Imperial

THE MAGAZINE FOR THE IMPERIAL COMMUNITY

WINTER 2016/17

ON THE ROAD

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Imperial/41

Publisher
Imperial College London
South Kensington Campus
London SW7 2AZ
www.imperial.ac.uk

Editorial enquiries
imperialmagazine@imperial.ac.uk
+44 (0)20 7594 7443
www.imperial.ac.uk/imperialmagazine

Alumni enquiries
alumni@imperial.ac.uk
+44 (0)20 7594 6138
www.imperial.ac.uk/alumni

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info@ybm.co.uk
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Editor:
Mira Katbamna
Commissioning Editor:
Steve McGrath
Art Director:
Finnie Finn
Project Manager:
Joanna McGarry

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DIGEST

RESEARCH

£30m for child health

Researchers in the Faculty of Medicine have been awarded more than £30m by the European Commission for research into public health issues.

The project, led by Professor of International Child Health Mike Levin, aims to develop a test to allow medics to quickly identify potentially lethal bacterial infections in children, such as meningitis and sepsis. It won £14m from the European Commission's Horizon 2020 programme.

During the five-year project, the team will study around 60,000 children across Europe and West Africa who arrive at hospitals and clinics with a high fever. At the moment, doctors have no quick method of distinguishing whether the child is suffering from bacterial or viral illness, but Professor Levin's team has identified two genes that are 'switched on' only when a child is suffering from a bacterial infection. A test based on this could allow doctors to identify early cases of potentially deadly infections.

"Our current methods do not allow doctors to reliably distinguish between life-threatening bacterial infection and trivial viral illness," said Professor Levin. "Rather than attempting to identify the bacteria, we believe bacterial infection can be recognised by the pattern of genes and proteins activated by the child's immune system in response to the infection."

Meanwhile, the European AIDS Vaccine Initiative (EAVI2020) consortium, led by Imperial, has been awarded €23m by the European Commission. The Consortium brings together leading HIV researchers from public organisations and biotech companies from across the world in a focused effort to develop protective and therapeutic HIV vaccines. It will enable experts to pool their knowledge and expertise to develop novel candidate vaccines that can be taken through to human trials within five years.

> **"The test will help identify potentially lethal infections such as meningitis and sepsis"**

Write to us

Email: imperialmagazine@imperial.ac.uk
Letters: Imperial Magazine, Level 5, Sherfield Building, Imperial College London, South Kensington Campus, London SW7 2AZ
Letters may be edited for length, grammar and accuracy.

@imperialcollege
fb.com/alumni.imperialcollegelondon

LETTERS

ATHLONE SCHOLARS

I am so impressed by the expansion of Imperial (*Imperial 40*), I feel compelled to share with you recollections as it was when I was there more than half a century ago. Both the size of the campus and its academic scope at the time seem dwarfed by comparison with the numerous locations and activities of the College now, and yet it was just as much at the forefront of scientific education and engineering development then as it is today.

I was a lucky recipient of an 'Athlone Fellowship', awarded by the British Board of Trade to new Canadian engineering graduates. Our contingent sailed in September 1956 from Quebec City to Southampton, and I was billeted at London House, in Bloomsbury, and later rented a house in Kensington with five others, at a cost of 14 guineas between us.

We each had to shop once in five weeks, mostly at Sainsbury's. The little old ladies who were in there every day for their egg and rasher of bacon, were astonished when the 'Americans' ordered two dozen eggs, two pounds of 'tom-eh-toes', please – yes sir – two pounds of 'tom-aa-toes', and so it went, every week.

In the evening, some of us would wander over to the Ennismore Arms for a pint before closing time. My favourite was Watneys Red Barrel. It cost 'one and eleven pence ha'penny', all of about ten pence today. I cherish my memories of the 1950s – it was a great time to be a student in London.
Gerald Crawford (PhD Metallurgy 1960)

I have to admit that when I received an Athlone, I had never been east of Montreal. However, my father was born in England, and studying in England for me meant studying in London. Though I had never heard of Imperial, it was Imperial by default!

London 1965-70 proved to be the world centre of the cultural universe. I spent almost as much time at the Royal Opera House, the National Theatre at the Old Vic, and at West End theatres, as I did at Imperial! And buying Rubber Soul, Revolver, and Sgt. Pepper on their first days of issue was incredible.

Athlones promulgated the 'legend' of Imperial College London in Canada over the years – amazingly, Imperial welcomed 303 Athlones in 18 years, far more than any other UK university!
Bob Morris
(DIC, PhD Electrical Engineering 1970)

IMPERIAL IN WARTIME

Obtaining my (wartime) physics degree owed a good deal to pure luck. We had to take four examinations in mathematics, including a last one on analysis, which I thought I might well fail, and therefore be thrown out. But on that day in July 1944, the Germans started sending over V1s in greatly increasing numbers. When their ramjet engines cut out, the sudden silence was followed a tantalising 20 seconds or so later by a loud bang as the bomb hit the ground.

Conditions for solving cubic equations were hardly ideal and so after half an hour of this racket, the examiners decided to terminate the exam. Since it proved impossible to re-schedule the exam at a later date, everybody was awarded their average mark from the previous papers. That was, for me, a real piece of good fortune.
Professor David Perkins CBS FRS (Physics 1945)
Professor Perkins was awarded an honorary DSc from Imperial in May this year.

BREXIT

As an Imperial alumnus I greatly appreciate having been able to study at an institution at the forefront of academia. In my view, it is essential that you retain and even forge ever deeper ties with academia in other countries including the EU. Unfortunately, a badly judged decision to hold a referendum means that this has been made that bit harder. However, I do hope that you persevere as the results of your research are still badly needed by society.
Jim Cooper
(MSc Mineral Resources Engineering 1977)

Thank you for the reassuring communication after the shocking vote to leave the EU. My question is, what happens to funding bids placed with the EU under schemes like Horizon 2020 where Imperial is an academic partner?

If funding bids are being assessed will the leave vote have an effect on the bids? I think that business and academic need some feedback from the EU to know if projects started and applied for will continue.
Robert Edwards
(PhD Mechanical Engineering 2010)
To read the President's communications on Brexit and what it means for the College, please visit: www.imperial.ac.uk/eu-referendum

#OURIMPERIAL

The alumni community share memories of life at the College on social media, using the hashtag #ourimperial

I use what I learned at the College literally every day in my career. I've travelled the world to work on some major structural projects: the second longest bridge in the world in Denmark, the Millennium Dome in London, the Olympic Games in Athens, the longest cable-stayed bridge in Korea… I think that one of the most telling things is that I still refer to my Imperial notes – they're in my study in their original folders, meticulously dated and numbered.

My degree at Imperial was heavily theoretical, but also very applied, and I was able to use what I learnt with immediate effect. I was impressed by the academics I worked with – Professor Patrick Dowling, who led the rewriting of the British design standards for steel bridges following some high-profile collapses in Germany, and Professor Thomas Wyatt, who had boundless knowledge and understanding of aerodynamics!
Stephen Byrne (MSc Structural Steel Design 1992)

PRANKSTER

It was the custom of Charing Cross and Westminster Medical School to play a prank on freshers. One year, an official notice appeared on the notice board informing all 190 new students that they would need to be screened for gastro-intestinal infection.

Each student had to produce a stool sample in a labelled container and deliver it to the Porter's lodge. Needless to say the Porters were inundated with faecal specimens, not always in airtight containers. They were not amused!
Melanie Douglas (Medicine 1987)

In my first year, I lived in Tizard Hall [on Exhibition Road]. One morning, we woke up to find a newly installed pedestrian crossing, zebra style, just north of the Southside exit from Princes Gardens to the main entrance at Mech Eng. The effect was marvellous. Traffic slowed and stopped to allow students to cross and we all thought it a great improvement. Unfortunately, it was not an authorised installation – later that day workmen from the council turned up to remove it. I never found out who was responsible.
Elliot Hirst (Mechanical Engineering 1972)

ILLUSTRATIONS: THIS PAGE TOMMY PARKER. OPPOSITE PAGE STEPHEN CHEETHAM

FROM THE PRESIDENT

Valuing quality

In challenging times, recognising and valuing quality is key, writes Professor Alice Gast.

We live in exciting times and a busy world. While our ability to connect globally with old contacts, new contacts, friends and family is extraordinary, the clutter of tweets, likes, wikis, blogs and chats can seem ephemeral. So it is wonderful to be a part of a community that values enduring quality. It is inspiring to turn these pages, and to see these values represented in prose, images and articles long enough to make us think. Some things just cannot be reduced to 140 characters.

Sometimes, however, it feels as though the world may not continue to value excellence the way we do. The traditional landscape of opinion is changing. Everyone everywhere is an expert. In our crowd-sourced social media world, reactions go round the globe in an instant and "what people think" can have little to do with quality. At times, it seems real expertise is becoming a precious resource and distrust of this is clouding public knowledge.

