth Sciences Degree in 2016.



Glen Gowers – Scientific Lead

Glen sought to combine his two major interests: the outdoors and biochemistry, to execute a scientific programme inspired by the 1932 expedition.

Using skills developed during his PhD in Biotechnology at Imperial, he aimed to identify microbial communities at the 1932 basecamp, using a miniaturised solar-powered DNA sequencing laboratory.

Glen has previous experience on offshore sailing expeditions and other expedition experience in the UK, Alps, and Tanzania. In addition to the scientific work, Glen was determined to improve his polar skills including nordic skiing, pulk pulling, and snow campcraft.

Valle de las Rocas in Bolivia

In the summer of 2019, a team of students (all but one from Imperial) made an expedition to Bolivia to go bouldering in the Valle de las Rocas. Bouldering, in case you don't know, is rock climbing stripped down to its raw essentials; instead of using ropes and harnesses, the climbers just use climbing shoes and a bag of chalk, with safety mats (pads) in case they fall. The challenge is to climb short but tricky bouldering 'problems' (a route, or sequence of moves) using balance, technique, strength, and your brain. Most boulder problems aren't more than 4 or 5 metres tall, most outdoor problems are located on large boulders (!) Successfully climbing a problem without falling is called a 'send'. The OC Trust helped to finance the expedition, and this article is derived from the entertaining expedition report.

Introduction

Our main aim was to travel to the Valle de las Rocas in Bolivia and develop the bouldering in that area. We also hoped by documenting our trip to encourage other climbers to visit the area themselves.

The Valle de las Rocas is in southwest Bolivia in the department of Potosí, within the province of Baldívieso and Nor Lipez. It lies 150km south of the city of Uyuni, between the villages of Villa Alota and Mallcu Villamar which are roughly 50km apart. The Valle de las Rocas is on the altiplano at an elevation of just under 4000m, where it provides a vast expanse of sandstone rock that is largely unclimbed and entirely undocumented.

The weather in the valley was pleasantly hot during the day but plummeted below freezing at sunset. There was no precipitation when camping in the valley. Overall, the conditions were excellent for climbing, if a little chilly at night. Very dry and hospitable.

We tried to leave as little impact of our stay as we could in the valley. We deconstructed any evidence of our stay, took all rubbish and litter with us and buried any ashes left behind. We also tried to avoid interfering with any wildlife.

Thankfully, despite avidly preparing for the potential threat of pumas, none were encountered. The main wildlife encountered were llamas, alpacas, donkeys and southern viscachas (large rodents resembling rabbits). Some small, flying biting insects were encountered at the third campsite but were not considered a threat.

The most widely spoken language in Bolivia is Spanish, which is spoken by many people in the east of the country and larger cities such as La Paz. Jon was the only member of our team who spoke fluent Spanish.

Diary

Day 1 (Saturday 29th June) We set off from Victoria station at 14:00 for the Gatwick Express. Successfully boarding our 17:30 flight to Madrid, despite the best efforts of a seemingly endless sea of Spanish schoolchildren ahead of us at check-in, we landed at Adolfo Suárez Madrid-Barajas Airport, marking the start of both our three-hour layover and a blossoming hatred towards the place.

Day 2 After surviving the eleven-and-a-half-hour flight to Santa Cruz de la Sierra, we began our second three-hour layover, awaiting

our final internal flight to El Alto International Airport in La Paz, the highest international airport in the world. We landed there at 09:30, but were unable to check into our hostel until midday.

Bouldering pads in hand, having met up with Jon, who travelled from Madrid through Bogota, and having rented our cars (two Toyota Hilux 4x4 pickup trucks), we left the airport and commenced the downward drive into the city.

The brickwork hills rising around us were the staggering backdrop to our first foray into Bolivian driving, with local rules of the road quickly becoming clear.

After finally reaching the hostel and checking in, our kind hosts politely baffled by the sheer volume of our luggage, we spent the remainder of the day exploring the city- trying new food, crossing terrifying bridges, and constantly losing our breath.

Day 3 Having successfully reached Bolivia and been rewarded with a restful night's sleep (on a bed, rather than the shoulder of a disgruntled fellow Air Europa passenger), the group divided into teams and set off to conquer La Paz, aiming to acquire much of what we would need for our time in the desert.

To maximise efficiency, four elite teams were formed: Team Food (Ben W, Jon, Martha, and Peter), Team Stuff (Charlotte, Jacob, and Stuart), Team Illness (led by Veera, who remained in the hostel because she felt unwell), and Team Dara (comprising Dara, who also stayed at the hostel, because he's lame).

Team Stuff got off to a rocky start. Lacking a fluent Spanish speaker and struggling to get by with Google Translate, it was difficult to track down more obscure items such as tarps and jerry cans. In the end, however, they emerged (somewhat) victorious.

Team Food, meanwhile, ventured into the city's food markets, charged with procuring basics such as oats, rice, and spices. This was an endeavour fraught with peril, for between every stall of pasta and lentils lay one of pastries and salteñas, and the team battled to stay on time and resist the beguiling Bolivian street food. Ultimately, we valiantly overcame this delectable adversity, stopping for snacks on a mere seven or eight occasions.

It is important here to note that among the



Photo: Benjamin Jones

The market in La Paz

spoils of our shopping spree, (pasta, potatoes, and porridge), was a selection of uncooked beans. We would like to take this opportunity to implore anyone who follows in our footsteps to avoid these beans, with desperate, reckless urgency, at any and all costs. Read on to find out why.

After a morning spent in the markets, the four teams combined (into the Bolivia Expedition Megazord) to have lunch at the local feminists' café. With Dara and Veera again remaining behind at the hostel, the evening was then spent seeing La Paz from above, completing a circuit of the cable car system, affording stunning sunset views of the mountain-encircled city.

Day 4 We began the long drive to Uyuni, stopping off in El Alto – the conjoining city which unfolds from the brim of the La Paz canyon and sweeps across the plateau above it – to pick up some more supplies.



Photo: Varalika Jain

The feminist café in La Paz

Supplies collected, lunch consumed, and Dara incapacitated (following a dare to eat a sizeable red chili pepper), we left El Alto and started heading for Uyuni. The route took us south along roads which slip through the vast expanse of the arid puna grassland, cast golden by the sun, interrupted only by the occasional town, tollbooth, or police checkpoint. While traffic was sparse, the presence of speedbumps, covertly and terrifyingly positioned at junctions on the motorway itself, ensured we remained wary.

In the light of the setting sun, we pulled over at a truck stop on the outskirts of a small town and sat down for dinner. Ben W questionably decided to sample some of the local delicacies (there of course not being anything inherently wrong with this decision, but there's a time and a place), and this rewarded him with a particularly dubious meal perhaps best described as a floss of crispy, shredded llama (but really, best not described at all).

With dinner completed and our destination now not too far away, we continued into the night. Save for periodic blinding by oncoming drivers' high beams, we reached Uyuni without incident, and checked into our hotel.

Day 5 Uyuni's bitter morning air crept throughout its dusty streets, noticeably colder than La Paz. With the life in us reignited by the gas burners of the breakfast room, and the sun beginning to warm the world outside, we headed to the market to tick off the final items on our list of supplies. While our original plan had been to leave Uyuni that afternoon, we resolved to stay another night, since Ben J – who had discovered he had lost his passport a week before we were due to leave, and had scrambled to get a new one as quickly as possible – would be flying into Uyuni to join us the following morning. We thus instead ventured to the outskirts of town to explore Uyuni's train graveyard – a tangled string of abandoned carriages, once part of the Bolivian mining industry, now washed in graffiti and rust.

Day 6 Having had our second Uyuni breakfast (where the jam tasted faintly of cheese, and the cheese tasted faintly of cheese), we began our final preparations to leave town and drive into the wild. Originally hoping to depart in the early afternoon, at about 12 o'clock we received a call from Ben J letting us know he had missed his connecting flight from La Paz to Uyuni, and wouldn't be able to get another until that evening (a further shining testament to his organisational finesse). Resisting the

compulsive, vengeful urge to desert Ben in rural Bolivia, it was decided that Veera (who was still feeling quite ill) and Peter would stay behind to meet him, with everyone else heading into the valley. Dara would then return to pick up Team Uyuni (providing Veera was feeling better) the day after next. Stuart, and particularly Ben W (perhaps due to his truck stop dining escapades) had also been unwell the previous night, but had recovered to the point that they didn't feel the need to stay behind.

Water bottles and jerry cans filled, and the cars all packed up, at around 3pm Team Valley set off on the final stretch of the journey. The drive was expected to take about two and a half hours, but the poor quality of the unfamiliar roads meant that by the time we turned off onto the dusty dirt tracks towards Laguna Negra (which had been identified as a reliable source of groundwater, and so was where we initially planned to make camp), it was already past 18:00, and starting to grow dark.

Persevering through the blackness, pierced only by our headlights and the stars, eventually we made it to the lagoon, and hurriedly set up camp. For the first time since our arrival in Bolivia, we were alone in the wilderness – the terra incognita – away from civilisation and security, only us, the fauna, the dust, and the Laguna Negra Gift Shop (rated an astounding 4.8 stars on Google Maps).

The hour of our arrival meant Team Valley did not venture much beyond the Laguna Negra car park (the lagoon being a popular spot for guided tours of the area, but with none ever journeying farther than needed to get a few scenic photos, into the rocky valleys themselves). A pasta dinner was made quickly, as the night turned ever icier, and washing up was deferred until the morning, upon the realisation that the washing up liquid had frozen solid. It was a piercingly cold night, and a bleak start to our stay in the desert.

Meanwhile in Uyuni, the town was astir with its weekly street market. In the early evening, Peter and Veera (who was starting to feel slightly better, now that all the ruffraff has cleared off to the valley) waded into the sea of stalls in search of food, and emerged with sugary fried dough and an entrancing drink like warm blackcurrant jam. Peter then met Ben J at the airport at 21:30, and was at least partly surprised to see he had, in fact, actually made it onto the plane. With Ben's storied voyage of tribulation and self-discovery coming to an end, the two of them went to



Photo: Charlotte Krishek

Our first campsite

join Veera at the hotel.

Day 7 We were roused by the rising sun struggling meekly to warm our frost-laden tents, and crawled out to our first view of the campsite in the light. A band of inquisitive donkeys eyed us nefariously from a distance, and everything was frozen.

Having surveyed our camp, our attention soon turned to what lay beyond it – a boulder-strewn sandstone landscape carved by rivers now long gone; alive, awake, and longing to be explored. Breakfast was temporarily forgotten as we headed out into our surroundings, an investigation yielding icy streams all set to slide across, the full seven-donkey family we had seen from our tents, countless promising rocks, and vast numbers of what we eventually found to be called vizcachas (but at the time were simply christened “weird chinchilla things”). Vizcachas might be described as half-squirrel, half-rabbit, large and bouncing, and much better at climbing than any of us. After returning to the campsite to “enjoy” some hot chocolate and porridge (which was really gruel, since it didn't have any milk), we set off keen to climb.

Our first day, along with many sends, was one of discovery – from llamas and alpacas, to large drystone walls standing seemingly abandoned, breathtaking rock forms cut by ancient waters and ancient winds, and several groups of tourists, led around by their guides.

A typical encounter with such a group would unfold as follows:

Tourists: “Did you guys really camp out here last night?”

Us (stifling traumatic flashbacks to frozen water, wet wipes, washing-up liquid, beards, breath, toes, and souls): “Yes, yes we did.”

Tourists: “I bet that was cold! Hahahaha!”

Us: (Pained laughter)

A slightly more uplifting interaction was that with a friendly local guide (one of many, who were always kind and always helpful), telling us exactly where we were (Valle de Catal), what the “weird chinchilla things” actually were, and where the true Valle de las Rocas (the area we primarily intended to visit) was.

At the end of a successful first day of climbing, the team settled back into camp and began to prepare for dinner. Charlotte, in the meantime, launched her earnest mission to ensure our evenings were never so cold again, constructing FirePit V1.0, and gathering dead and desiccated brushwood to fuel it.

Jacob had brought with him a book about colours – each chapter a different colour and



Photo: Jon Urquidí Ferreira



Photo: Jon Urquidí Ferreira

The train graveyard in Uyuni

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its story. That night began the tradition of a bedtime fireside reading from this book, adeptly narrated by Ben W, who opened with mauve: a tale of Queen Victoria, malaria, and Bunny – the eccentric inventor of Capri pants. This evening proved far warmer, both in temperature and in spirit, than that which came before it.

Back in Uyuni, be it due to Ben J's inextinguishable cheer, or Peter's medical mastery (there being no other conceivable explanations), Veera was thankfully starting to feel much better. After the three of them had breakfast, Veera returned to bed, whilst Ben, determined to make up for lost time, took Peter to experience some authentic street food. Peter, being a squeamish eater and until this point opting to eat as much western food as possible, very graciously kept his complaining to a minimum

Reuniting for lunch, the trio decided to return to the train graveyard in the early evening (which Ben J was yet to see). They sat in a street level dining room adjoining the market hall. Here, they ate a rich, salty vegetable stew, into which a fiery chilli salsa could be mixed to ward off the cold. With cakes and pastries purchased in town, they sat atop one of the broken locomotives and watched the sunset over the deserted steel cemetery. They followed the rusted tracks back to town under starlight.

Day 8 Charlotte and Dara left that morning to retrieve the straggling team members from Uyuni, the route now familiar, and negotiated in far better time. In town, the group stopped by the market to grab some lunch and fetch some extra supplies, bringing back sensational new culinary possibilities, as well as at least a kilogram of biscuits. Lunch consisted of thin strips of chicken, beaten flat, battered in egg and fried. Before driving back to camp, the return journey accommodation in Uyuni was rebooked a day earlier, and another night was

booked in La Paz, offering us an extra day to explore the city and tie up loose ends.

Back at camp, the morning was spent battling a very broken stove, it having somehow become clogged with molten plastic the previous evening. After some considered tinkering, the blockage was successfully removed, the team treating themselves to some salty porridge in celebration, followed by a mindful yoga session led by Ben W and Jon. While many tourists stared, the group were too engrossed to care – since yoga (as it turns out) is hard. The session completed, Team Camp capitalised on their newfound physical, mental, and spiritual liberation, heading out to explore a new area close to the Laguna Negra itself. One of the more iconic climbs of the trip – Fat Africa – was set up, and they sat down to birdwatch across the water.

Team Uyuni having returned, camp morale improved decidedly with the arrival of Ben J and his dazzling collection of fairy lights, really putting the cute and cosy into desolate desert campsite. A freak pasta spill proved but a small obstacle to people hungry enough to eat straight off a rock, and Charlotte upgraded the FirePit to V1.1. The nightly "Poo Circle" was born, to check in and make sure that everyone had a healthy digestive tract, and before we all went to bed, Ben W read to us about celadon green, in the flickering light of the campfire, the fairy lights, and the Milky Way.

Day 9 Every morning, the strained grunts of Ben W trying to get out of his 3 sleeping bag liners echoed throughout the valley. This particular one was the morning we decided to move from Valle de Catal to Valle de las Rocas, so we packed up and bid farewell to the llamas and vizcachas. We initially ended up in the car park for Valle de las Rocas, where we had lunch and a local guide told us of a mystical river somewhere in the valley. We all split up and discovered, over the course of an hour and some sunstroke, that there was

no river. There were only dry and depressing streambeds containing bones and dead shrubs. However, despite this misery and dehydration, Dara and Jon managed to find us the Most Perfect Campsite of All Time.

It was enclosed by tall stacks of pockety rock, with a naturally formed entrance, back door, and places for the kitchen and living room. However, there were also a lot of plants that looked like soft grass but were in fact sharp and insidious cacti which we fondly named Devil Pubes (Do Not Sit On!). Best of all it was far away from the road and potential tourists.

Then began the water adventures. We split into Team Camp and Team Water – Team Water had several disasters while Team Camp peacefully pitched tents and found a table rock. Because there was no water in Valle de Las Rocas and we had nearly run out, it was decided to do the short drive back to a lagoon we had spotted and filter the water from that. The disasters included but were not limited to:

- Wet, boggy, muddy ground requiring building of a dead-shrub bridge into the lagoon
- Red larvae in the water
- Leeches in the water
- Loose filter and no tool to tighten
- Filter washer broken
- Thought had fixed filter, it rebroke with a popping noise
- Containers used to collect water from the one functional filter were leaky
- Water so sedimented it took 4 people to pump the filter
- Even when filtered through sock, silk, and sand, water was too sedimented to go through Ben W's filter without immediately clogging, deeming it undrinkable

Due to this, Dara and Jon had to head back to the closest village by car to fill all our containers from taps there. Team Camp made FirePit V1.2, set up the fairy lights, and started chopping for dinner. Dara and Jon returned just as people were starting to worry, and just



as dinner was done – perfect timing.

That night we made bananas with dark chocolate melted in them, wrapped in tinfoil and put in the fire. They were delicious but very hard to retrieve. People realised that feet can be even more warmed if you take your shoes off, and many socks were happily singed as toes defrosted.

That night's colour was gamboge yellow – poisonous, earwaxen, yet beautiful. A comparatively warm night!

Day 10 As soon became tradition, Jon led a topless yoga session whilst a small contingent of clothed rebels left the campsite to investigate the rocks nearby. Many top-class climbs were set up, and eventually the flexible people joined the stiffers. All routes were sent except “Tall and Snappy”, which was avoided after the largest hold snapped off in a freak accident. Peter told the rest about a mystical cove of steep, tempting overhangs that he'd seen on his morning run. Everyone set off to try and find it but settled for a slightly less overhanging area after doing several exploratory loop-the-loops to no avail.

The first tragedy of the day came when Stuart, whilst trying the group's most difficult ascent so far, ripped a chunk out of his finger on a small spike in the rock. It was a gruesome scene. Blood was everywhere, Stuart was put out of action, and we no longer had a resident wad. The climb was named “Finger Shredder,” to honour the occasion, but was never finished.

Little did we know that this was just the beginning. A lovely peaceful evening, containing a blissful massage train and a stunning watercolour by Ben W, was a brief respite in our stress, before the most notorious event of the trip began: **Beangate**; the longest wait for beans any group of humans has ever endured.

We boiled the beans for 20 minutes, having soaked them in the day – they smelled absolutely delicious! Oh, how joyfully and naively we chopped the onions to throw in.

We were told they'd stew for an hour. We made the table; we played cards on the table. We built a fire. We wrapped corn in tinfoil and put it on the fire. We listened to music. We unwrapped the corn and passed it round for 1 bite each at a time, ultimately having 8/9 of a corn cob each. We waited hours. The beans kept being “nearly done”. The rice was cooked. The beans still weren't done, and the rice went cold and mushy. Peter went to bed, no longer hungry. Eventually, the beans were given up on. We had cold rice with soy sauce and avocado, followed by desperate handfuls of very dry cake that Ben J had bought in Uyuni. There was no poo circle; no colour bedtime story. Just desperately trying to warm up by the fire before bed.

“Possibly the most disappointing thing to have happened in the universe.” – Stuart McClune, who'd recently lost 5% of a finger on a climbing expedition over 6000 miles from home.

Beangate was at least 4 hours long. It was a cold and empty night.

Day 11 After another morning of topless yoga, we decided to head back to the car park of Valle de las Rocas in search of good rocks to climb. Peter's excellent rock divining ability lead us to the moon boulder at the start of a ridge full of many promising rock formations. Stuart and Martha went on a hike southwards to do some adventuring despite the shredded finger, and still ended up finding a beautiful boulder to climb despite their trekking intentions.

By this point in the trip we were starting to feel quite comfortable in the flow of wild camping. Our campsite became very homely. The kitchen included a table, stove, drying rack; the living room had a great fireplace; the bathroom was massive, with amazing views.

That evening Ben created firepit V2.0, inspired by the cooking of the corn the night before. Firepit V2.0 was an impressive

feat of engineering, allowing for a flow of air underneath the embers to keep the fire burning hot all night. It enabled us to keep warm whilst we tried to contain our anticipation for the arrival of the beans. Unfortunately, despite having been cooked for many hours the night before, they still took another 3 hours of them being almost ready for Beangate to finally be over. That night, we also treated ourselves to dessert. We combined the last of Ben J's cake with two cans of unsweetened condensed milk. This was passed around the fire with varying degrees of enthusiasm. It was only by the next morning that some of the more lactose-challenged members realised that maybe they should have had a little less concentrated milk cake. That night we learnt about Vantablack before bed.

Day 12 Everyone woke up exhausted. The day started with a slow breakfast and no yoga, and then, with three climbing days in a valley filled with literally thousands of rocks, we decided to go back to the ones we went to the day before. The worst thing about Bolivia continued to be the extremely persistent flies that refuse to leave you alone. Dulce de leche wafers ran out rapidly – a highly prized currency in our desert community.

There came a point where we'd exhausted the boulders in our small area, so decided to check out what we called “The Lone Boulder” – a reasonable-looking rock a short walk away (or so we thought). What we hadn't considered is the distance-warping effects of the desert light on a vast flat plane. We eventually reached the boulder, not sure how far we walked to get there.

We decided that there was some interesting, if probably quite hard climbing on it. However, we hadn't brought crash pads or shoes.



Our second campsite

Photo: Charlotte Krishek

After the walk back, Martha and Stuart led us to a boulder they had found on their hike the previous day. It had one challenging, sharp problem, removing 30% of the group's fingertips. However, it was finally defeated by Jon, but only after he had taken his top off.

That night, we discovered that if you don't eat carbonara quickly enough it turns into a solid cold mass that's quite hard to eat. Martha's feet were so cold that she melted the soles of her shoes before her feet were successfully warmed by the fire. The new and aggressively ventilated firepit was much needed.

Day 13 Dara, Jon, Peter and Charlotte left early in the morning for a general resupply, heading to San Cristobal. Unfortunately, because it was market day in Uyuni, the market in San Cristobal was somewhat depleted. Nevertheless, the group was still able to buy some jerry cans for water storage and top up food supplies. Jon also went on a mission to try and find a source of internet as Charlotte and Peter's exam results had been released and they were eager to know whether they needed to start practicing for re-sits. He tried asking a man who worked in the local phone shop, but the shopkeeper didn't appear to know much more than we did. It was only after talking to the local youth that we discovered you can get data after purchasing a Bolivian SIM. Jon then successfully purchased a SIM card and Peter and Charlotte found out they had passed their exams!! But not before a dramatic day of Peter refusing to look at his results *cough*.

The San Cristobal team returned to the old campsite where everything had been packed away ready to move on. In a handstand/stretch session, Ben J did a forward roll straight into a cactus. After packing everything onto the back of the 4x4s, the group said a sad goodbye to a perfect campsite, then ventured off into the unknown – towards Lost Italy.

As we drew close to Lost Italy, the group became slightly skeptical, looking up at the tall rocks on either side of the road. Becoming conscious of the time, we pulled over and split up into pairs, heading in different directions to find somewhere to set up camp. The terrain was so full of guinea pig burrows that people frequently fell through the ground. Jacob and Charlotte came back victorious with a

potential site away from the roads. At this stage in the trip the group set up camp like a well-oiled machine, quickly identifying the kitchen, living room and sleeping areas. Firepit V2.1 was set up and the group settled into their new home. Ben W read aloud about woad and its indigo defeat, and everyone felt much better after food.

Day 14 At this point in the trip, people were starting to feel quite tired. Half of the group went on a long walk up a nearby hill ...

The other half decided to chill at the campsite. For some people this decision was made due to laziness. For others, it was due to unfortunate ailments, mainly diarrhoea. A very relaxed day was had lounging in the sun, and occasionally disappearing out of sight with a shovel.

Martha and Stuart went on a hike, and found a valley containing a stream and very many llamas. The llamas had tiny scarves, and while lots of them made normal llama sounds, a select few made noises of other species – cats, sheep, quiet cows.

Dinner was good and lentilly. The colour we studied that eve was heliotrope, which is so pleasing to say it "feels like a rich, buttery sauce in the mouth."

Day 15 On the morning of the 13th, half of the team woke up to find that the other half had diarrhoea. Ben and Peter left at 10am to climb a nearby 5200m mountain, in a casual manner. The campsite boulder was climbed, and a route was named "fizzy pineapple", after the slightly fermented pineapple that we suspected was the cause of the diarrhoea. Stuart made the decision to climb again – but with his finger very strapped-up – and climbed a very difficult route annoyingly quickly after making this decision. Ben and Peter returned victorious to a beautiful sunset, having climbed a closer 4990m mountain instead of the 5200m one.

After dinner, a car stopped quite close to our camp and everyone was healthily concerned. Then they turned their lights off, and a large portion of the group became unhealthily concerned with thoughts of bandits and people creeping towards us in the darkness, with us blind to their progress. Just as we let the fire die down to gain better night

vision, another car drove towards the first and stopped, lights off.

"They could outnumber us now," said most of the team.

"They probably have a puncture and that's the mechanic," said Stuart.

In a chaotic move, Ben J sneaked away in the darkness and then jumped out at us, causing several near-heart-attacks. Eventually both cars turned their lights on and drove away, presumably because the faulty tyre had been replaced. Ben W read to us about khaki, which comes from the Urdu word for "dusty". **Day 16** The group decided to relax and climb in an area that Jacob and Ben J had found the day before. Peter did a little climbing, attempting some more challenging boulders which he didn't quite manage to top, then went back to camp and relaxed in the sun with a facemask and some good music. He has absolutely no idea what anyone else was doing.

The first cloudy day of our expedition led to some very calm and creative cloud-spotting by the people who stayed at the climbing place. We walked back to the campsite along a very beautiful sunset-lit ridge, as the full moon rose.

As a treat for dinner, we chopped up all the potatoes we had left, and Dara deep-fried them in a wok above the fire. Ben W was the "monkey with a bunch of spices" who seasoned the chips before they were passed round. We also had corn on the fire, and deep fried some bananas in whiskey sauce. Whilst we were eating our delicious desert-junk-food, a dog came up to us! It was a bit scared though, and only emerged twice before disappearing forever (or so we thought). It had a bow around its neck and a single dreadlock and was very overgrown.

People went to bed at different times due to differing levels of illness, so there was not a colour that night.