The clearest evidence that we value quality and promote excellence at Imperial is in our people. We value Imperial's excellent academics as they rapidly move the world forward with new and important discoveries. We value our students who excel in the concert hall as well as the lab and lecture theatre. We value our tutors who mentor and guide students in both their academic and non-academic pursuits; and we value our operational and administrative staff who make the College run smoothly. We have a diversity of the highest-calibre students and staff from across the UK and from more than 136 countries.

Our partnerships and collaborations include more than 2,400 universities, institutes and companies in more than 110 countries. Commitment to excellence is the common thread across this global network. People are excited to be part of this, and part of Imperial.

The recent referendum damaged this ideal. Many in our community felt undervalued and worried about their futures. So we must be clear. We will not let Brexit hamper our ability to pursue excellence in research and education for the benefit of society. We will continue to think and act internationally and make our voice heard by those responsible for negotiating the UK's exit. We will also support all of our international staff and their dependents in every way we can.

We realise that we must ensure that others see the value in what we do and we look for ways that others can help us to achieve this. Our alumni and friends across the world are among our biggest champions. Your successes inspire and sustain us. Your ideas, support and encouragement drive us forward. In 2016 a record number, more than 4,500 alumni, supported the College alongside 3,000 friends who are donors. This is a vivid illustration that you value quality in the same way we do.

We are also, in the words of our strategy, "sharing the wonder and importance of what we do". We are making scientific, medical, technological and business breakthroughs visible and accessible to those beyond our campuses.

We also set out in our strategy to "inform decision makers" in order to influence policy. We need the government to measure and reward excellence in our teaching and research. We work hard to help define excellence within the frameworks the government uses to target support. Unfortunately, sometimes the rewards and support are not solely based on merit. Thus we are vigorously seeking partners who value quality and will support our mission. Philanthropic and corporate support of research and education is more vital than ever.

We have some new initiatives to celebrate and reward excellence at Imperial. Using earnings from the President's endowment shares, we launched a £1m Excellence Fund to reward excellence and promote innovative ideas in research and teaching. Each summer we celebrate staff excellence in teaching, operations, research, service, volunteer work and collegiality with a garden party. Every spring we celebrate our colleagues at my annual address and reception.

> **"We will not let Brexit hamper our ability to pursue excellence"**

We will always be true to our values, and we value quality. I hope that you will join us in celebrating and rewarding those values.

ILLUSTRATION: DAVID SPARSHOTT

42

According to *The Hitchhiker's Guide to the Galaxy*, 42 is the answer. But what is the question? We investigate the questions scientists are asking to solve global challenges, starting with the Zika virus.

Halting the spread of the Zika virus is one of the greatest health challenges of our time, because of the risks of microcephaly, severe brain malformation and other birth defects that are associated with the infection. A team led by Professor Gavin Screaton, Dean of Imperial College London's Faculty of Medicine, is producing some of the most promising research into the disease – in particular, on its similarities to dengue fever.

Developing a vaccine is Professor Screaton's answer. His question is this: could another virus explain why Zika has been so devastating – and hold the key to stopping the outbreak?

"We've made a whole load of human antibodies for dengue over the years, and worked out what they bind to, which of them are good and which ones are potentially harmful," says Professor Screaton. "It just so happens that some of the very potent ones cross-react against Zika. That gives you a possible idea how you might create a new vaccine against both diseases."

Dengue fever, which is endemic to many of the regions where the Zika outbreak began, is often more serious on a second infection. This is because there are four different strains of the dengue virus, and antibodies produced after exposure to one type may actually help a different strain attack the immune system. It's a phenomenon known as antibody-dependent enhancement (ADE).

Professor Screaton's team discovered that ADE may also make people who have been exposed to dengue fever more susceptible to Zika. This could be one of the factors behind its explosive spread. However, the researchers also discovered that one group of antibodies that work against dengue, known as EDE1, may also prevent the Zika virus from entering the body's immune cells. These are now the focus of further research at Imperial. "We're trying to design vaccines that protect against dengue and Zika," says Professor Screaton. "We've just got some funding from the Wellcome Trust to do that."

The researchers are employing a method known as reverse vaccinology. According to Professor Screaton: "It's a new approach for dengue and Zika, though it has been tried in other diseases – principally HIV and RSV [Respiratory Syncytial Virus]. It doesn't involve making the whole viruses, just the proteins that are involved. You work out what protects, and then design a vaccine that will induce that response."

However, Professor Screaton urges caution, pointing out that the work is at an early stage. He says: "In terms of having a viable product, I think we're probably talking four or five years. We should bear in mind that 50 years have been spent trying to make a dengue vaccine, and we still don't have a good one."

ILLUSTRATIONS: TOMMY PARKER. STEPHEN CHEETHAM

MEDICINE

Brain hallucinogenics

An Imperial researcher is seeking to understand how hallucinogenics affect the brain – and how they might be used to treat mental illness.

In a study published in *The Lancet Psychiatry*, Dr Robin Carhart-Harris found that psilocybin, better known as the psychedelic compound in 'magic mushrooms', can be safely used to treat depression. And in a separate study, published in the *Proceedings of the National Academy of Sciences*, his team used various leading-edge and complementary brain-scanning techniques to visualise how LSD alters the way the brain works. The results suggest that the drug brings about a fundamental change in the way consciousness works.

Dr Carhart-Harris said: "Normally our brain consists of independent networks that perform separate specialised functions, such as vision, movement, hearing and attention. However, under LSD, the separateness of these networks breaks down and instead you see a more integrated brain."

STUDENTS

International student visas

International students wanting to study for a Master's at Imperial will find it easier to move to the UK following the introduction of a new Home Office scheme.

The Tier 4 Visa Pilot scheme opened for students starting their studies in 2016, and will be available for students joining the College in 2017/18. Students who achieve places on any one-year Imperial Master's course will have access to a streamlined visa application process. They will be able to stay in the UK for a further six months after their course ends, allowing them extra time to find work or pursue further research or study.

Imperial's President, Professor Alice Gast, said: "International students are a priority for Imperial; they add to our diverse community in myriad ways. They bring creative, entrepreneurial and academic excellence. This pilot scheme is an encouraging step forward. The ability to stay on for six months will bring benefits to the students and to the country, as our graduates will be able to pursue their entrepreneurial ideas, further study or add to the UK's talent pool." Imperial is one of only four universities to be selected for piloting the scheme.

SOCIETY

The Techtonics

Imperial's own award-winning a cappella singing group took on the best – and won.

Words: **Sarah Woodward**
Photograph: **Hannah Maule-ffinch**

Forget American football. Forget cheerleading. For really cut-throat stateside competition you need to attend a collegiate a cappella group-singing competition. And now, Imperial's very own a cappella group – The Techtonics – has beaten the Americans at their own game.

In April, the 13-strong band of singers travelled to New York to compete at the final of the International Championship for Collegiate A Cappella (ICCA). Beating 340 other groups to bring home the two-foot-tall trophy, it was the first ever non-US team to win.

But while they may have made it look easy on stage, there were still some backstage hitches, as outgoing President Arran Bayliss-Chalmers, tenor and geology student recalls. "Our bass, baritone and beatboxer got stuck in the lift moments before we went on stage. Had they not managed to sound the alarm it would have all been over before we'd sung a note!"

And now, after a stint at Edinburgh's Fringe, the group is back to its usual routine, welcoming visitors to many major College events (including the Alumni Weekend in 2016), and performing every Saturday at Portobello market – though these days they draw rather bigger audiences. "The police have had to move us on a couple of times – the audience block the road!" says new President Edric Ramirez-Valdez, a biology student in his final year.

The Techtonics has been in existence since 2008 and each year the group recruits new singers as senior members graduate. All-comers are welcome: Ramirez-Valdez went to his first audition in Freshers’ Week as a beatboxer but ended up singing tenor – despite not having any singing background.

This year’s musical director, Arun O’Sullivan, has plans to take the group back to its roots during his year in charge. “We were founded on electronic music, hence the name, but recently we have drifted towards more popular music”, he says, noting that the team also sang Sam Smith’s Lay Me Down at the ICCA. “I want to include more dance and trance. It’s all in the vowel sounds.”

ILLUSTRATION: TOMMY PARKER

SECRET SAUCE

Jayson Goh

(Electrical and Electronic Engineering 1998)

Director of Operations at Singapore Changi Airport, Jayson Goh, says his ‘secret sauce’ is the dedication of the Changi team.

There’s a unique sense of shared purpose that unites our team at Changi Airport, something we call the One Changi Spirit; regardless of who you are, it’s your mission to make the airport experience the best it can be. And that dedication is the special ingredient that makes my job possible.