Day 17 We woke up early to set off for the National Park, leaving some beans to soak ready to be cooked on our return. We stopped off for a quick breakfast at Villamar Mallcu before taking some small winding roads towards the National Park. Whilst stocking up on petrol there, we saw the same little dog that had visited our campsite! We ate in the restaurant "todo pollo", who definitely don't normally do breakfast, and had bread with jam and eggs. On the drive, some concerns were raised as one of the cars seemed to have a slowly leaking puncture. However, with no way of fixing it, the group decided to carry on. There were a few hiccups at the entrance to the National Park, including not having enough bolivianos to enter. Fortunately, the group had enough US dollars, but these needed to be exchanged inside the park before we could leave. After much deliberation and Jon's expert help in translation we were let in. The scenery inside the park was amazing, with magnificent multicolored mountains. The first attraction we saw was an outstanding orange lake, home to a fair flock of flamingoes. After taking an appropriate number of pictures and doing some litter-picking, we set off to try and find the geysers.

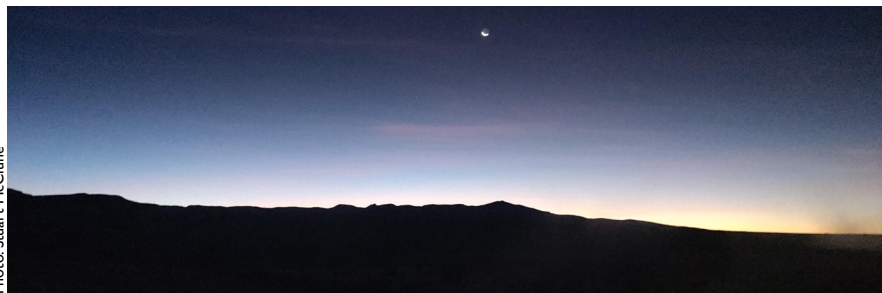
After some wrong turns, we ended up at some hot springs. It was at this location that we learnt that usually when tourists went to the National Park they would spend a few days there to make the most of it. The group thought that this was a good idea and decided to stay the night. Despite the last-minute change of plans, half the group miraculously had their toothbrushes. Unfortunately, none of the group had any swimwear. We checked with the locals if there was a dress code for bathing in the hot springs, and we were assured that going in naked was acceptable. We cautiously peeled all our layers off and dashed into the deliciously hot water. To our alarm, there was also a group of young local children trying to enjoy the hot spring as well. We made sure to keep to opposite ends of the pool. As we sat there soaking, the grime that had built up over the last two weeks slowly washed away revealing whether you really had got a tan or not.

Unfortunately, all good things must come to an end and as the sun started dipping down towards the horizon, we decided that getting out of the hot water was probably better done sooner rather than later. Shivering and somehow with only 9 towels between 10 people, we got dressed again and headed back to the hotel. Long hair held enough water to freeze, which we discovered as Veera's hair turned into dangerously sharp corkscrews. Exhausted, after a much-needed warm dinner we went to bed. To maximise warmth we decided to sleep two to a bed with double the amount of blankets. This was a good tactic, as the 'beds' were actually just blocks of concrete that were continuous with the concrete floor. It was not warm.

Day 18 Without the light of the sun to wake us up, the group had a long lie in. During breakfast we exchanged our dollars for bolivianos so we could pay to exit the park. After talking to the local guides of the park we set off for Laguna Verde, a bright green lake as the name suggests. Next we went to the Geysers, where you had to choose between freezing winds or smelly warmth.

After this we decided we should head back to camp to try and avoid returning too late. We had decided to not visit the fabled rock tree of the National Park (a rock that is in the shape of a tree) as you can't climb it, and what's the point of a rock if you can't climb it? We were sure that there were plenty of better rocks back at camp. The drive back to camp was long, requiring us to use our emergency fuel after following the wrong path. It was getting late by the time we returned to Villamar. We had a to beg a local restaurant to stay open and feed us. Whilst they prepared our food, we were entranced by the TV showing *Clash of the Titans* poorly dubbed in Spanish. After *Clash of the Titans* finished, we set off for camp, guided by the GPS.

We were blessed by our previous forgetfulness of not turning the fairy lights off (also blessed by long battery life). A thin line of light amid the darkness guided us home (helped by Peter having saved the camp



The setting of the desert sun

location to the GPS – a useful, albeit slightly less romantic tool).

Day 19 We woke up to our last full day in the valley. One last day to fulfill our climbing dreams. The morning started slowly, with people trying to get their sends in on the camp boulder. However, some members were keen to find some new boulders. Jon and Peter wandered off to investigate some potential new boulders...

Charlotte, Jacob and Ben tried to find them, and, when they couldn't, ended up going back to the cloud-spotting area where they found some parkour problems and an interesting traverse. Unfortunately, skin got too thin and stomach started to gurgle before anyone could send the traverse. They left it as a project and went back to find out what everyone else had been up to.

The unfortunate incident of the undercooked beans part II, moral of the story – don't try to soak beans for three days, or even better, just avoid them at all costs while camping. **Beanageddon.**

If you recall, some beans were left soaking before we left for the National Park. We thought we were being smart by leaving the beans to soak for all that time. We thought we had learnt from our previous mistakes. We split the beans into two large saucepans and started cooking them on the fire. As they cooked we reminisced, laughed and planned for the next day. A few hours later one of the saucepans of beans was cooked. We eagerly dished out the beans, proud that they had cooked in only one night. Only Peter, who wasn't feeling hungry did not have any beans. There was an incentive to eat everything to minimise food waste, thus those who could eat more forced themselves to have as many beans as possible. We forced ourselves to wash up after dinner so we could pack away everything ready for the morning. Everyone settled in for an early night, aware that we would be waking up early the next morning to get back to Uyuni in good time.

As people settled into their sleeping bags Beanageddon began. Frequently through the night people had to run out of their sleeping bags, grab some toilet roll if they were lucky and sprint as far as they could make it into the night (which sometimes wasn't very far).

Day 20 After a miserable night for some (and miserable morning for others) the group packed up camp as quickly as possible, shivering with cold and generally feeling sorry for themselves. Soon they were in the cars with the heating on full blast, driving back through the valley towards civilisation. We stopped

at a mechanic in San Cristobal so they could check the tyre of the car. It turns out there was a large nail through one of the tyres. This was quickly patched and we were on our way back to Uyuni, feeling a bit better.

We checked into the hotel around lunch time, marvelling at the luxury of it all. However, we didn't have time to stop as we wanted to go and see the salt flats. After hurriedly unloading a mountain of equipment into the foyer we divided up into our different rooms. We paused quickly to buy some food before getting back on the road and heading to the salt flats.

We marvelled at how truly flat and salty they were. We visited a closed-down hotel made out of salt, and saw the sunset from a cactus island. The group was sad, as it was likely our last beautiful sunset in Bolivia, and our last chance to see the magnificence of the stars.

We returned back to the hotel and got changed for dinner. We returned to the restaurant recommended by Ben J. It was very strange to be around other Caucasian people and to be spoken to in English. After a very satisfying dinner, everyone headed back to the hotel for a much needed shower with soap.

Day 21 In the morning we had to wait for the cars to be cleaned after our salt flats adventure. This allowed the group to have a luxurious buffet breakfast and do some last minute shopping for friends and family. Once everything was ready, we packed up the cars and started the drive back to La Paz. In Dar's car, we were initially entertained by medical facts from Peter. However, the drive was long and things soon changed.

Peter the indestructible medic who had been well all throughout the trip was struck by an awful bout of diarrhea and vomiting. He ended up almost pooping in someone's front yard on our journey back out of urgency and desperation.

The fog as we drove through Oruro, a major city on our way back was incredibly thick. Making it very difficult and stressful to drive. However, we managed to get through unscathed and the rest of the journey to La Paz was uneventful.

Day 22 Last day in La Paz. Team car split off to take the cars back home to Europcar. On the way, they were rewarded for their hard work as they stumbled across a Peruvian Gastronomical Festival and gorged on local(ish) delicacies. The remaining part of the team went around La Paz for last opportunities to buy mementos and soak up the culture. The last evening with

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the whole group together, now more a family than a team, was spent eating traditional local food, drinking locally brewed beer and being absolutely exhausted but merry.

Day 23 Our alarms went off painfully early, with many people only getting a few hours sleep. We rushed to get our final things packed and get to the taxi. However, we had to do all this as silently as possible as one person in the room wasn't part of our group. We made it successfully to the airport and blearily walked through security, crossing our fingers that all our luggage would make it back to the UK. We tried to amuse ourselves by reading, sleeping or watching the free movies on tiny screens. Dara loved watching *How to Train your Dragon 3* for the fourth time.

Day 24 We landed in the early hours of the morning in Madrid, exhausted after the long flight. As it was early most of the shops were closed. We hoped that Burger King would open before our next flight. But alas, our dreams came crashing down and we had to eat more expensive but equally unhealthy food. The only redeeming aspect of the airport – and perhaps the biggest triumph of the expedition – was the 3 for £10 deal on 300g bars of Milka in duty free.

After a not-too-long flight to Gatwick, we stood waiting for the train back into London with our mountain of luggage (thankfully it all made its way to London with us). It was a moment of strange surrealness. Returning to normal life after spending two weeks in the desert without showering. Sadness spread through the group as one by one, people parted ways from the group they had spent all their time with for the last 3 weeks. It was a truly unforgettable experience with a bunch of amazing people (and Peter).

What we would do differently

In the future, we would make sure to properly check water filters are working before the trip, and to take with us methods of pre-filtering water. This would have saved a lot of time and money on our trip.

The vast majority of Bolivian people only spoke Spanish. Many people of our group did not speak any Spanish. This therefore made communicating quite tricky, for all aspects of the trip. It was infinitely useful having Jon on our trip as he spoke fluent Spanish. It would have been useful if more members of the group had a greater understanding of the language.

Trying to cook dried beans was a mistake both times. We would not recommend attempting to cook beans on any camping trip.

It would have been useful to have more information on the National Park before visiting it. It was difficult to access information online beforehand as the main way people visit the Park is through tour guide companies. However, it would have been useful to know the cost beforehand and how long it would take to drive round. Then we could have planned for a two day trip rather than it being a spontaneous decision.



Photos: Stuart McClune

The expedition team

Expedition Leader

Charlotte Krishek

Medicine 6th year, BSc Medical Sciences with Respiratory Science (2019)
2017–18: ICMC, President
2018–19: ICMC, Stores Manager

Chief Medical Officer

Peter Rhodes

Medicine 6th year, BSc Medical Sciences with Pharmacology (2018)

Treasurer

Varalika (Veera) Jain

BSc Biological Sciences (2019)
2018–19: ICMC, Secretary

Junior Medical Officer

Dara Vakili

Graduate Entry Medicine 2nd year (Imperial),
BSc Applied Medical Sciences (2018, UCL)

Official Route Grader

Stuart McClune

BEng Computing (2019)
2018–19: ICMC, Vice President

Chef, Water Master

Benjamin Warmington

MEng Biomedical Engineering 4th year
2018–19: ICMC, Social Secretary

Motivational Cheerleader

Martha Gutteridge

BSc Biological Sciences 3rd year

Eager Newbie

Jacob Mitchell

MEng Design Engineering (2019)

Photographer and Videographer, Backup Ben

Benjamin Jones

Medicine 2nd year

Translator, Coordinator and Driver:

Jon Urquidi Ferreira

Graduate Entry Medicine 2nd year (KCL)

Managing Black Swans

Professor Atula Abeysekera, FCGI took over as President of CGCA at the (virtual) Annual General Meeting held on 8 June 2020. Following the AGM, he gave a talk entitled 'Managing Black Swans'. It was timely in June, and is still as timely (maybe more so) now. We present a transcript here as it will be of wider interest than just those attendees of the CGCA AGM.



The story about No 10

Can you imagine Downing Street in the frantic days of February, March, April and May of this year?

Well, I can give you an insight as to what it's like there.

In 2010, shortly after the financial crash of 2008, I was invited to No.10 to advise one of the most senior members of the Coalition Government.

The picture above is me on the day ...

... I confess it was rather thrilling.

My meeting – which then became a series of meetings – was with the Minister of State for Government Policy. And later I had interactions with other Junior Ministers.

Our first conversation was about sharpening up government's ability to foresee and plan for the unexpected.

1. To be better prepared for and smarter about avoiding risks.
2. To be constantly alert and avoid being mugged by what are commonly called ... Black Swans.

Is there anyone in Britain today who hasn't heard of Black Swans? Or, as Donald Trump would probably call them, Chinese Swans.

Our conversations were constantly interrupted by Larry. Larry as you may know is regarded as very important. He's allowed to go everywhere in the building and make his views and presence felt.

But ... Larry is a cat.

He's a rather irritating cat.

With all my meetings with the Minister he'd rub himself against my legs and occasionally give me a disapproving look. I'd reflect, "Larry doesn't agree with risk assessment and crisis planning" as the cat glared at me.

My thinking was this: Get rid of silo thinking.

I said the government should introduce "system thinking". In managing extreme risk there's always been too much departmental thinking. Cut across departments and a much broader and more intelligent consideration of risk challenges emerges.

This very nearly happened, but the politics of Brexit intervened. The iceberg that is Covid19 seemed a long way away from the Titanic of government back in 2010, despite my and others' cautions.

And that was very disappointing.

Today I wonder if I shouldn't have been more blunt and echoed George Osborne's mantra – *fix the roof while the sun's shining*.

But I didn't and – anyway – I suspect they wouldn't have listened ... then.

Government is – always – more concerned with today's news story than the future.

Its preparedness for risk remains more hopeful than prudent.

My role in all this is that I've spent my life in risk management. I'm regarded as having expertise and long experience in the field for over 30 years.

"Engineering thinking" leads the way

My proudest day – apart from the achievements of my three children – was when I was asked to become Professor of Risk at Imperial College, London. This was at the department of Civil Engineering, arguably, the best civil engineering department in the world.

I started life as a chartered engineer. I did a 5 year stint of apprenticeship at Mott MacDonald, an organisation over a century old. It was a wonderful place to learn about engineering. Engineers learn about risk the hard way. If they get things wrong, buildings fall down and people die.

Recently on a BBC Radio 4 programme the achievements of George and Robert Stephenson, the Victorian engineers and 'Father of Railways', were being discussed. An interviewer asked how important engineers were seen as being back then. Engineers were revered in the 1880s – we were told. They had great influence. Men like Brunel, Bazalgette and Watt.

Of Prime Ministers since 1721, only five graduated in anything scientific: Gladstone

and the Marquis of Salisbury studied mathematics; Baldwin and Chamberlain engineering metallurgy. Alone ... Margaret Thatcher ... read Chemistry. She was our only real scientific PM in 300 years. (Incidentally, Angela Merkel is a physicist by education.)

Only two engineers. A great shame. Because engineers are good at risk assessment. This is what they spend most of their life doing.

That's what the recently late, and certainly great, Jack Welch, Chairman and CEO of General Electric in the 1980's believed. He graduated – and did his PhD – in Chemical Engineering and he said:

[Engineering is...] "one of the best backgrounds for a business career. There are no formulaic questions to most business problems. The same is true of engineering."

So a third of me is an engineer. A third is a senior risk officer at Schroder Cazenove (an institution that's 236 years old, where risk assessment is vital.) A third is a teacher at Imperial College.

Risk, engineering, investment and teaching – these are my greatest loves after my family.

Thinking Small – a new way forward

The benefits – and the risks – of globalisation have been brought to life – and death – by the coronavirus pandemic.

Ten years ago I produced for government a short book called "What's the small idea?" In it I argued that a big drive of innovation was key to our future national prosperity. And innovation starts in *small* places. Usually with individuals and small businesses.

But innovation by definition takes one into the unknown and that's risky. Innovation is found in a *small* lake where Black Swans swim. I talked about *small ideas* because one of the things government consistently exaggerates is the power of big, centralised government. I believe exactly the opposite is needed: *decentralisation and the licence to think small*.

In trying to solve any problem, you need to break the problem into smaller components and take small steps. This is better than attempting great, audacious, problem-solving leaps.

In computer science a divide-and-conquer algorithm works like this. By recursively breaking down a problem into two or more sub-problems of the same or related type until these become simple enough to be solved directly.

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What has changed as a result of my Initiative?

First – some good news.

The most satisfying thing about my spell at No.10 is that a few things did change and to good effect.

1. Each government department now has a lead Non-Executive Director responsible for interrogating Black Swan Risks.
2. Investment has been made into “*Horizon Scanning*” thinking about tomorrow and the day after tomorrow not just today. These are made up of academics, people from industry and ‘wise’ men and women.
3. The initiation of “Three Lines of Defence” for risk framework for major infrastructure projects. Treasury now insists on a documented risk assessment encompassing three lines of defence.

The real key lay in shifting thinking away from “*how do we react?*” to “*how would we react if the unthinkable happened and what’s missing in our toolkit to deal with such an eventuality?*”

Interestingly the former Minister of Government Policy has just written a book called “*Apocalypse How?*” set in the year 2037. Its thesis is that our increasing reliance on integrated digital technology may be leading us, and ultimately every country in the world, in the direction of a catastrophe. We are getting so integrated that when the system fails, everything in our lives will fail ... driverless cars, WiFi, phone systems, utilities, emergency services and media – everything blacks out. It’s a disturbingly dystopian vision. As I read it I felt rather flattered to find so much of our conversations in Downing Street had found their way into his book.

But here’s the bad news.

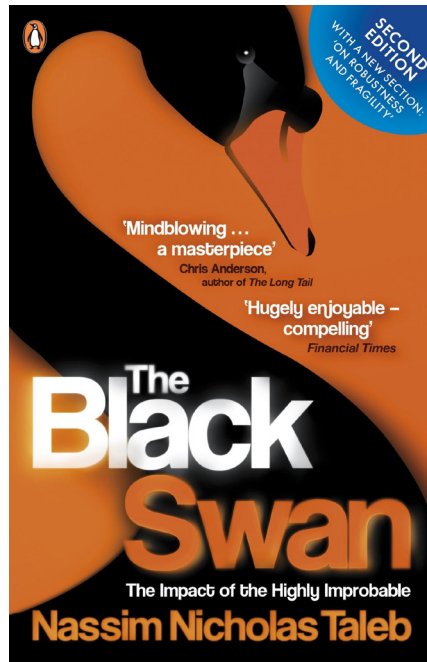
All that listening, all that nodding and all that’s in his book says that he got it. That he understood the importance of being ready. But then? Nothing happened as it should have done. Especially in investing in critical issues like crisis planning.

What about the story of Black Swans?

Where did this strange breed come from? The phrase “*black swan*” was created by the 2nd-century Roman poet Juvenal signifying something that doesn’t exist, that can’t exist.

Black Swan was widely used in 16th century London as a statement of impossibility. But in 1697 Dutch explorers saw Black Swans in Western Australia and the impossible became reality.

More recently author, academic and future and options trader, Nassim Taleb wrote a book called ‘*The Black Swan: The Impact of the Highly Improbable*’.



In a fast moving world we’ve come to believe that our advanced technology has given us greater control over our destinies, that social media has given us information, opinions and news at such breakneck speed that this makes us omnipotent.

We are constantly told that knowledge is power ... but it isn’t. We never know enough. Even the smartest get it wrong. A Black Swan is something that you don’t know about because:

1. It occurs outside projected expectations.
2. It carries an unexpectedly extreme impact.
3. It seems only explainable after the fact.

A Black Swan could manifest itself like this: it actually happened to a friend of mine. He took a great-sounding C-suite job involving moving from the UK to Tokyo. This was at a considerable personal cost and disruption to the family. On the day he arrived, a major earthquake happened in northern Japan. There, a nuclear reactor was flooded by sea water. The waves produced by the particular earthquake were so large that the sea barriers at the reactor proved 8m too short to stop the resulting tsunami. The damage was substantial, and this created a mini-recession in Japan with remediation cost of \$250bn. He was made redundant and returned to the UK at significant personal financial costs.

Could he have predicted this? No. It was a Black Swan – an extreme event. An unforeseen event. But on reflection an event that should have been foreseen (and was foreseen by an ignored few engineers.)

Big companies spend a lot of money identifying Black Swans but this expertise is not widely available to individuals or small businesses or governments.

In the future we shall increasingly need to assess how much we must invest to mitigate the risk of something bad happening.

Be they floods, earthquakes, invasion, war, a global collapse of the Internet, a worse pandemic and so on.

Apparently, all risk analyses done as recently as last year’s Davos Economic Review thought a pandemic would potentially have high impact but that there was only a relatively low likelihood of its happening.

They simply forgot to factor in an important component – Velocity. When something bad happens it behaves like a tsunami. It gets bigger, worse and accelerates very quickly.

One way to help avoid Black Swans is to widen your research and consult people outside your industry network. This helps to reduce groupthink, get fresh ideas and understand the potential risks you face.

I must also stress the importance of modelling – stress testing and scenario analysis. A ‘good’ model is as good as the quality of data feeding into it. Otherwise garbage in and garbage out. The models need to be independently validated and continuously recalibrated.

Whilst a model can give some guidance, sole reliance on it can be equally dangerous. Ultimately, in my opinion, there’s nothing to beat experience and knowledge from other, diverse industries.

Black Swans are often bad luck. You can’t beat bad luck but you can shorten the odds.



In 1697 Dutch explorers saw Black Swans in Western Australia ... and the impossible became reality



My work on the Grenfell Enquiry

I am a little closer to that particular Black Swan event. I was asked to serve as one of the industry experts to assist the Government on how to change the culture to support greater building safety following the tragic Grenfell fire. We had to implement recommendations from Dame Judith Hackitt's Independent Review of Building Regulations and Fire Safety in 2018.

Twelve of us, made up from different industries, met every two months from November 2018 under the Chairmanship of Dame Judith with the remit to:-

1. Hold to account industry players responsible for driving forward specific changes of the Building Safety Programme and ...
2. Accelerate the industry culture change to prevent a Grenfell disaster ever happening again.

Dame Judith's 159 page final review pulled no punches and concluded:

"... the current system of building regulations and fire safety is not fit for purpose. The system failure identified in the report has allowed a culture of indifference to perpetuate."

A culture of indifference ... hmmm!!!
 "A culture of indifference" is pretty damning.

The increasing need for rigorous scrutiny in a number of sectors in their processes and their attitude towards risk has been deemed urgent. Perhaps some of my urgings and pressure have helped make this happen. I hope so.

Recently I've been asked by Dame Judith to examine the relationship between the insurance business and the construction industry which many believe is broken. I'll be doing this as an external expert working with and guiding a ministry team.

This world of risk is getting hot.

Why are you doing this?

There's a big question I was frequently asked. For instance, a senior and active member of the House of Lords quizzed me as to why I

Consider the Coronavirus issue.

The Government was juggling. It was trying to protect the NHS's capacity to cope, to safeguard the lives of the fit and well, to save the elderly and less fit from untimely death, to keep the economy ticking over and capable of being restarted and, finally, it was trying to sustain trust and confidence in central government.

It got some things right. But it did not grasp the importance of velocity and failed to prepare adequately.

In 2007 Black Swans were rare – now they're everywhere

Black Swans are not only a reality – they are becoming commonplace. There are flocks of the wretches wherever you look. Plagues of locusts in East Africa, bush fires the size of the UK in Australia, floods – a month's normal rainfall in a day now commonplace in parts of the UK – earthquakes in Turkey, volcanoes in New Zealand and of course catastrophes like the Grenfell Tower fire.

was doing this. Why was I prosecuting my lonely course of trying to get busy politicians and cabinet ministers to turn their attention towards and think about the unthinkable.

There are four simple reasons:

1. Because I believe it really matters, especially in such a fast moving world.
2. Because I believe by being intelligent, circumspect and calm we can avoid many expensive and tragic events.
3. Because I passionately believe the short termism culture must change. Politicians' attitudes towards managing risk are woeful.
4. *Because I believe we can tame Black Swans*

Advice from an Advisor, Professor and Thinker

I'd like to conclude with seven pieces of advice that I'd urge you to think about.

1. **Think small.** Think in manageable chunks. Remember the computer engineers who take small steps solving big problems. Thinking small can lead to big solutions.
2. **Think velocity.** We are (as I've said) living in a fast moving integrated world. And it's getting faster. If we can't keep up with its speed we shall fail.
3. **Think about resilience.** Are you tough and calm in a crisis? Do you panic?

In another book by Nassim Taleb called *Anti-Fragile. Things that gain from Disorder* he reflects that human bones get stronger when subjected to stress and tension. Similarly many things in life benefit from stress, volatility and turmoil. *Anti-Fragile* is resilience lifted to a new level. Anti-fragile describes things that not only gain from chaos but gain immunity when exposed to change.

4. **Think radical.** People are prone to talking about normal ... in a crisis they say "when things get back to normal". In my experience normal is history and you can't turn back the clock. You must go forward. Radical is the new normal.

An example of this was the speed of construction of the Nightingale Hospital at the Excel centre. Not normal. Just radical.

5. **Think failure.** When I was young, I remember a friend who deliberately broke his toys. He pulled them apart to see how they worked.

We test cars by crashing them. We constantly run pressure stress tests to see how financial systems will survive or fail. Thinking about failure is thinking about consequences.

6. **Think individual, then local, then national and then global.** Build your thinking from the bottom up. Thinking about the big picture and globalisation leads us away from the most important thing of all ... people.

7. **Think people.** Put people first, not processes. If you think about people first, I believe you'll be on course to help create a better, stronger and happier world.

If you have questions please ask them. I'll take the risk that I can manage to answer them.

<http://www.small-idea.co.uk/>



Grenfell Tower

Photo: Alex Danila / Shutterstock.com

Mineral Deposits of

In September 2019, the Imperial College London Society of Economic Geologists Student Chapter organised a Field Trip to Peru. It was funded, in part, by the OC Trust. This article is derived from the report produced by two of the organisers, George Nicholas and Jay Ward, who were 4th year MSci Geology students.

Preface

This year's field trip to the Central and Southern Peruvian Andes built on the success of the 2018 trip to Namibia and was organised by George Nicholas, Jay Ward, Dan Keogh, Tom Matthews and Jonny Coad of Imperial College London SEG Student chapter.