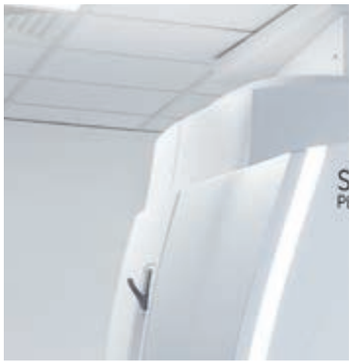
From the moment I started my job here three years ago, I have been continually amazed by the enthusiasm of the community – all 40,000 of them from 200 different agencies. I’m unable to single out any particular group as everyone in the airport contributes to the experience. One that we also hope will be delightfully surprising. I mean, how many airports have a butterfly garden and a four-storey slide?

I often walk around the airport at different times of the day to get a feel for what’s going on. Yes, we are a big place – the airport handles more than 150,000 passengers a day – but there are always friendly faces surrounding our passengers and, although it’s always busy, we don’t want them to feel they have to rush.

We hope Changi Airport is seen as not just somewhere you catch a plane but somewhere that is enjoyable to visit. There are orchid gardens, waterfalls, cinemas, works of art and al fresco dining. And we are putting in a range of exciting experiences in the new lifestyle development we are building at the heart of Changi, called Jewel.

An airport is a big system that is running 24 hours a day and my background as an electrical engineering graduate helps me appreciate the complexity and the coordination needed to run it well. But at Changi, beyond having a well-run system, it is all the people working here who give it the special flavour that defines that Changi Experience.

Jayson Goh (Electrical and Electronic Engineering 1998) is Managing Director in charge of Airport Operations Management at Changi Airport Group, the company managing Singapore Changi Airport. Jayson is also President of the Imperial College Alumni Association of Singapore.













DECONSTRUCTED

The Imanova Facility's MRI-PET scanner

Professor Paul Matthews, Edmond and Lily Safra Chair and Head of Brain Sciences, deconstructs a unique scanner that gives clinicians new views of the brain.

Words: **Lucy Jolin**
Photography: **Marcus Ginns**

OVERVIEW: This £3m MRI-PET scanner is one of just five in the UK and forms part of the Medical Research Council (MRC) Dementias Platform UK (DPUK). It is the first scanner to bring together two main imaging approaches – magnetic resonance imaging (MRI) and positron emission topography (PET). While MRI takes detailed images of the body's interior, PET allows clinicians to look at specific molecules within the body, such as chemicals in the brain.

THE SCREEN: Information from the scanner is digitised and reconstructed into an image that we can interpret, which is presented on the screen.

THE OUTER DOUGHNUT SHAPE: The outer part hides a superconducting magnet with the strength of about 50,000 times the Earth's magnetic field. This magnet and the associated radio frequency antennas embedded within it allow the MRI image to be created.

THE INNER DOUGHNUT SHAPE: Hidden beneath the plastic cover is a ring of detection crystals that are sensitive to very, very tiny amounts of radioactivity. The person who is being scanned will have been given an injection of a minuscule amount of radioactively labelled chemical that targets and identifies the molecule of interest for PET. The crystal picks up the signals which these then emit.

THE BED: The position of the bed allows it to slide into the doughnut. Its precise position is determined by computer controls in the operator room. We know that there are certain toxic molecules - and molecular changes associated with their damage - that occur very early in the brains of people who later may develop Alzheimer's disease or similar disorders. The scanner takes simultaneous images of the brain and body, and means we will be able to study with great sensitivity the appearance of these molecular signals and their relationship to the subsequent damage and loss of neurons.

THE WALLS: MRI depends on detection of very small radio frequency signals that are generated by the combination of a magnetic field and the associated radio frequency pulses. They are very sensitive to interference from many kinds of electric noise – something as simple as lighting on ceilings. So the scanner room is protected from the outside world by a radio frequency cage embedded in the walls which blocks signals from entering that room. Even the glass that the operator looks through has a fine mesh of wire that blocks radio waves from moving through. Also embedded in the wall is steel shielding that blocks the very powerful magnetic field from moving outside, where it could risk damaging instruments or cause hazards to people carrying metal objects.

THE OPERATING ROOM: Even though the amount of radiation that's used in the experiment is very tiny, the environment and operators are kept at a distance from subjects during the experiment.

“Playing frisbee on the Queen’s Lawn when I was supposed to be studying for finals”

William Quinton (Physics 1995)
What’s your favourite Imperial location? Tell us at #OurImperial

STUDY

MBA tasters online

The Imperial College Business School has launched its first series of MOOCs (massive open online courses) for those who are thinking about doing an MBA. It’s the first time that Imperial has offered a free online taster for people who don’t yet meet its rigorous entry requirements.

The Essentials MBA provides learners with a solid grounding in the foundation topics needed to embark on an MBA: maths, finance, data analysis and accounting. The course is aimed at people who are ready to start an MBA degree and want to identify any gaps in their knowledge before they undertake a full degree. They’re designed to appeal to learners who have studied management topics in the past and are considering applying for an MBA.

The MOOCs are offered as part of a new agreement between Imperial College London and edX, a non-profit online learning destination founded by Harvard and MIT.

For more information on the Essentials MBA course, or to sign up, please visit the Imperial page on the edX website: www.edx.org/school/imperialx

BUZZWORD

OVERHEARD ON CAMPUS

Inulin-propionate ester *n.*
A food supplement based on a molecule produced by bacteria in the gut which reduces cravings for high-calorie food – by making them seem less attractive.

Bagnold Dunes *n.*
Desert dunes discovered on Mars and named by the NASA team in honour of Ralph Alger Bagnold, a pioneer of desert exploration who was at the College during the 1930s.

Topological insulator *n.*
A material that can conduct electricity on its surface via special surface electronic states, used in the development of a potential new form of light by binding light to a single electron.

ALUMNI

ALUMNI WORLD

Imperial alumni groups are bringing local communities together all over the world, from a panel discussion on funding entrepreneurial ventures in Malaysia to a sailing trip on Lake Union in Seattle.

In Beijing’s Birds Nest Stadium, for example, the local association hosted Imperial’s Grantham Institute for Climate Change. Regional groups have also helped to shape our alumni and friends receptions with Professor Alice Gast.

Closer to home, the City and Guilds College Association and the Royal School of Mines Association are busy preparing for their prestigious annual dinners, while shared interest networks are bringing together Imperial women, alumni working in finance and those interested in healthcare.

To find out more about alumni groups and how to get connected and involved, please visit www.imperial.ac.uk/alumni/take-part

ILLUSTRATION: TOMMY PARKER. PHOTOGRAPH: THOMAS ANGUS

MEDICINE

Bacterial swimmers

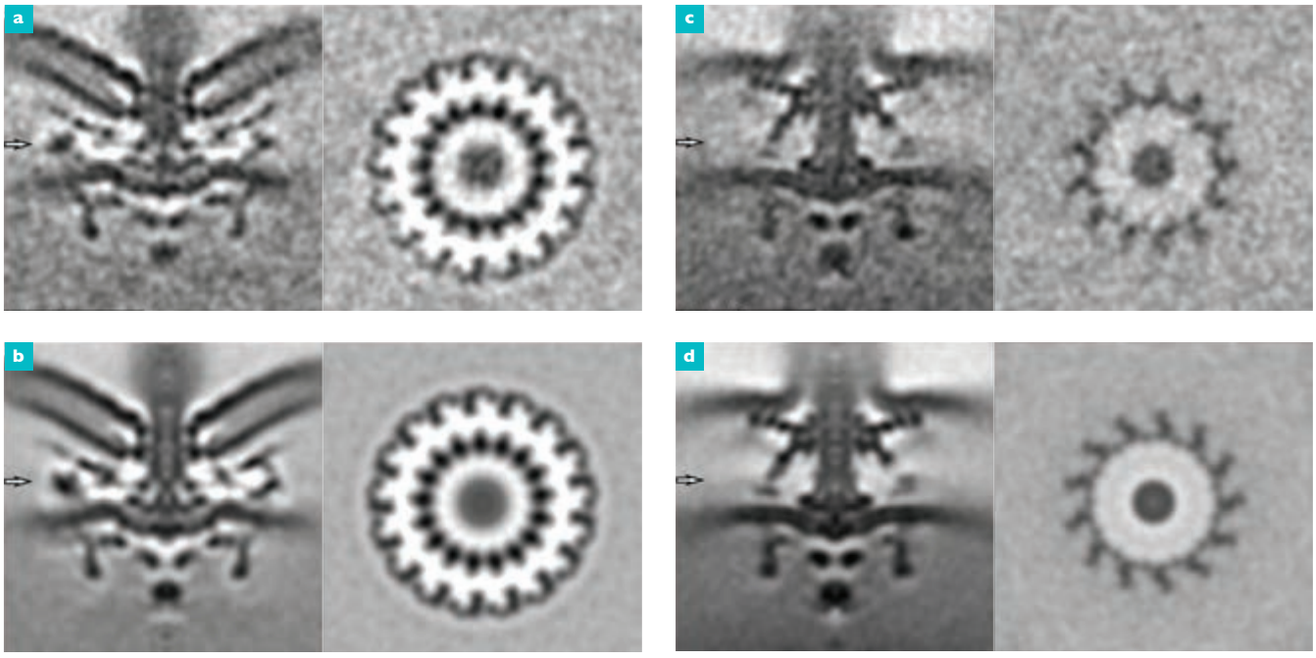
Nanoscopic 3D imaging has revealed for the first time how different bacteria have geared their tiny propeller motors for a wide range of swimming abilities.