The trip ran from the 1st to 12th of September and was attended by 11 students – 3rd and 4th year MSci Geology students from Royal School of Mines, a Minerals Processing MSc student from Camborne School of Mines, two PhD Research Students from the Natural History Museum and a MSc Mining Resources student from Pontificia Uni. Católica del Perú (PUCP). In addition, our group included a Project Geologist from Mineco, a Base Metals Analyst from CRU Group, a Geological Analyst from CD Capital, and Diego Mesa, a PhD Research Student from Imperial who was also acting as our guide and interpreter.

We visited nine sites across a variety of operations to provide attendees with an overview of the whole mining process; including: open-pit mines, underground mines, smelters, processing plants, SXEW plants and even geochemical laboratories.

**2nd September:
Joint-PUCP SEG Symposium**

The Geological Society of Peru (Sociedad Geologica del Perú) hosted our annual symposium, jointly organised and chaired by Jay Ward (Imperial SEG Chapter) and Raquel Chang (PUCP- UNSAAC SEG Chapter). The Symposium included talks from professors, researchers and students from Imperial College London, Natural History Museum (London) and PUCP (see box below for a list of the Symposium presentations).



Full auditorium at the Geological Society of Peru for the joint symposium

**3rd September:
Cerro Lindo Cu-Zn-Pb VMS**

We started off our first field day with a long, early morning drive south of Lima, arriving at the primary security gate for Nexa Resource's Cerro Lindo VMS deposit at about 10 AM. An unfortunate breakdown of communication between the mine site geologists and security contractors meant we had to leap through a fair few bureaucratic hurdles to get our insurance documents confirmed. Following this, an unexpected 2-hour drive up into the mountains to arrive at the actual mine site then meant that we didn't arrive on site until around 2 pm. Though this meant our visit was cut a little short, this is part and parcel of operating a mine in remote areas and I think the whole group was left impressed at the ambition to build this large an operation in such inaccessible terrain.

Cerro Lindo is a polymetallic resource with primary income derived from its Cu & Zn content. The group were given an in-depth and knowledgeable introduction to the deposit and regional geology; also learning about interesting processes such the remobilisation of toxic elements (e.g As or Bi) which are usually associated with VMS deposits by metamorphic fluids, and how this has resulted in a cleaner ore body relative to others within the deposit class.

One half of our group were then taken to the original discovery location of the deposit whilst the second were given the chance to inspect the drill core. Here we picked up useful tips on finding mineralisation using texture mapping (e.g. monomict vs polymict) – whereby mineralisation is generally found only in breccia not conglomerate, because the structure more easily allows fluids to percolate through.



Photos courtesy of Imperial SEG Student Chapter

Pure pyrite in drill core

**4th September:
Pisco Sn Smelter**

A short morning drive brought us from our accommodation in Pisco to the Funsur smelter. Once again, we had a few paperwork issues but the staff at the smelter were fantastic and really went out of their way to get the necessary insurances sorted in order to make our visit happen.

The smelter is one of the biggest of its kind in the world and solely processes tin from the San Rafael mine, also owned by Minsur. The concentrate is shipped overland by daily truck convoys.

We were given an introductory lecture from Alexis, the H&S manager, who talked us through the novel and pioneering technology employed by the smelter such as a Top-Submerging Lance – of which there are fewer

Symposium Outline

Session 1: Mining operations – From exploration to processing

- Exploration Project Celebici:* Dragana Stojanović, Mineco
- Copper Market Outlook:* Jaime Sepúlveda, CRU Group
- Challenges in Minerals Processing:* Diego Mesa, Imperial College London

Session 2: Geochemical insights into ore systems

- Titanite in Porphyry Systems:* Tom Matthews, Natural History Museum
- Apatite in Porphyry Systems:* Emily Brugge, Natural History Museum

Session 3: Peruvian geology and mineral deposits

- Peruvian Mining and Mineral Endowment:* Miguel Cardozo, PUCP
- Critical Elements in the Central Andes:* Jean Vallance, PUCP
- Au-bearing Pyrite at Shahuindo, Peru:* Lisard Torró, PUCP
- Organic-rich Facies in Eocene Red-Beds:* Silvia Rosas, PUCP

Central & Southern Peru



A view of the Pisco Funsur smelter from the car park (no phones allowed inside!)

than 25 in the world. Alexis provided detail on the smelting process far beyond what we have received in our lectures which resulted in an enriching expansion to the students' knowledge of the mining industry beyond the purely academic geological understanding which tends to be covered in lectures.

We were then treated to a tour of the smelting operation and took in the huge stockpile warehouse before inspecting the furnace – where we saw the lances being repaired – and then watching a live pour of molten metal, a first for many of the group who had not visited a smelting operation before.

5th September:

A minerals processing grand tour Plenge Metallurgical Laboratory

In the morning we stopped off at Plenge Laboratories, a mineral processing consultancy, where Angélica guided us around and explained the whole Metallurgical process in great detail along with some fantastic demonstrations of the froth flotation process. Despite most of the group having taken a minerals processing module at university, seeing a small scale operation close-up was a first for many. It was also interesting to see their geochemical equipment and miniature processing plant, featuring a mini SAG. A worthwhile visit!

Río Seco Mn Processing Plant

After a brief drive to the north of Lima we arrived at the Río Seco Mn processing plant. The plant ingeniously turns unwanted Mn-rich impurities in Uchucchacua's concentrate into a valuable by-product, avoiding concentrate penalties as a result. We were given a fantastic introductory talk by Richard Villagary, the Head of Process, before being taken on an in-depth tour of the operation. The efficiency, cleanliness and smooth operation of the plant impressed all of us and the facility really set a gold standard for the other facilities we would visit throughout the rest of the fieldtrip.



Looking across the Río Seco facility

6th September: Uchucchacua Ag-Mn-Pb-Zn Skarn

A tough day but well worthwhile! After an especially early (4.30 AM) wakeup to avoid road closures, and a windy drive up to 4500 m.a.s.l. (through stunning scenery) we arrived at Uchucchacua, feeling somewhat worse for wear and certainly noticing the lack of oxygen. Welcomed by our hosts we took breakfast, completed our medicals (those who needed it enjoyed a dose of oxygen) and then we headed off to inspect some rocks.



Half the group pose for a photo with the Uchucchacua's flotation cells

We were split into two groups, with the first group heading immediately underground and the second receiving a lecture on the regional

geology and four-stage paragenesis of the Uchucchacua deposit, before inspecting rocks and drill cores from different mineralisation zones and then learning how the Buenaventura geologists had built their resource model. A varied and novel way to gain a good understanding of the operation.

The trip underground was fascinating and, again, represented a first for many of the student members of the group. We observed mineralisation hosted in the tunnel walls and machinery conducting daily operation. Of course, some time was spent hunting for samples!

Finally, both groups received a tour of the processing plant. This was especially interesting given we already had an understanding of how the Mn-rich concentrate was being treated further down the valley. A much older and more 'traditional' operation than Río Seco the plant certainly gave us an appreciation of how investments in new technology can result in higher levels of efficiency.

7 & 8th September:

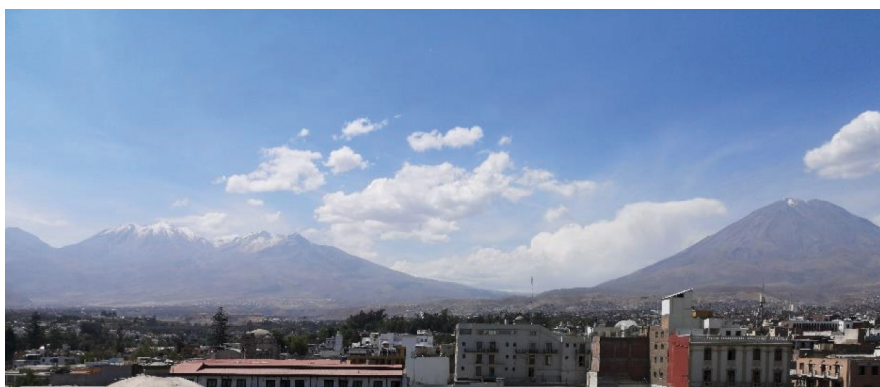
Rest weekend (Lima & Arequipa)

After a hectic week of early starts and long bus journeys, including an 8-hour monster back from Uchucchacua, the group finally got the chance to relax and recuperate. This gave us the chance to take a bit of time to appreciate Peruvian culture (and cuisine...) and importantly make our way to Arequipa in order to begin the second leg of the field trip!

9th September:

Cerro Verde Cu-Mo Porphyry

Ready to get stuck back into the field trip proper, we were collected by a Freeport minibus from our hostel in Arequipa for a short drive to the Cerro Verde mine. Consisting of three separate deposits: Cerro Verde, Santa Rosa (both porphyrys) and Cerro Negro (tourmaline breccia) with current life-of-mine running to 2040 we were all impressed by the detailed exploration work which had gone into defining three such large ore bodies. Defining such a large resource required Freeport to drill exploration holes up to 2 km deep – and there



Enjoying the view in Arequipa

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is still significant exploration potential!

A massive deposit deserves a truly massive processing facility. Although we were unable to tour the processing plant, the entire group was astonished by the sheer scale when we looked from a nearby viewpoint. Currently processing 360,000 tpd the facility is the world's largest copper processing plant.



The group outside Cerro Verde's Concentrator II. What can't be seen in the photo is, just to the left, two erupting volcanoes – making this possibly the most picturesque processing plant I have ever visited.

We were then allowed to inspect some of the core in the coreshed with Freeport geologists on hand to point out interesting textures and mineralisation features to us. Aside from the usual culprits of pyrite, chalcopyrite etc., we were able to pick out some seriously cool and colourful minerals. Unfortunately pictures were not allowed inside so you will have to take our word for it!

10th September: Caujone Cu-Mo Porphyry

The first of the two Southern Copper mines that we visited, the group enjoyed an excellent tour of Cajone.

Oscar Concha gave us a very informative general presentation covering the long history of the operation (during which time they have been able to drill 44,898,218 m of core), the whole suite of 51 lithologies at the deposit and the various deposit models which Southern Copper have built e.g. alteration, hardness and specific gravity.

We then headed for our first tour of an operating open pit of the trip. From the first of five viewpoints we were able to observe preparatory blast drilling in action and saw a wide range of mine vehicles in operation.

The tour then continued on to four more viewpoints, each progressively deeper inside the pit and highlighting a different style of mineralisation for the deposit. At each location the Southern Peru geologists would point out



The group inside the Cajone open pit

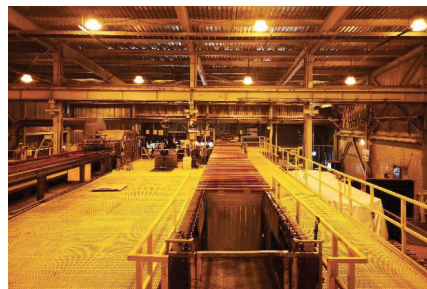
the key lithologies and mineralisation types giving us the opportunity to take samples and develop a well-rounded understanding of the deposit's geology.

Following the visit, Southern Peru kindly treated us to lunch in their canteen before we headed on to our overnight stop in Moquegua. Filling the free afternoon, on the recommendation of our bus driver, Don Elias, with a tour of a local Pisco vineyard.

11th September: Toquepala Cu-Mo Porphyry

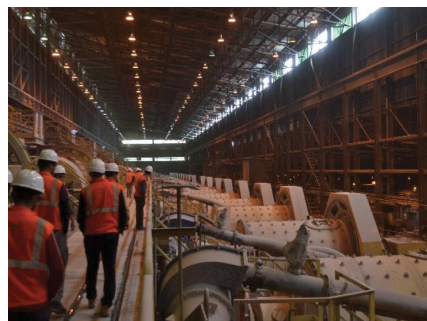
Once again, route issues meant we arrived slightly behind schedule for our visit. This time the road was too narrow and dangerous rather than closed and we had to take a longer lowland route – though, of course, safety first!

Our tour began at the Toquepala SXEW plant with a very thorough presentation (and a great set of demonstrations) illustrating exactly how the process works. This was followed with a walk to the operating room for an overview of the plant – certainly a quieter and more pleasant place to be than the crushing and flotation plants we had toured earlier in the fieldtrip.



A view from the control room of forming copper cathodes

We were then able to tour Toquepala's Concentrator I – a plant which has been in operation since 1960. With a 60,000 tpd capacity it is certainly dwarfed by the operation we saw at Cerro Verde but this only served, yet again, to highlight the positive impact new technology can have – especially in reducing the considerable footprint of mine sites.



Our tour of the processing plant – very different from the four huge SAG mills utilised at Cerro Verde

Unfortunately, due to our delayed arrival we were unable to view the open pit or coreshed so, after a delicious lunch in the workers canteen, we departed for our long drive to our overnight stop in the border town of Tacna.

12th September: Pucamarca Au-Ag Epithermal

A colossal day to round off the fieldtrip. Following another early (4 AM) start – so we could get the necessary documents from a Tacna checkpoint in time to avoid temporary road closures – we took a roughly four hour drive to the mine, arriving there at 9AM, after a 4300m climb in elevation.