Most bacteria swim using a long tail called a flagellum, which is attached to a tiny 'motor' made of proteins. This spins the flagellum, which works like a propeller and drives the bacterium forward.

Now, using a recently installed high-powered electron microscope, a team of researchers, led by Dr Morgan Beeby from the Department of Life Sciences, has been able to visualise these motors in unprecedented detail. This means they can work out why some bacteria, such as *Campylobacter jejuni*, which causes food poisoning, are more powerful swimmers than others.

The visualisations reveal that stronger swimmers have evolved by adding extra parts to their motors called stators, creating more powerful motors that have increased turning force. "For the first time, we have been able to see and explain how these nanoscale molecular machines have evolved in bacteria to colonise new environments," said Dr Beeby. "It's a fascinating insight into the awe-inspiring diversity of life that has evolved on Earth, and also presents possible drug targets. We may be able to design drugs that specifically sabotage the flagella only in targeted bacterial species."

> **"For the first time, we have been able to see and explain how these nanoscale molecular machines have evolved in bacteria to colonise new environments"**



Unprocessed and symmetry-enhanced images of cross sections across and through (a,b) the *Campylobacter jejuni* motor, and (c,d) the *Vibrio fischeri* motor.

IN BRIEF

Regius Professorship
Imperial's Regius Professorship, granted by the Queen as part of her 90th birthday celebrations, has been conferred on Professor David Holden, one of the world's leading experts on salmonella bacteria.

Two-metre sea rise
Imperial researchers who are examining the impact of melting Antarctic ice on the world have suggested current rates of climate change could trigger instability leading to more than two metres of sea-level rise.

Spider silk sound
An acoustically customisable violin, made from a composite material that includes spiders' silk, has been developed by Luca Alessandrini, a postgraduate from the Dyson School of Design Engineering at Imperial.

ENTREPRENEURS

£15,000

The prize money taken home by Imperial startup Motion Metrics at the Santander Universities Entrepreneurship Award. The team's Carv project, a wearable device for skiiers which gives performance feedback, was on display at the Alumni Showcase, part of the 2016 Alumni Weekend. Motion Metrics is made up of Jamie Grant (Business School), Pruthvikar Reddy (Mechanical Engineering), Bo Xuan Hon (Aerospace Engineering) and Samit Patel.

STEM

Wohl Reach Out Lab

Education philanthropist David Dangoor has donated £300,000 to support the work of the Wohl Reach Out Lab.

This state-of-the-art facility, overseen by a team of subject experts, is dedicated to providing hands-on activities aimed at engaging schoolchildren in STEM subjects – science, technology, engineering and mathematics.

The Lab raises the aspirations of school children from diverse backgrounds, who may attend schools from where few students progress to university, helping to break down barriers and nurture the talents of potential young scientists of the future by giving them the chance to take part in hands-on experiments. Children can take part in activities ranging from seeing what it's like to perform an operation in the pop-up surgery and carrying out titration experiments to handling live bugs.

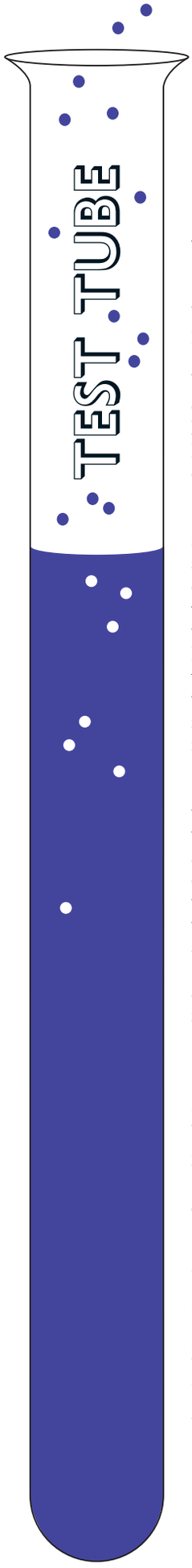
The Lab is championed by Professor Robert Winston, the College's first Chair in Science and Society.

LECTURES

Hawking at Imperial

Professor Stephen Hawking was reunited with five of his former students – now all professors in the Department of Physics at Imperial – at a sell-out lecture this autumn. "Imperial continues to be one of the world's leading centres for research in theoretical physics," said Professor Hawking, "and the College should be very proud."

PHOTOGRAPH: THOMAS ANGUS



Innovate. Invent. Experiment. In this series, Imperial alumni tell us what they are working on.

WHO **Alfredo Belfiori** (MSc Biomedical/Medical Engineering 2014).

WHAT FlickTek Ltd is a consumer electronics company that creates new technology capable of detecting and interpreting human bio-physiological signals to control electronic devices. It's about coming up with technology that helps people communicate with connective devices more seamlessly.

HOW ARIA is a tiny chip that sits on a bracelet, watch or smartphone and reads the finger movements from the wrist area, turning these finger movements into commands that can control any connective device. It's the only technology in the world that can do this and the idea is to replace voice control or touchscreen in situations where these aren't the best options. For example, touchscreen doesn't always work for runners with sweaty fingers and voice control doesn't work when there's loud background music. Simple finger movements mainly involve pinching and flicking because these are very repeatable and easy to perform.

INSPIRATION When I was at Imperial, I investigated the idea of a skin-applied sensor as an improvement to touchscreen and voice control. I was surprised to find absolutely no systems that could read finger movements, so I decided to try and find a way to help people communicate with technology from the wrist area. I started the company with three other people, including Liu (Leo) Qing (Statistics 2015) and Chia-Hung (Mick) Lin (Innovation Design Engineering 2015), who I met at Imperial by posting the position offer around the campus. Business Angels were quick to jump on the idea as it's so innovative.

MOTIVATION The fact that these technologies are so new and exciting. I'm overwhelmed by how far we've come in so little time. I also love that anyone can benefit from this technology. Who wouldn't prefer to move their finger about instead of having to physically go to the machine to switch it back on, then open the app, then switch the buttons?

THE FUTURE We have two goals. First, for this to become a standard way of communicating, making finger movement gestures part of all new wearable technologies, as well as augmented reality. Second, we want to expand the gestures out. So far, we use gestures that are easy to remember, and only a small number of them. But we are working to create a whole language for human-to-machine communication via hand gestures, as well as for human-to-human communication, for example sign language, so that deaf people are more widely understood by people who aren't familiar with it.

Alfredo Belfiori is the co-founder and CEO of FlickTek Ltd. He took part in Imperial Create Lab, a pre-accelerator which helps Imperial students to learn real innovation skills, build amazing projects and provide the framework to take their ideas forward into the commercial world.


Specimen taken for
'Rainbow Scarabs'
display drawer.
February, 2008.
CPDT Gillett
X2
2 specimens in
'Beetle Diversity'
display drawers
C. Gillett

‘Knowing how many species there are is a very fundamental question’

FROM BEETLES TO PALM TREES, THE ANSWERS TO THE BIG EVOLUTIONARY QUESTIONS CAN BE FOUND IN THE MOST UNEXPECTED PLACES

Words: **Lucy Jolin**
Photography: **Marcus Ginns**

Previous page:
Dung beetles in the genus *Phanaeus* (rainbow scarabs) from South America.
This page:
The beetle collection at the Natural History Museum, which is kept in metal cabinets holding more than 50,000 wooden drawers. The collection provides a synoptic view of the species on Earth.

One day, around 50 million years ago, a beetle encountered a pile of dung. Other beetles, perhaps, saw the dung simply as an obstacle. This one saw a feast, and that beetle's decision meant more than just a good day for the beetle. It sparked an evolutionary chain reaction that eventually led to a whole new lineage – dung beetles.

The combination of thousands of tiny choices like these are the forces that drive evolution. But with many decisions, and so many species, where do scientists start in trying to answer the big questions: why do species diversify? How do they diversify? What can that process tell us about the Earth's past and future? The solution: find a group that embodies the question you are trying to answer. When it comes to evolutionary diversity, those answers could be lurking anywhere: the legs of a beetle, the flowers of a palm or the eggs of a ubiquitous animal which most of us will never notice.

In his office in the Natural History Museum, Professor Alfried Vogler, Professor of Molecular Systematics at Imperial with a joint appointment at the Museum, reaches into the fridge and takes out a single small jar. It is filled with beetles, all of which were obtained from a single rainforest tree sprayed with an insecticide. They now await identification using DNA sequencing. Almost certainly some of them will be new species: there are currently 400,000 known species of beetles in the order Coleoptera, which is arguably the largest of the insect class. Probably more than half of them are represented here at the Museum, either dried and pinned neatly in drawers within hundreds of filing cabinets or as frozen DNA samples. Around 70,000 of the dried specimens are the 'types', marked by round red labels, indicating that they are the specimens used to describe a newly discovered species.