The highest mine of the trip at 4700 m.a.s.l. we necessarily had to spend some time passing the requisite medical checks – with variable performance across the group. Eddy Zapana gave us a great introduction to the geology and geochemistry of Pucamarca highlighting the relatively low grade and very fine nature of the gold (just 4 – 10 µm).

We were then bussed around the various pits in operation, some being mined and some under development. Though always disappointing not to find visible gold, it is amazing how a mine can be sustained both at high altitude and in such a remote location – a logistical triumph and great example of the advances in mining technology.



Observing the Pucamarca open pit

After a spot of light lunch we were able to look through some of Pucamarca's core – a treat for the geological purists amongst the group before heading back to the meeting room to learn more about the processing aspect of the mine. We also had the chance to hear about the sustainable practices of the operation, Minsur have impressively managed to control their water supply tightly enough so they are not abstracting any water from basins which are utilised by the local community.

Following the visit, we bade goodbye to our final hosts, returned to Tacna for the final group meal and then began the monster drive back to Arequipa where we would end our trip after a great 12 days.

Sponsors

We are very grateful to our sponsors for the funding to make this field trip possible.

- Institute of Materials, Minerals and Mining (IOM³)
- Old Centralians' Trust
- The Minerals Engineering Society (MES)
- MinSouth
- Geological Society of Perú
- MDSG
- SEG Stuart Wallace Fund
- Mineco
- CRU Group
- CD Capital
- AMInpro Metallurgical Services

Seismic 2020

The Role of Seismic in Unlocking Value in the Energy Mix

Meiling Cheng is a third year Research Postgraduate student in the Department of Earth Science and Engineering. With financial support from RSMA, she attended the Seismic 2020 conference in September 2020, and wrote this short article about the conference and her experience of it.

Why I attended Seismic 2020

As seismic plays a significant role in the Energy Mix, geophysicists and engineers have been using seismic data to image and understand the subsurface for decades. However, due to the complexity of seismic events, it is a challenge to efficiently and accurately identify the earthquake response from the detected seismic data. Recent advances in computing power and machine learning methods have been recognised as powerful statistical tools to tackle this issue.

My PhD research is to develop new numerical tools for data assimilation and optimal control applied to dynamical systems. I have developed different machine learning methods like generative adversarial networks for efficiently simulating nonlinear flows in a dynamic system with large data-driven computation. I think it is a very good opportunity to share and discuss with others about these machine learning methods applied into seismic prediction. In addition it could broaden my knowledge in the area and skill development. Machine learning can automatically mine data sets for hidden features or relationships. From extracting meaningful sensing data to unveiling seismic events that are below the detection level, machine learning assists in identifying unknown features to accurately predict earthquake activity.

For me, it is an opportunity but also a challenge. It provides a very good opportunity to have face-to-face discussions and share experiences in seismic technology research. It will boost my understanding and awareness of the development of new seismic technology combined with machine learning. In addition, attending this conference will accelerate my personal maturity, broaden my horizon, inspire potential and enhance my ability.

What is the impact of Covid-19?

As it became apparent that Covid-19 was hard to contain and spreading at an alarming rate in many countries, the conference was cancelled in April 2020 and then rearranged to September as an online event.

I think it is a pity for many students and scholars that they were not able to be there in person to take advantage of the networking and communications. Also, I think cancelled conferences may impact the diffusion of



the latest scientific findings and discussions among scholars, which could lead to new developments and future collaborations.

However, after I attended this well-organised conference by SPE, I realised that there are some advantages for online conferences. First, we can continue scholastic conversations and ensure the diffusion of research findings. In addition, we can save much time, effort and money in long travel, and it is easier for us to talk to other researchers even if we are all at home. Another positive aspect has been cutting the carbon footprint of researchers while reaching a wider audience. All these talks have been recorded, and participants can also watch them on demand, while virtual breakout rooms can provide networking opportunities among scholars and the possibility to discuss research questions.

How was the online Seismic 2020?

The online Seismic 2020 was held from 14 to 18 September. It covered the entire spectrum of seismic technology from exploration through development and production to re-purpose or abandonment – the full lifecycle of the asset. It included different themes, such as New Seismic Technology, Machine Learning, 4D, Quantitative Interpretation, Acquisition and Processing, Novel Methods, The Geophysics Value Chain, The role of seismic in

CCS, and Energy Mix. These sessions provided me with a beneficial learning experience, as it was a great opportunity to participate fully in discussions with plant-related researchers and to share findings and views.

One of the interesting themes is 4D imaging. David Blake proposed an *Ocean-bottom node processing technique for 4D imaging at the Ivar Aasen field*. Special processes used for high quality 4D imaging hinge around up/down deconvolution, which enables the efficient attenuation of free-surface multiples, corrects for source signatures and mitigates water-column velocity changes. David presented an evolving sequence of five processing workflows, with a focus on missing-trace reconstruction and 4D co-denoise as enabling techniques for up/down deconvolution. The final workflow includes re-imaging using a velocity model built with multi-parameter FWI, showing significant changes in anisotropy and introducing geologically consistent details in velocity around localised injectites. Their results reveal strong 4D changes in the seismic image consistent with the reservoir model, production and water injection history.

This is a creative technique because the interpretation of 4D seismic data helps ensure optimum oil and gas recovery in realistic applications. As we know, during production, changes in reservoir pressure, temperature and fluid saturation can cause changes in

FEATURES

the physical properties of the reservoir rocks themselves. The 4D image results in high-definition images of seismic changes that enable us to interpret changes in a reservoir with more certainty. In a long research perspective, I think the 4D image de-noise technique could also be applied to other areas, like ocean modelling or medical imaging.

Another interesting talk was Seismic Image Processing by machine learning. Can Yang's presentation was *De-risk West of Shetland (WoS) Area Exploration using Generalized Radon Transform (GRT) Depth Imaging and Unsupervised Machine Learning Methods*. Can used GRT migration to preserve true amplitude and output exact angle gathers, and then integrated machine learning methods into Quantitative Interpretation workflow. Can Yang also discussed the importance of parameterisation, algorithm choice, and data quality. He drew a conclusion that GRT migration, integrated with machine learning methods in QI workflow, can de-risk WoS exploration and enable the precise understanding of the amplitude anomaly for any further field development. It was one of the most innovative talks as it looked at how to introduce the popular machine learning methods to improve the accuracy of traditional methods, which also highlights the great promise of machine learning methods applied in seismic technology research.

What have I learned?

The conference was incredibly valuable and useful. It provided a great platform for the geoscience community for sharing ideas, knowledge, and experiences. What most impressed me is that we often ignore some challenges or details in developing our models for the realistic cases. In realistic cases, the true conditions are often more complex and challenging. To develop an accurate computational model for a realistic case, researchers may spend many years exploring the structure of geometry, glacial features, and gas distribution, and then characterise these structures by parameters in models. In this conference, with their talks many speakers from different famous industries provided me with a great insight into differences between the industry approaches to research and development. This inspires me about my future career in industry.

Overall, it was a great experience, I would like to acknowledge SPE and the Department of Earth Science and Engineering, Imperial College London for letting me be able to attend. In addition I would like to thank the Royal School of Mines Association for providing the financial support in order to attend the conference.

**Alumni:
we want
your news**

(see page 2 for contact details)

IMPACT Photographic Contest

The College summer term of 2020 was like no other summer term in history. The Covid-19 lockdown and subsequent restrictions closed College, and students were left to study alone. Realising this piled even more pressure on students, CGCA felt some light relief may be needed and ran a photographic contest open to all students of the Faculty of Engineering. We called it the 'IMPACT Photographic Contest'.

It was simple. Just take a picture on a smartphone that portrayed the effect of lockdown and submit it together with a short title. Quick and easy so as not to distract from vital studies,

exams and projects. A first prize of £50 in vouchers was supplemented by two 'honourable mentions'.

With support from CGCU, we are glad to report the contest was well supported and the standard of entries gave the judges quite a task to select the winner! The winning entry and honourable mentions are below, and the winning entry is also on the cover of this issue of IE.

Following this success, we have decided to run the photographic contest on an annual basis starting in 2021, hopefully with a theme not related to a virus!

First Prize



"Just a Call Away"

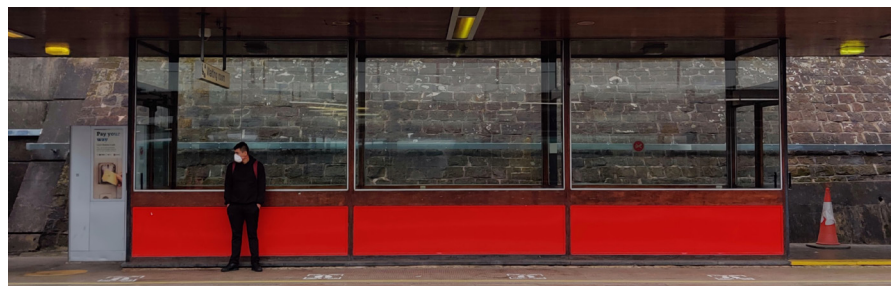
by Chin Yeung (Bioengineering)

Honourable mentions



"London underground rush hour scenes – coronavirus edition"

by Wei Ooi (Chemical Engineering)



"The Lone Rider"

by Yaashiene Pukazhendi (Mechanical Engineering)

HS2, ROI and the builders

Our lives are largely governed by an agenda out of our personal control. It is also surprisingly out of the control of our so called “lords and masters” or in these times perhaps our “ladies and mistresses”? I will try to illustrate this by linking our builders (construction companies), ROI (return on investment) and HS2 (High Speed 2 rail project).

I spent several years in the City of London in the 1970s working on major international private and public sector projects. Some were of the order of a US\$ billion (1970s values) or more in total first costs. They took a minimum of ten years between first serious action and seeing any income. A few were to take much longer.

Some were in countries where the political risk was high. There were always technical risks. The attraction was that potentially they could become a major source of steady high income over many decades. The risks however were usually ours.

Emotion is often a major factor in decision making and anything which keeps this aspect under control can be helpful. Where company and individual survival becomes paramount, logic can easily fly out of the window. The company I worked for had become complacent and been threatened by a takeover – it certainly focused minds. It had an impressive history and was still influential, but had no clear future. It took risks and very luckily, they led it to a “generous” takeover by an oil giant with delusions of grandeur.

HS2 is a case in point. I have some knowledge of the mindset of major

construction companies, having worked for a couple of them in the 1980s. Their holy grail is a base load of steady building work guaranteed for decades. Private sector work is notoriously volatile; what is sought is a long-term public sector base workload. Inevitably, this leads them in to the political arena.

Wearing your safety helmet, you are chasing public money. You are looking for one (or more) projects with an implementation period of decades. Public sector housing is an obvious one; another is a major infrastructure scheme. Transport is a perennial here and for many decades the motorway system provided a steady source of work.

The Channel Tunnel served the constructors well, although financially for us, Joe Public, it was a disaster. Currently, airport expansion is in the political spotlight. Crossrail 2 is a growing horror story.

The one that interests me most is rail, in the shape of HS2 and its peripherals. I was a fairly active train spotter in my childhood, and the project is quite close to my doorstep, in NW Hertfordshire. It has a current price tag of around £60 billion; the suspicion is that this is very much on the low side.¹

It is supposedly a high speed link between London and the West Midlands for the economic benefit of the West Midlands with an extension north to come. A cynic might say that it will probably turn

¹ Current HS2 costs are now beyond £100 billion and in the light of the COVID 19 Pandemic there is wide debate about the role of the office and indeed the need to commute at all!

part of Birmingham into a commuter suburb for London.

I commuted to the City of London for about fifteen years. Some was from my then family home in mid-Buckinghamshire and some was from a daughter’s flat in the North London suburbs. Part of that time I drove in by car, part travelled by underground, part by train and shanks’ pony and part by a mix of all four.

I came to realise that, door to door, none were that different in time terms although costs and stresses were very different. Birmingham / HS2 to central London fits into that general description.

As a country, we have a long history of successful investment in the railways, going back to the 1800s. Money was made and money was lost, but it left us with a system which is still serving us surprisingly well. It is going through something of a rebirth, largely driven by environmental concerns.

My guess is that HS2 will offer a minimum of ten years (and very probably much more) of steady civil, mechanical and electrical engineering work plus a lot of peripheral ‘software’ support. This excludes the new trains themselves and their operating system. It is potential bread and butter for the big constructors and, not surprisingly, they are lobbying hard.

We tend to assume our MPs are dependent for their thinking and action on the wishes of the electorate. Ignore these and deselection / seat-loss beckons. Lobbyists are very blatant in US politics but we are more subtle

here. A large but low key campaign donation to a party or a candidate in or adjacent to a project location is a standard way of gaining support for it. Our major constructors (builders?) are very experienced and good at this.

Coming back to my original theme, and wearing a private sector investor’s hat, your personal investment yardstick is a simple one. You can leave your money on deposit in a bank or you can invest it in something riskier and more volatile but with the promise of a high and steady income later. You now become a speculator.