That 400,000 figure is just ten per cent of the total number thought to exist, though the destruction of the rainforests means that thousands of species could disappear without ever being identified. Professor Vogler's life's work is to identify as many species as he can and gain insights into their evolutionary history.

In fact, that innovative dung beetle wasn't the first of its kind: far from it. The ancestor of a wider lineage that also includes many chafers and stag beetles appeared around 150 million years ago. By identifying the major ecological types and sequencing their DNA, Professor Vogler can work out where the different lineages branch off and where new characteristics originated – perhaps in food source, or environment – creating a new branch of the tree. And then, from that species, the same thing happens again – and again, creating a hugely complex tree-of-life of beetles that tracks the evolution of Earth itself.

"The sequential evolution of chafers and dung beetles tracks the rise of angiosperms – flowering plants – which came first," says Professor Vogler. "Then the mammals came, and they fed on the flowering plants. The lineage leading to the dung beetles initially fed directly on the plants, and many still do today, and the dung-feeding groups only arrived after the origin of the mammals. So you couldn't have one without the other. Study the genealogical tree of the beetles and you have an image of Earth history."

What beetles are really good at, says Professor Vogler, is seizing any opportunity for a new food source. What the earliest ones fed on is unknown. But, for example, in the lineage leading up to dung beetles, some of the earliest offshoots are stag beetles, which feed on rotting wood – and there were woody plants long before the angiosperms. Early dung beetles fed on decaying vegetation. From there, it's not a big step to dung.

"And these shifts happened multiple times, creating huge diversity within beetles," he says. "Even within dung beetles, there are different characteristics. Some roll the dung, before burying it in the ground for their offspring. Others tunnel into it and bury it on the spot. Now, you can tell a roller from a tunneller just from looking at it. If you dig a hole, you need really strong front legs. But dung beetles roll dung with their hind legs, so while their front legs are still adapted for digging, the hind legs are a kind of caliper around the dungball, and much longer."

Yet the very lack of diversity in a species can also make it perfect for studying. There are just two species of Howea palms, *Howea belmoreana* and *Howea forsteriana*, and they both originate from the same tiny, isolated place – Lord Howe Island, 600km off the Australian coast. (They are, however, anything but rare. The plant-collecting Victorians helped them spread across the world as the most popular species of ornamental indoor palm. If there's a palm in your office or home, chances are that it's a Howea palm.)

Turning the origin of species on its head

Professor Vincent Savolainen, Professor of Organismic Biology, homed in on Howea palms to try to answer a big question: how do species which are not separated geographically evolve? "For many years, biologists thought about the origin of new species in terms of populations that got stuck," explains Professor Savolainen. "Jaguars and lions, for example, have a common ancestor. But when the continents divided, the common ancestor living in North America evolved into a jaguar and the one in Africa evolved into a lion. The theory goes that once a population is split, it adapts to the new environment."

Opposite page:
A drawer showing the diversity of dung beetles (top right) and their relatives in the families of stag beetles and chafers. The tray on the bottom left holds longhorn beetles, which are equally diverse and colourful but are not closely related to dung beetles.

Darwin, however, suggested that there might be a mechanism whereby two different species could evolve from a common ancestor even though they stayed in the same place. And Professor Savolainen's team believed this could happen with plants.

Lord Howe Island is the perfect place to look. It has an area of just 12 square kilometres and can be dated accurately to around six million years ago. Professor Savolainen's team set out to examine all the plants on the island, identify them, look at the relationships between them, and see if they could find two species that were each other's closest relations. They found 300 species, including two species of Howe palms. Mapping their genomes and tracing back their phylogenetic trees, Professor Savolainen's team found a point where the two lines diverged.

How did this happen? Professor Savolainen's team observed in the field that the two palms flowered around six weeks apart. This change came about around a million years ago, when the sea brought in more dead sea animals – shells, coral and the like. In some parts of the island, this changed the composition of the soil. The palms that grew in this soil were stressed by this change. It changed their flowering time, which ultimately got fixed in their genes. Now there were some palms that flowered six weeks earlier than the other palms. The two kinds could no longer pollinate each other, and the species split.

Professor Savolainen received, he says, "a lot of emails from creationists" after his discovery was announced. He had turned a century-long controversy on the origin of species on its head, leading some to use his new discoveries as an example of how evolutionary biologists can't agree on any mechanism, and that's why they must be wrong. "But we have answered a question – how do species evolve in the same place – without invoking creation," he points out. "And we have also now a better idea about how species can disappear. If two species evolve in one place, if you then fine-tune the environment, we can revert this process and have them fuse into one species."

In search of the bdelloid rotifer

While tropical islands are certainly hotbeds of diversity, single-species answers to evolutionary puzzles can also lurk in the most prosaic of places – a dish of moss on the Silwood Park Campus, for example. This is one of the preferred habitats of the bdelloid rotifer. These microscopic animals live anywhere where there is fresh water: squeeze out a handful of wet moss growing on a house or tree and you'll find them. This makes Professor Timothy Barraclough's fieldwork pretty simple. "We just pop out the back and collect them," he says.

What's special about the bdelloid rotifers is their abstemious lifestyle. Although they have been known about since the invention of the microscope, no males have ever been observed. Females reproduce asexually – they produce eggs that are essentially clones of themselves. Yet there are more than 500 known species, with thousands more probably undiscovered. Whatever the bdelloids are doing, it's working for them.

"One of the leading theories about why it is a bad thing to be asexual is that it should be very difficult to evolve," says Professor Barraclough, Professor of Evolutionary Biology. "You can't bring together beneficial genes from different individuals. If parasites are attacking you, you should only be able to respond slowly. Whereas if you are sexual, you can always produce new combinations of genes which might then be resistant to the parasites."

Professor Barraclough and his team are mapping not just the genomes of the bdelloid rotifers, but also the evolution of a particular parasitic fungus that invades them.

"Most animals and plants have a sexual stage in their lifestyle," he says. "Why is that? One theory is that we need that sexual stage in order to cope with co-evolving with parasites. If we find that rotifers have co-evolved with parasites despite being asexual, that would challenge that theory."

It is easy to see how this work sits alongside the other main strand of his research: looking at how bacteria evolve to deal with other species. In the lab, his team is looking at how bacteria in the human gut respond to antibiotics, or a change in diet.

"The rotifers aren't causing diseases. They are not economically important. They are fairly inconspicuous members of the terrestrial ecosystem," he says. "But because of their unique features, it allows us to get an insight into these general ideas, which we can then apply to predicting evolution in general."

Back at the Natural History Museum, Professor Vogler is planning his next project: the Museum's Biodiversity Initiative, which aims to discover every species of beetle on the planet. He estimates that in ten years, he will have DNA sequences for around 100,000 species – a resource of untold value to future scientists.

"Knowing how many species there are is a very fundamental question," he says. "To begin to understand diversity, you need to first know what is there. As the biologist Edward Wilson says, not knowing what the species are is like doing astronomy without knowing the stars."

PROBABILITY OF BEING STRUCK BY LIGHTNING:

300,000 TO ONE

PROBABILITY OF WINNING THE LOTTERY:

45,000,000 TO ONE

Chance. Fate. Coincidence. Things may happen for a reason – but as **Professor David Hand** explains, that reason is maths, not magic.

Have you ever had anyone tell you that "things happen for a reason", by which they mean that there are mysterious, unrecognised causes underlying extraordinary coincidences? Or that thinking of someone just before they called you on the phone meant there was some sort of telepathic link? Or that your dream about an accident on the night before a major road crash meant a connection between your dream and the future?

It has certainly happened to me. And my response is that, yes, these things do happen for a reason. But that reason is not some mystic or supernatural connection. It is, in fact, well understood: the link underlying these coincidences is the mathematics of chance. But looked at from a rather unusual perspective: the perspective that I call the 'improbability principle'. This principle essentially says that highly improbable events are commonplace.

The improbability principle is not a single law. Rather, it's a set of laws – rather like Newton's three laws of motion, or the four laws of thermodynamics. In this case, it's five laws.

Perhaps the most straightforward of these is the law of inevitability. This says that one of the set of all possible outcomes must occur. If I throw a die, it is inevitable that it will land showing one of the numbers from one to six. Like the other laws of the improbability principle, this law often manifests itself in other and sometimes quite subtle ways.

For example, while there is no guarantee that, in a conference with 1,000 delegates, someone else will have the same birthday as me, it is certain that some two people will have the same birthday.

Indeed, I can guarantee holding the jackpot winning lottery ticket if I buy all combinations of possible numbers – though this might be expensive! In fact, several groups of people have sought to take advantage of this, by buying up all possible lottery ticket combinations when a rollover jackpot became large enough.

For example, the so-called International Lotto Fund aimed to spend $7m to buy all tickets for a $27m rollover jackpot. It works, but it takes some organising – and there's no guarantee that you won't have to share the jackpot.

Truly large numbers

The second law of the principle, the law of truly large numbers, says that even an outcome which has a tiny chance of occurring becomes almost certain if you give it enough opportunities.

For example, if you generated a random sequence of eight digits, you'd be amazed if they just happened to form your birth date. But if you look through the infinite number of seemingly random digits in the decimal expansion of the mathematical constant pi, you will find your birth date eventually. For example, my birth date, 30 June 1950 – 30061950 – starts at digit 190,652 (you can try it for yourself at www.mypiday.com).

The law of truly large numbers also explains why extraordinary lottery coincidences have occurred, such as people winning lotteries multiple times. While the chance that it might happen to any one person is microscopically small, there are so many people playing so many lotteries so many times that it becomes almost inevitable.

One way of putting the third of the laws, the law of selection, is that it tells us we can make events as likely as we want if we choose after the event. I can make it certain that the next throw of a die will be no larger than the last one – by choosing to follow up only those throws that show a six.

One of my favourite examples of this law occurred during the First World War. The British military were experimenting with dropping bundles of metal darts from aircraft onto enemy troops. To explore how the darts dispersed, experiments were conducted, dropping the darts onto a field and then putting squares of paper over the darts to show where they had landed. A cavalry officer rode up and, when told that there was a metal dart in the centre of each square, commented: "I didn't think you could be so accurate from an aircraft."

Beware the black swan

A fourth law, the law of the probability lever, tells us that if we slightly change the circumstances or assumptions we can dramatically change the probabilities. A classic example of this is the so-called 'black swan' phenomenon in the financial sector, where dramatic market crashes seem to occur much more frequently than they should.

But this is only if one calculates their probability making assumptions that don't accord with reality. For example, if we assume that the sizes of market movements are distributed according to a normal distribution then we seriously underestimate the chance of such events. If, however, we use a so-called 'fat-tailed' distribution – in which extreme outcomes are more likely than you might expect – then they occur with the sort of frequency one would expect.

Another manifestation of the law of the probability lever is when we assume that events are independent when in fact the occurrence of one makes the other more likely. Then we can significantly underestimate the probability of coincidences.

This was the case in the trial of the British solicitor Sally Clark in 1999 for the murder of her two children, when the paediatrician Professor Sir Roy Meadow was – subsequently – deemed to have "grossly" underestimated the chance of two sudden deaths within the same family from natural causes.

The final law of the improbability principle is the law of near enough. This says that if you

The law of truly large numbers says that even an outcome that has a tiny chance of occurring can become almost certain if you give it enough opportunities

expand what you mean by a coincidence or improbable event sufficiently you can make it as likely as you want. There's a one in 365 chance that my birthday is on the same date as that of a randomly chosen reader. But a one in 52 chance that it's in the same week. And a one in 12 chance that it's in the same month.

When laws come together

Last year, I was invited to give a talk about the improbability principle in Bournemouth, a town I'd lived in when I was a child. By coincidence, the venue was in Coronation Avenue, a road I'd walked along every weekday for some years, on my way from my home to my junior school. I hadn't been back to Bournemouth since I was a child, and it seemed an amazing coincidence to be invited back to that particular road. But what if instead the venue had been in a street next to the one I'd walked along, or nowhere near it but I'd simply been driven along that street to get to the venue, or ... Not quite as sharp a coincidence as occurred, but near enough in each case to have made me say: "What a coincidence!".

In Chapter 39 of his novel *The Old Curiosity Shop,* Charles Dickens writes a wonderful passage in which the mothers of two characters marvel about the coincidences in their lives, discovering "sundry circumstances that tallied with wonderful exactness" but all of which are absurd expansions of the conditions for a match. It's a perfect illustration of the law of near enough.

As the examples above show, each of the five laws of the improbability principle can make apparently highly improbable events much more likely. But when the laws work together, the result can be even more startling. A bookmaker's chance of winning any particular bet may be only a tiny amount greater than yours. But with many bets, placed time after time, things add up. They are taking advantage of the law of the lever (their chance of winning each bet is slightly greater than yours) and the law of truly large numbers (their chance of losing over a great many bets is tiny). Do you know any poor bookmakers?

Coincidences are striking because of their personal meaning. Soon after my book about the improbability principle was published, I was contacted by a novelist named John Ironmonger. He'd just had a book called *The Coincidence Authority* published. This described a researcher who was an expert on coincidences, who lived in London (as I do), with the female protagonist being a University of London academic (as is my wife), and whose birthday was 30 June (as is mine). He said he'd never heard of me. It was just an extraordinary coincidence.

When I give talks about the improbability principle, I'm often asked if understanding the cause of apparently miraculous coincidences makes the magic go away. Does it reduce the world to a grey uniformity?

My answer is that the opposite is the case. When you understand the improbability principle, and appreciate the elegance of the mathematics constituting its five laws, and the inevitability of the coincidences that they imply, then things seem all the more amazing. Rather than making the sense of wonder vanish, it makes the world all the more awe-inspiring and beautiful.

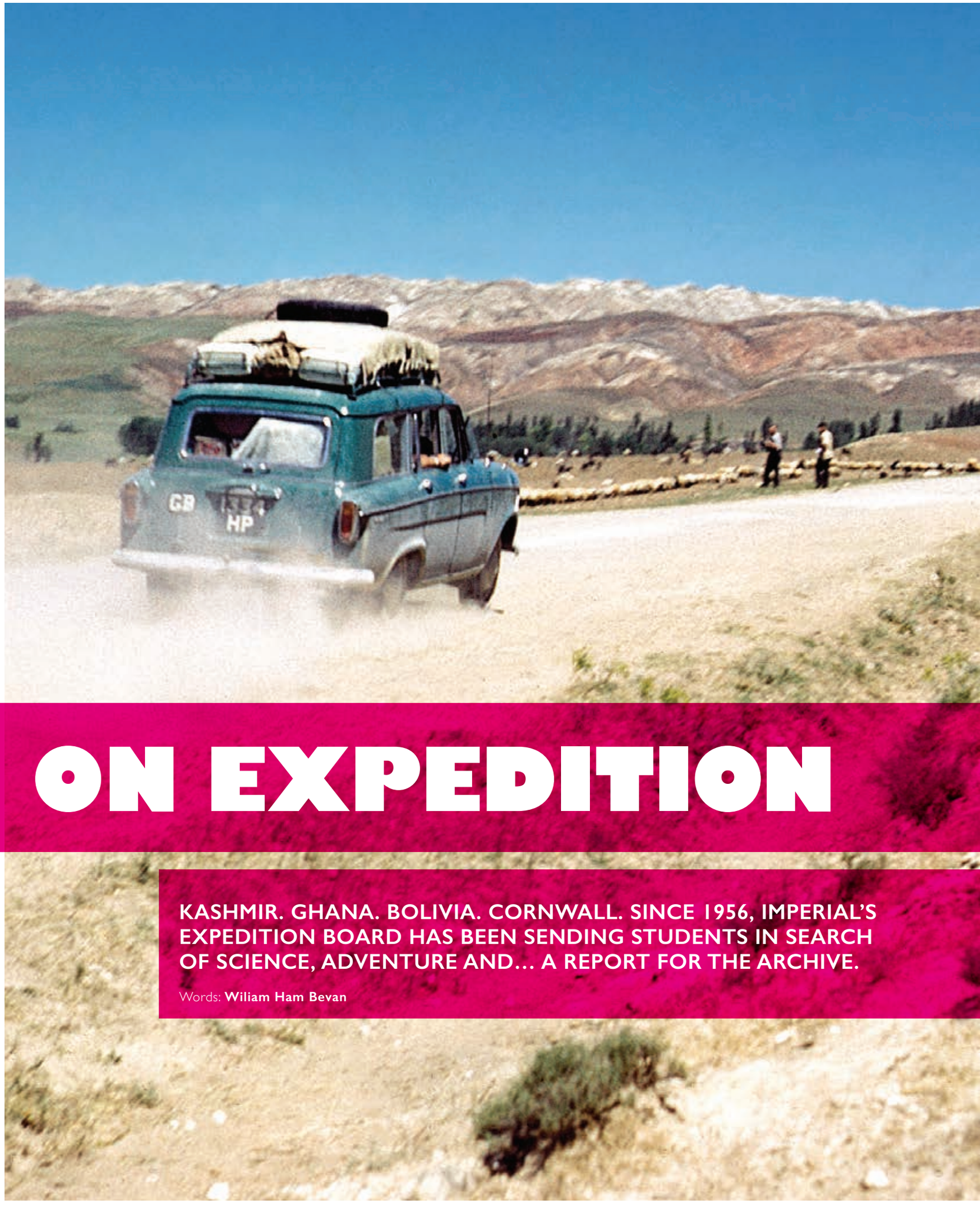
Professor David Hand's book The Improbability Principle: Why Coincidences, Miracles, and Rare Events Happen Every Day *is published by Corgi Books. Have you experienced an Imperial-related coincidence? To win a signed copy of* The Improbability Principle*, share your story by emailing imperialmagazine@imperial.ac.uk or using #ourimperial to contact us on social media.*

IT'S A LOTTERY

Professor Hand explains why we overestimate our chances of winning the lottery – and underestimate the chances of being struck by lightning

Generally, people don't have a very good feeling for very small probabilities. My guess is that, say, one in one thousand is sufficiently small that people will regard it as equivalent to one in a million. Perhaps both satisfy Borel's Law – they are so small one should act as if neither will happen.