The criterion that is particularly important is ROI, the project equivalent to the interest on a bank deposit. It takes into account the delay of seeing income. If you do nothing else with your money, you might expect to earn a steady 5% per annum or so. Taking risks and timing into account you might look for a minimum 10% per annum from a fairly safe project when up and running. This ignores any extra borrowing you might need.

The problem with this is that you will earn nothing in the early years, while you are spending heavily. This is balanced (notionally but unpredictably) by much higher earnings later in the project.

I strongly suspect that the ROI on HS2 is low even on current timings and costings. The first costs can only rise and the building programme grow ever longer. Income? No private investor will touch it with a bargepole.

RSMA’s own John Simpson



HS2’s Tunnel Boring Machines Florence and Cecilia at the Herrenknecht factory August 2020

Letters

Recent reminiscences about zebra crossings, in *Imperial's alumni magazine*, prompted Peter Reinbach (Elec Eng 1958-63) to write to us about a prank in the early 1960s.

A zebra crossing for Imperial

In a recent issue of the *Imperial alumni magazine* there was a letter from an alumnus questioning the existence of a zebra crossing in Prince Consort Road.

That brought back memories!

And yes, there was a zebra crossing; right outside my room in Beit Hall! The crossing only lasted one day and one night. I know, because we put it there one clear dark night!

It was in 1960 or 61, the night before Imperial had a very important visitor (probably royal), something to do with the opening of a wind tunnel or similar in the new RCS building.

It was laid down, between 1 and 2 am, by a group of six Elec Eng undergrads who wanted to show their welcome.

So the plan was for a zebra crossing in Prince Consort Road to run from the main entrance of the Union building to the main entrance of RCS. Unfortunately, the entrances to the two buildings were not directly opposite each other so there was a lot of discussion over whether the zebra should be an unbroken straight diagonal or have a kink in the middle.

I think it finished up diagonal. Fortunately, that evening was dry, as water-based paint was not then available!

The working bee was four, plus one driver and one lookout, and it was a moonless night.

When completed, someone took a photo of the group which was a heart stopper at the time, as the flash nearly gave the game away. The B & W photo is around somewhere and was lent to an IC area rep about twelve years ago for the records.

The powers that be were not amused and the zebra did not last long. I am not sure if it was actually used as intended as everyone kept a very low profile over the next few days!

Unfortunately, most of these E1's did not make it to graduation. So, I guess there are not too many around to recall that event!

Peter Reinbach
Melbourne, Australia

Events in Hong Kong reminded our regular Canadian correspondent, Nigel Fitzpatrick (*Metalurgy 1962-65, 65-68*), of his letter to his local newspaper (*The Whig Standard*) in March 1990, reproduced here.

Sad accommodation

Recently, the *South China Morning Post* carried a picture of the new flag proposed by Beijing for Hong Kong in 1997, together with a description of the final agreement between London and Beijing on the form of Hong Kong's government after 1997.

At around three in the afternoon of that day, we, the organizers of a conference to be held in December 1990, entered Hong Kong University to visit the department of electrical engineering. On unloading from a small bus that had stalled several times on the hills coming up from the city, our attention was first drawn to sensors that monitor the stresses in the hillside above the university. Heavy rain can cause landslips in that area.

Absorbed in our own conversation about landslips, we walked towards a group of students before we realized that they were at the edge of a vast demonstration. Then we noticed that there were small groups of police dotted around the periphery. The crowd parted easily though to allow us to reach an elevator.

Amongst other things, we were there to test drive an electric vehicle, and we did so amongst police standing in a relaxed fashion beside their motorcycles. We had witnessed one of a number of demonstrations that day against the London/Beijing agreement.

That evening, our group was entertained by senior members of the current Hong Kong government. The dinner conversation focussed upon our own purpose for being there. We had witnessed a significant event in the evolution of a society, yet it had not drawn us out of ourselves.

The atmosphere seems to be one of accommodation and sadness and not one of anger.

Nigel Fitzpatrick
Kingston, Ontario, Canada

* The conference mentioned, held in December 1990, was EVS 10, the tenth conference in the World Electric Vehicle Symposium and Exposition (EVS) series, organized by World Electric Vehicle Association (WEVA), for academic, government and industry professionals involved in electric drive technologies. Nigel was involved on behalf of Alcan.

One of the first DJs?

REGINALD GILL
(Elec Eng 1946-49, 1949-51)

Reg Gill, a life-long member first of the Old Centralians, and then CGCA, was born in Derbyshire on 29 August 1921, the son of a railway engineer who had completed his apprenticeship at 'the Plant' – as the Railway works in Doncaster were known – under the GNR's Chief Mechanical Engineer, Nigel (later Sir Nigel) Gresley. Reg, however, was more interested in electrical than mechanical engineering and, on leaving school just before WW2, he obtained a job in the local coal mine, initially as a clerk but then as a coal face electrician. This was a reserved occupation, and he spent the war underground, servicing the mine's electrical systems.

After the war, the Coal Board offered him a scholarship to go to University. He was offered a choice of Cambridge or London (things were different just after the war!) and he chose Imperial. He arrived at City & Guilds in 1946, graduating in 1949. During his time at college he was Student Chairman of the Engineering Society (1947-48), and he also helped found the entertainments committee. There were few dance bands, and no money anyway, so he put together two record decks and a 30W valve amplifier in order to play records for people to dance to. Perhaps he was one of the first DJs! Whilst at college he was also involved in one of the annual Faraday Lectures of the Institution of Electrical Engineers.

Reg stayed on at City & Guilds to do some research for an MSc, but his tutor most unfortunately lost the only copy of his thesis, and he never completed it. However, as a postgraduate he was allowed to dine in the Masters' dining room, which must have made a pleasant change from the Union refectory. Meanwhile, Reg's future wife Terry had just arrived in London from Ireland. Her brother – who had fought in the British army during

the war and now worked for the War Office – had arranged a job for her but, until her clearance came through, she took a temporary job serving in the Masters' dining room at Imperial, where she and Reg met. They married in 1951, and their son Peter was born in 1955, followed by Paul in 1959 and Michael in 1964.

After marrying, Reg took up teaching, initially at a college in St. Helens in Lancashire but then at the College of Technology in the new town of Hatfield, where over time he rose to be Principal Lecturer in Electrical Engineering, at what was to become Britain's first 'Polytechnic'.

Due to problems with his eyesight (he had a family history of glaucoma) he took early retirement, a move he



regretted not long afterwards, when to his chagrin 'Hatfield Poly' became 'The University of Hertfordshire' – and had he stayed on he would then have been re-graded as a professor.

In later life, Reg's two passions were steam engines and jazz music. He got to drive a steam engine on the Nene Valley railway and, when his son Peter – by chance – found himself repairing a computer for Kenny Ball's bass player, he was delighted to meet his hero at a concert in Stevenage.

Reg and Terry – they were married for nearly 70 years – lived together at their home in Bedfordshire until Reg died on 4 November, 2019, at the advanced age of 98.



Reg and his family

Hard work, charm and tremendous good humour

ANDREW EDWARD PANTER (Civil Eng 1962-65)

Andrew Panter, had two distinct phases to his life.

Following a successful 34 year career as a civil engineer, senior manager and director in the construction industry, he devoted the next twenty years to works of charity and services to his local community. In his first career, after initial training, he worked for the George Wimpey group of companies, rising to Managing Director of Wimpey Homes. An important part of his subsequent charitable work was devoted to the Prince Philip Trust Fund for the Royal Borough of Windsor and Maidenhead and to his role as a Deputy Lieutenant of the Royal County of Berkshire. In parallel with these later activities, he used his knowledge of the construction industry for the benefit of several housing associations through membership of their boards of directors. He also served as Master of the Worshipful Company of Paviers in the City of London in 2009-10.

Born in Ealing in 1944, he lived with his parents, Hugh and Hillary, and brother, Howard, in South Australia from 1951 to 1958. He was educated in Scotch College, Adelaide, the John Lyon School in Harrow and Imperial College, graduating in 1965.

The first six years of his career were with the civil engineering consultancy, Binnie and Partners. This provided the experience needed for him to qualify as a Chartered Civil Engineer and he worked on major projects including the Mangla Dam in Pakistan and the Plover Cove scheme in Hong Kong.

Having decided that his career would be best served in the field of contracting, he joined Wimpey in 1972 and filled a number of increasingly important engineering and management roles. Andrew was appointed to the Executive Board of George Wimpey plc in 1984.

Andrew moved to Pennsylvania in 1993, where he served as CEO and President of Wimpey Minerals, North America.

The 1990s were an interesting and challenging time for Wimpey as the company was transformed from a family-owned heavy construction firm to a sharp, lean, profitable public company specialising in house building. The final stage of this was the major asset swap negotiated in 1996 between Tarmac and Wimpey, which resulted in Tarmac taking on

all the civil engineering, aggregate and asphalt interests and Wimpey doing all the housing. The immediate consequence for Andrew was that he became a Tarmac employee overnight. This move was reversed within a year when he came back to the UK as MD of the expanded Wimpey Homes business, a position he held until his retirement in 2000.

Following his retirement, Andrew used his experience to voluntarily assist the affordable housing market and also became very active in charitable work as Chairman of Windsor and Eton Rotary Club and the Round Table.

He was regarded as a tower of strength in his work for the Prince Philip Trust, with his engaging style and capacity for getting things done. He took leadership roles in major fund-raising events, notably the Classic Car Rallies on the Long Walk at Windsor and a series of Ascot Race Days. A good leader but also a team player, getting results through his hard work, charm and tremendous good humour, his outstanding contributions will be sadly missed by the trustees.

Andrew also made a huge contribution as a Deputy Lieutenant, always being ready to take on tasks in support of the Lord Lieutenant.

Andrew was able to take most events in his stride, including the occasion when, on a rainy day, he found an umbrella in the grounds of Windsor Castle clearly left by someone who had watched the parade of classic cars that afternoon. As he examined it, a voice from a window in the castle shouted that it belonged to her and that she would come down and fetch it. Andrew presented it to the Queen without turning a hair.

Andrew became active within the Worshipful Company of Paviers, chairing key committees and representing the Livery during his year as Master in 2009-10. In 2015, he was appointed MBE for services to charity and the community.

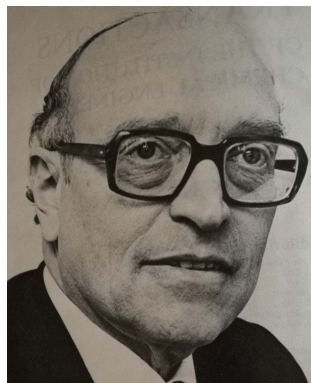
Despite his busy schedule, Andrew still allowed time for his favourite hobby of sailing, which he would undertake with a group of friends each year.

Andrew died in June, 2020, aged 76.

He is survived by his wife Tui, née Cooke, whom he married in 1967 and by his daughter, Tiffany, son-in-law Dominic and grandson, Inigo. He will also be greatly missed by his brother, Sir Howard Panter and sister-in-law, Dame Rosemary Squire.

A long, happy and fulfilled life.

JOHN MORELLO SOLBETT (Chem Eng 1937-41)



Born in Bucharest on 28 October, 1919, John spent his school days in Romania before coming to England in 1937 to read chemical engineering at City & Guilds College, graduating in 1941. He was a life-long member of the Old Centralians, and of CGCA.

As one of the earliest chemical engineers to be trained on a formal undergraduate course in Britain, he went on to be involved in a number of ways in the introduction of chemical engineering to industry.

After graduation, John worked for British Industrial Solvents Ltd, which at that time was part of the Distillers Company. He was based at the company's Carshalton works where they made a wide range of solvents and plasticisers in relatively small quantities under the control of the Ministry of Aircraft Production. He started on plant operation as what was then known as a shift chemist and later went on to become the first Works Chemical Engineer to be employed at the site in that specific function. It was during this period that he met Audrey, and they were married in 1945.

In the same year, they moved to Cheshire, where John took up a position with the Chemical Plant Development Department of Simon-Carves. Here, he gained his first experience of plant design and the many other aspects of contracting. He became an all-round sulphuric acid specialist, being one of the first people to develop a flowsheet incorporating SO₃ removal from the main process gas stream before the final stages of catalytic conversion. He coined a name for the process, although during his days with the company he never saw the process commercialised – as it was a decade or so before the introduction of processes of this type, first in Germany, and then elsewhere.

In 1956, John moved back to London to take up a post at

Humphreys & Glasgow, where he established a Process Department. He was by then fully conversant with the emerging chemical engineering procedures, and was responsible for selecting new staff to form the company's Process Design team.

After 10 years with H&G, John left to start a British subsidiary of the French contracting company Heurtey Ltd, and to develop its furnace design and construction business. It was as Managing Director of Heurtey Ltd that he first came into contact with the iron and steel industry.

He returned to Humphreys & Glasgow in 1973 as European Sales Director, before taking on the role of Director for development activities and consultancy. He then remained at Humphreys and Glasgow until his retirement and, during this time, he travelled extensively for work, including two world trips. He was often accompanied by Audrey, who sadly died in 2001.