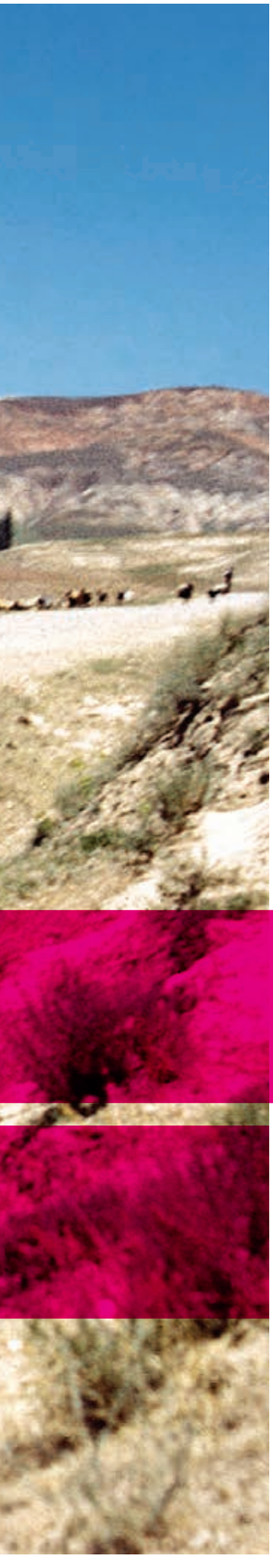
Of course, that does not explain why people play the lottery. A one in 45 million chance means it's less likely than getting 25 consecutive heads when tossing a fair coin. I suspect that if you gave people the chance to pay £2 to win £1m if a fair coin came up heads on 25 consecutive tosses, you wouldn't get many takers. There is also another point. With things like the lottery, or tosses of a fair coin, we can work out the probabilities exactly. But with things like being struck by lightning, or hit by a meteorite, it's difficult to work them out. And when probabilities are very small (as in these two examples) the estimates of the probability are very rough.



ON EXPEDITION

KASHMIR. GHANA. BOLIVIA. CORNWALL. SINCE 1956, IMPERIAL'S EXPEDITION BOARD HAS BEEN SENDING STUDENTS IN SEARCH OF SCIENCE, ADVENTURE AND… A REPORT FOR THE ARCHIVE.

Words: **Wiliam Ham Bevan**



Expedition to Kashmir
The pictures in this feature show images of the overland expedition to Kashmir undertaken in 1960 by Imperial students Michael Armstrong (Physics 1960), Alan Duncan (Physics 1961), Dennis Fulford (Physics 1960), Robert Grasty (Physics 1961, PhD Physics, 1964) and David Murphy (Aeronautics 1960). Clockwise from left: On the road to Sivas, outbound to Turkey; Mianeh to Zanjan, Iran; lunch, west of Erzurum; resting by Lake Garda.

Imperial's student explorers have reached the roof of the world in the Himalayas and plunged miles underground in the cave systems of Slovenia. They've tackled a wide range of missions, from repairing bridges for remote African communities to surveying the "cockroaches and wood-rotting macrofungi" of Papua New Guinea. And then they have come back and filed a report for the Exploration Board.

Founded in 1955, the Board includes student, staff and alumni representatives drawn from across the university, plus external members co-opted for their specialised medical and mountaineering knowledge. Dr Lorraine Craig, Associate Dean (Learning and Teaching) in the Faculty of Engineering, and the Board's current chairman, says: "It was set up to consider proposals for expeditions, advise the Rector and administer funds. From the start, it was a collaboration between the College, the old Student Associations and the Students' Union, and it still is. The Union gives us money every year, and that's an important principle."

The records of the earliest trips offer a valuable and sometimes humorous insight into a very different age of exploration. Team members are mentioned somewhat formally by surname only, and the diaries are permeated with a gentlemanly, stiff-upper-lipped stoicism. When a roped-up student falls into a crevasse during a 1957 trip to Karakoram, Pakistan, the writer drily notes that he "disappeared rather rapidly from sight to find himself dangling upside down... with nothing very much below him".

When read through the lens of modern sensibilities, the reports throw up some surprises. The 1957 expedition to Arctic Norway includes an acknowledgement to "Philip Morris & Co. Ltd. and W.D. & H.O. Wills" for supplying free cigarettes. Likewise, there is something very much of its time in the team's tribute to a Norwegian field nurse "for her pluck and stamina in carrying out a man-sized job" when aiding a medical evacuation.

However, the first all-female expedition would take place only three years later, when a pair of undergraduate zoologists travelled to the Caribbean island of St Kitts to survey

its wildlife. Plans had to be altered when the police refused to allow two unaccompanied women to camp out in the open, though the report admits that "subsequent weather proved so atrocious that camping would have proved disastrous". This was something of an understatement. On 4 September 1960, Hurricane Donna flattened large swathes of the West Indies.

Shared experiences

The early expeditions were unusual enough to attract a lot of media attention. David Attenborough not only interviewed the St Kitts duo for BBC television, but took time out to offer them travel advice. There was also extensive press and TV coverage for another 1960 trip, when five undergraduates squeezed into a Standard-Vanguard Estate (above) to "show that the overland route to Kashmir is possible in a standard production car". Despite multiple tyre punctures, a fractured shock-absorber and several bouts of dysentery, they managed to prove the hypothesis.

Alongside all the period detail, what's most noticeable in the reports is the amount of scientific data that many groups bring back – from hand-plotted topographical maps to daily weather information, painstakingly tabulated by typewriter. Dr Craig says: "Lots of those trips were very much about people going up mountains and doing old-style surveying, then coming back and presenting their findings."

And while the technology and equipment has changed, the goal of expeditions remains the same – and the reports remain just as vivid. Take the 2011 trip to Svalbard, in which six students travelled to the remote Arctic archipelago to live without support for a month. Like most of the records, the report sets out the objectives of the trip, presents a detailed day-by-day diary and concludes with equipment lists, scientific observations and financial accounts. But it's the details that make the experience leap off the page.

There are hard-fought achievements, such as reaching the summit of Newtontoppen, Svalbard's highest point ("Incredible views all around, far into the distance"). There are sore disappointments; the group was unable to fulfil their aim of reaching a latitude of 80°N – further than any previous Imperial expedition – or climbing the 1,628m Galileotoppen, thanks to "a very thin section of rotten ice, which crumbled away beneath our feet... Mildly terrifying."

Naked bathing

Some moments verge on the surreal. The students of the Svalbard expedition earn their "Arctic Naked Bathing Certificate" by stripping off and running into the icy sea in front of two witnesses, one armed with a rifle to ward off polar bears. Another day's journal mentions that they: "Made a snowman called Phil." No further explanation is given. And then there's a full account of what became known as the Night of the Freezing Rain, which team member Heather Jones (MSci Physics 2012) still recalls with a shiver. "We had to give up and sit in our tents for 36 hours," she says, "and 36 hours in a two-man tent is a very long time. You don't go to an Arctic desert expecting rain; afterwards everything was frozen solid. We called the weather people on our satellite phone and they said, 'You're experiencing some precipitation'. Well, thanks. We knew that!"

Expedition leader Alex Kendall (Biology 2010, MSc Conservation and Forest

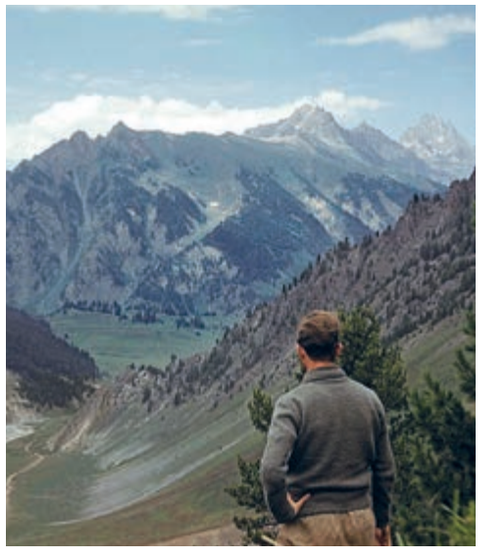
Near misses
Travelling through Iran, Afghanistan and Pakistan some of the team were struck down with dysentery ("the onset was frequently so sudden that one could not stop to speak, just tap the driver on the shoulder"), possibly caused by cooled down unleavened bread they had been eating. There was also a near miss when one of the five fell asleep at the wheel: "We were relieved not to have crashed and appreciative of Rod's recovery skills, but the rest of us were very free with our comments." On route to the Khyber Pass the team "noted the glint of binoculars from the top of the valley cliffs – we definitely got the feeling we were under observation in enemy territory". Clockwise from left: Farah, Afghanistan; on the Chalus to Tehran road, Iran; Rod refuelling the car in Herat, Afghanistan; Rawalapindi, Pakistan; the Jalalabad to Kabul local bus passes the team's rest day campsite.