John was elected a Fellow of the IChemE in 1955, and took an active part in its operations. He supported the Institution's work through his service on a number of standing committees, was a member of Council from 1964-1967, Chairman of the Membership Committee from 1976-1977 and – prior to taking on the Presidency in 1978-79 – was a Joint Honorary Secretary. In 1968, he was awarded the IChemE's Council Medal for his work as Chairman of the sub-committee of the Engineering Practice Committee which produced the 'Model Conditions of Contract for Process Plant'.

His involvement in contracting throughout his career led to his becoming Chairman of the Safety Committee of the British Chemical Engineering Contractors Association. His wish to see Institution members gain an increased awareness of the characteristics of the contracting industry was evidenced by his involvement in the production of IChemE's Green & Red Books of Contract Conditions.

During a long retirement, John enjoyed playing the piano, listening to music and playing bridge which gave him a good social life. This was evident at his 100th birthday party in October 2019, where he was in his element celebrating with all his family and many friends. He remained reasonably well and passed away suddenly on 3 April 2020, having lived a long, happy and fulfilled life.

‘Top Banana’

GILES EDWARD BAYNHAM
(Mining Eng 1991-95)



Giles was born on 28 May, 1972.

He was a father, husband, engineer, banker, director, chairperson, entrepreneur, and fun-loving soul and, over multiple adventures, demonstrated the larger-than-life individual that he was.

On the business and professional side of life, he was tireless and thoughtful. He took the time to think through the options and consequences of the various courses of action that presented themselves in his business life.

He had the ability to tease out game plans and solutions to issues that others did not see and provide the clear guidance on how to execute and implement them. He was a man of wisdom, integrity and vision in a world where these virtues are not always visible.

Giles spent four years studying Mining Engineering at the Royal School of Mines and some of his

more notable achievements included captaining the RSM RFU 2^{nds} and teaching rugby to four generations of Dutch mining engineers from the Delft school of mines. Giles was also a member of the Chaps Club and was a great supporter of all the activities of the Club.

After graduating and rejecting an offer to join Rio Tinto in far northern Queensland, Australia, Giles entered the mining finance world. His career spanned three phases:

- the banking/project finance world with NM Rothschild and IBJ/ Mizuho Bank, which took him all over the globe;
- the financial advisory world with Endeavour Financial, which also took him all over the planet;
- the mining corporate world including Baja Mining (Cu/Co Mexico), CB Gold (Au, Colombia), Fengro (Phosphates, Brazil) and his continued and unflinching support of Aton Resources exploring for gold in Egypt.

Giles was involved with and can be credited with some significant achievements over his career. Some of the most notable are:

- the Baku–Tbilisi–Ceyhan oil pipeline, worth 3.8 billion dollar;
- the acquisition of a share in a gold producer in Argentina that was the cornerstone for the creation of Goldcorp which has subsequently grown to a 70 billion dollar company;
- the financing of the Kupol gold mine in Siberia, half a billion dollars;
- Baja Mining, arranging a one billion dollar deal for their project in Mexico;
- his role as a founding partner of CB Gold with interests in Colombia;
- his role in taking on DuSolo, a failing fertilizer producer in Brazil and turning it around into Fengro and spinning out the assets;

and his early and continued support of Aton Gold.

All told, it is estimated that he had a hand in at least 50 billion US\$ worth of transactions.

Throughout his mining, banking and finance career, Giles maintained a long standing relationship

and ongoing support of the Royal School of Mines, through the Alumni Association, the RSMA, that he joined in 1995.

Giles was passionate about preserving the RSM legacy for future generations. He was President of the RSMA between 2003 and 2005 and in 2010 Giles was awarded the RSMA’s highest honour, the Peter Harding Memorial Award. This was given to Giles in recognition of his sustained commitment and outstanding contribution to the RSM. It is particularly poignant to note that whilst a student Giles met and struck up an enduring friendship with Peter Harding. They could often be seen in the Union Bar swapping stories, laughing and, of course, singing.

Giles cared about the people who worked for him and depended on him. He was a consummate champion of the people around him and we should not forget his loyalty and sense of fair play. These traits resulted in direct interventions and actions which prevented harm and avoided unfair treatment of others. This last could raise his passion and yield sharp comment when he considered events to be unfair or unjust.

Giles had a serious distrust of authority, particularly politicians, civil servants and unions. He loved programmes that lampooned such people, hence his love of Spitting Image, Black Adder, Monty Python and, of course, *Private Eye*.

Giles was one of those bright lights in our universe—a kind, old soul that lit up the life of all he touched.

There was always the good-humoured, fun-loving side of him; a quick wit and quicker riposte. He enjoyed his sports, whether it be rugby or rugby or rugby, or his true passion in BC: skiing. Many of his friends and contemporaries have their own stories of Giles and his skiing trips. They are all the same: good food, good wine, lots of laughter and a bit of skiing!

Giles was a connoisseur of the world around him. Music, art, cars, wine, clothes, technology, watches, books, you name it, he knew the best, sought the best, was the best.

Along the way he met people, he loved people and he created life with his children Abigail and Oliver.

Giles died on 25 August, 2020 and was laid to rest in Vancouver on 8 September, after a small service that was live-streamed. His casket was adorned with his Chaps Club tie.

Rest in peace Giles, our friend. You were a Top Banana and you will be forever loved and forever missed.

An outstanding Chap

JOHN MORTIMER
(Mining Eng 1972 – 75)



In his last student year, John was elected President of the RSMU. An exemplary President, he encouraged everyone to get involved in the Union and its many activities. He was tireless, a natural leader, a true gent and an ideal role model for young students. He behaved in a way that was an example to all.

Like his father, Gerald, John had a long career in mining, specifically aggregates. One of his more interesting claims to fame was being sent to Port Stanley to run the quarrying operations to increase the size of the runway after the Falklands war.

The RSM was never far from John’s mind and he was instrumental in collaborating with the Mineral Resources Engineering Department to create a Mine and Quarry option for final year mining students. In addition, John was heavily involved with the Royal School of Mines Association and led this Alumni body from 1991 to 1992 as President.

Post mining, John joined the CLA (then the Country Landowners’ Association) as Director of the South West Region in 2002. He was actively engaged in the running of the Association until March 2019 when his health deteriorated.

John was also the Chairman of the Swindon and Wiltshire Local Enterprise Partnership from 2016 having joined the Board in 2015. He was an ardent supporter of LEPs locally and nationally and champion of all things rural.

A keen gardener, John grew prize winning vegetables of every size and colour.

On 15 September, 2020 John finally succumbed to the invasive oesophageal cancer that was diagnosed some 20 months previously. Despite many associated and painful setbacks he made the most of his shortened life and remained stoical to the end, never losing his wonderful sense of humour. He is survived by his wife Carole.

He can now rest in peace and will be remembered not least for his embodiment of everything that makes an outstanding Chap.



An exceptional man

Dr. GEORGE JEFFREY (JEFF) HAWKSLEY
(Mech Eng 1969-72)

Jeff Hawksley was born in Sheffield, on 26 July, 1935 and grew up in the Peak District. His father was director of Hawksley Stainless, and his mother, a teacher.

During his childhood, the family made regular trips to the coast to alleviate his chronic asthma, instilling in him a love for the sea.

Jeff attended Dore village school and was awarded a scholarship to King Edward VII school in Sheffield. At 16, he began his career in engineering, becoming an indentured apprentice to the Anglo-Saxon Petroleum Company (Shell).

Under the Merchant Navy Apprentice Engineers' Training Scheme, he undertook the Diploma Course at Bolton Technical College, with vocational training at Ruston Hornsby in Lincoln.

After qualifying, Jeff went on to circumnavigate the world many times, progressing from fifth to Chief Engineer with companies including Shell, United Baltic Corporation and Christian Salvesen.

Following his marriage to Mavis and the birth of his children, Robert and Susan, Jeff came ashore to spend more time with his family, initially working for the engineering firm Lister Blackstone.

He went to night school to obtain an HND in Mechanical Engineering, then started teaching at Stamford Technical College.

He attended Imperial College (City and Guilds College) as a mature student, graduating in 1972 with first class honours in Mechanical Engineering, and was awarded a prize for his outstanding project work and overall work at Imperial College.

To support the family during his time at University, Jeff worked at Stamford brickworks and returned to sea every summer.

Subsequent to graduation, Jeff took up a post as Senior Lecturer in Marine Technology at Southampton College of Higher Education (now Solent University), moving to live in Romsey, Hampshire. He was also visiting Lecturer at Warsash College of Nautical Studies, and at the University of Southampton, where he studied for his Doctorate, awarded in 1980. His research speciality was thermodynamics, and his PhD thesis explored combustion, noise and performance prediction of high-speed turbo-charged diesel engines.

Jeff pursued many other passions throughout his life. He was a keen photographer, taking mainly

portraits and landscapes with his treasured Leica and developing his own film (commandeering a bedroom as a darkroom, much to his children's consternation).

He retained his love of travel. He and Mavis made many visits to France and, with the Romsey Twinning group, they made friendships and connections across Europe.

On retirement, Jeff went back to sea, but this time sailing with a friend in a classic wooden-hulled sloop; ever the engineer, he restored the engine.

He developed an interest in mills and waterwheels and was an active member of local history groups and the International Mills society.

Becoming an expert in the design of waterwheels and water-lifting devices, Jeff served as a trustee of the International Molinological Society Educational Trust, supporting many aspects of mills and milling, particularly in Eastern Europe.

As a member of the Lower Test Valley Archaeological Society, Jeff researched and mapped all the known waterways and mills of Romsey in the 18th and 19th Centuries.

His research into the history of boatbuilding in Romsey led to his involvement in the identification and preservation by English Heritage of one of the few remaining collapsible lifeboats designed by the Rev. Edward Berthon.

Jeff also took up his boyhood hobby of woodwork, making a series of accurate working mechanical models based on detailed research of original drawings. His models included overshot and undershot waterwheels, beam engines, and an educational model of a turbine engine. He also made an exquisite precision model of the Berthon lifeboat, which is now housed in the King John's House Museum in Romsey, while other models are on permanent display at the museum La Planète des Moulins in Luzech, France.

Jeff was an exceptional man, kind, generous, hardworking and a perfectionist.

Jeff died on 25 March 2020 and is survived by his wife, Mavis, his brother, Peter, children, Robert and Susan, five grandchildren and a great-grandchild.

He was much loved and respected by family, friends and colleagues and will be sorely missed.

*Provided by his daughter,
Sue Hawksley*

Warm, gentle and caring

FRANK CHARLES LEIGHTON
(Civil Eng 1946-49)

Pakistan, South Africa and Brazil among others.



He later served on the British Columbia Utilities Commission.

Frank met Phyllis Grantham in Vancouver and it was true love at first sight. They were married in 1953 and had two children, John and Barbara.

They spent most of their lives on Vancouver's North Shore. Frank's international engineering career often meant long absences, so he especially appreciated returning home to Phyllis and the serenity of his West Vancouver garden where he spent many happy hours.

Frank's love of gardening kept him going until the age of 95 when they moved to a small townhouse in Ocean Park, in 2015.

On 27 October, 2019, Frank passed away peacefully in his sleep after a brief illness, attended by his family throughout his final days, less than seven weeks before his 100th birthday.

Predeceased by his wife Phyllis – who passed away in 2017 – and sisters Mary and Freda, Frank is survived by his younger brother Arthur, son John (married to Teri), daughter Barbara (and husband John), five grandchildren (Heather, Jennifer, Mark, Ian and Sean), seven nieces and nephews in Washington State and England, as well as extended family in the UK, Australia and New Zealand.

Frank was a warm, gentle and caring individual who inspired many friends and colleagues – a true gentleman.

He is deeply missed and will be forever remembered by his family, friends and neighbours.

Provided by his son, John Leighton

Frank was born on 11 December, 1919 and grew up in Norwich, England. At the outbreak of the Second World War, he enlisted with the RAF, Air Sea Rescue Marine Craft Section.

Service took Frank to Malta where he remained under siege for nearly two and a half years, enduring relentless daily bombings, finally being relieved by the Pedestal Convoy a few weeks before surrender was imminent. He participated in liberating Sicily and post D-Day France.

Service took Frank to Malta where he remained under siege for nearly two and a half years, enduring relentless daily bombings, finally being relieved by the Pedestal Convoy a few weeks before surrender was imminent. He participated in liberating Sicily and post D-Day France.

Frank graduated from Imperial College, in 1949, with a degree in Civil Engineering. He then emigrated to the USA, but soon settled in Canada where he joined the Vancouver-based firm of Swan Wooster Engineering, with whom he enjoyed a career of more than 30 years.

Coastal and port engineering became his specialty and he then went on to take those skills internationally, working on the development of major port infrastructure projects all over the world: Indonesia, Central America,

IN BRIEF

WILLIAM HENRY GORDON PARKER

(Elec Eng 1943-48)

William Parker was born on 17 June 1926.

He studied Electrical Engineering at City & Guilds College between 1943 and 1948 and was a long-term member of CGCA.

After graduation, William practised as an Electrical Engineer, achieving membership of the

Institution of Electrical Engineers in 1956, and Fellowship in 1983.

William was latterly a property developer and, up to retirement, was Managing Director of WG Parker (Builders) Limited, of Keinton Mandeville, Somerset.

William died on 10 March 2018, aged 91 and was survived by his wife Jimema.