Protection 2012) says that the advice and guidance offered by the Board was as valuable as its help with funding, equipment and contacts. "We were attracted to Svalbard's remoteness, and that came with risk," he says. "Getting you to think about that is one of the things the Board is good at. They said, 'Yes, this is perfectly possible to do, but you have to think about this, this and this': in our case, polar bears, crevasses, sub-zero temperatures – and what you do if someone gets injured."

Indeed, the support of the Board proved vital for Sara Arbós i Torrent (MEng Aeronautics 2009, PhD 2013) and her group of four on their 2012 ski-mountaineering expedition to Alaska. Her group was dropped off on a glacier by ski-plane and lived there for four weeks, building an igloo to serve as the focus of their base camp. During this time they made a number of successful first ascents of surrounding peaks.

But when Sara fell on a descent and badly gashed her leg on an ice screw, the emergency procedures established by the Exploration Board immediately kicked in. "As soon as I was off the mountain, we assessed my injury," she says. "We could have stitched it ourselves

They said: 'Yes, this is perfectly possible to do, but you have to think about this, this and this'. For us, that meant polar bears, crevasses and sub-zero temperatures



Reaching Kashmir
The full, London-Kashmir-London expedition took 87 days across 16,645 miles, at a total cost of £548 for the five travellers (£50 of which was an Exploration Board grant). **Clockwise from left:** meeting locals near Amritsar, India; Dave on a mountain climb in Kashmir; Mike, Alan and Rod on the mountain climb in Kashmir; a shikara ride to the Dal Lake Houseboat in Srinigar; Alan cutting Rod's hair in Kashmir.

– we'd done the medical courses to be able to do that – but we decided to call for rescue. We called Imperial on the satellite phone, and the next day the pilot came to pick me up and take me to Anchorage."

"It shows that our preparation worked," she says. "We knew exactly what to do because we'd been trained for every eventuality." After hospital treatment in the Alaskan capital, Sara recovered fully within a month. Meanwhile, the others were able to carry on the expedition.

A whale of a time

In 2015, Frances Wensley (MBBS Medicine 2015) became the first Imperial explorer to cross the 80°N line in Svalbard. She and her expedition partner, Gareth Watkins, sailed a 35ft yacht up the Norwegian coast and across the icy Barents Sea to the islands – a part of the journey that is glossed over in the report as "676 miles of cold, wet and waves".

The islands more than made up for the hardships of the voyage. One of the most memorable experiences was exploring long-deserted whaling stations, strewn with 200-year-old boats and whitened whalebones. "That was very moving," she says. "Just trying to imagine the lives that those people lived. And we went to see the places where they made the first ill-fated attempts to reach the North Pole by hot-air balloon – you can still see the remains of the balloon sheds."

Although the academic value of an expedition can still play a part in the selection process, Dr Craig believes that taking on an adventure in a remote environment is an end in itself. "The current view of the Board is that for many students, organising an expedition – everything from coming up with the original concept to returning safely and submitting a report – is enough of a challenge. A student who does a full-scale expedition, perhaps 18 months in the planning, will be developing a huge range of transferable skills."

That was certainly the case for Wensley, whose experience was life-changing. "You get so much independence out of an expedition and you learn so many skills," she says. "I'm now working for the NHS, which is very different: it's rigid and strict in its training programmes. But I think it can be just as important to learn to understand risks and cope with difficult environments."

So how does today's Exploration Board choose the expeditions that it will support? "We back the ones we think are a challenge to the students who are undertaking them, but they have to be clear in their thinking and planning," says Dr Craig. "We'll sometimes say, 'You're not ready to go away yet,' and advise them to consider a more modest proposal. And there are some that are completely bonkers and are never going to go ahead, not least for health and safety reasons."

"When I look back at it," says Alex Kendall, "I think it's amazing that we were able to all carry on having a regular daily routine while we were living on a glacier in the middle of nowhere. We all got on with each other and had normal conversations. There was no survivalist rubbish about it being a horrible mission, and thinking we were all close to death all the time. It was about enjoying the outdoors – not enduring hardship for no reason."

» *Delve into the Exploration Board's extensive archive, and read more about the expedition to Kashmir, at www.imperial.ac.uk/be-inspired/exploration-board*

PHOTOGRAPHY: ROBERT GRASTY

You don’t go to an Arctic desert expecting rain. Afterwards everything was frozen solid

BEYOND VISION

Seeing is believing. And now, new imaging techniques are taking human vision beyond nature.

Words: **Becky Allen** / Photography: **Joe McGorty**

It started with a piece of glass, possibly ground out of rock crystal in Italy, probably at some point in the first century BC: a tool to magnify what can be seen. Crude, yes. But effective. No wonder people were fascinated: it was a chance to see beyond the limits of our own senses.

Today, that fascination is even more intense as imaging science enables us to perceive not only the smallest phenomena in the universe but also some of the largest. But seeing is just the beginning; by harnessing the incredible power of modern imaging science – from medicine to robotics, and biophotonics to environmental sensing lasers – we can take human visible perception and understanding to new levels.

It all starts at the very highest level, way out in space, where scientists want to monitor climate change, pollution and even vegetation health using a new laser system being developed for the European Space Agency.

"Imagine a sensor small and powerful enough to be placed in a micro-satellite and which can assess the chemical state of an entire ecosystem with centimetre precision," says the project's technical lead, Dr Gabrielle Thomas of the Department of Physics. "The thing we are most excited about is that it can be used for remote monitoring of vegetation. It's technology that could transform agriculture and land management, and support government and humanitarian efforts to manage and conserve resources across the globe."

Using lasers rather than relying on the Sun as a light source means remote sensing devices can work 24 hours a day and deliver much greater detail. By emitting 10,000 pulses a second, each only a few

Name: Jack Maxwell
Prescription: Right eye -.5, left eye -.25
Research team: Adaptive Optics in the Photonics Group, Physics department
Research project: 3D refractive index tomography

"I first got my glasses at the end of my undergraduate course, and wearing them transforms the world. Ocular optical aberrations relate closely to my research, which involves sending light through general biological specimens to see what aberrations they impart on the light, to then work out what structures must have been in the object. It's like holding a slab of glass up to the light and seeing how the light you see varies as you rotate it."

Name: Vanya Valindria
Prescription: Short-sighted: right eye -6.50, left eye -7.0
Research team: Biomedical image analysis (BioMedIA)
Research project: Analysis of whole-body human MRI images

"I cannot imagine how I could live without glasses. When I put them on, things that were previously blurred or unrecognisable become clear. In a similar way, before we run our software on whole-body MRI images, all we see is the regular MRI scan. But after the software processes the image, we can detect, segment and recognise multiple organs."

nanoseconds long, Thomas's laser will be able to resolve things down to around 15 centimetres, compared with tens of metres from devices that use sunlight.

What is unique about her laser, however, is what it will be able to see, and that is thanks to alexandrite, a ruby-like crystal more commonly used by the cosmetics industry to remove unwanted hair, tattoos and wrinkles. Alexandrite produces light between the red and infrared end of the spectrum, and because this is where the response of green plants to incident light changes rapidly from absorption to reflection, it means the laser can accurately measure the health of a forest or crops in a field. And by making it small and light enough to be mounted on mini-satellites and drones, the laser will be able to monitor the health of huge swathes of forest or arable land.

"By 2050, we need to increase the amount of food we produce by 70 per cent, and we need to manage our growing population's impact on the planet. By helping farmers spray or irrigate crops only where needed, our system could be a really powerful tool in areas where resources are limited."

The light produced by alexandrite covers just one part of the optical spectrum and, of course, scientists image using the full range. One optical technique, fluorescence imaging, has its roots in the sixteenth century, but the observation of green fluorescent protein in jellyfish in the 1960s began a transformation in imaging science. Today the phenomenon, where a material absorbs light at one wavelength and emits light at a longer wavelength, underpins many of the revolutions in microscopy that are transforming bioscience.

Fluorescence microscopy generally is so sensitive that individual fluorescent molecules can be tracked in space and time, and the ability to map specific proteins in live organisms enables scientists to directly 'watch' biological processes. At Imperial, life scientists work in multidisciplinary teams with physical scientists, like Professor Paul French of the Photonics Group, to gain further information about biological processes that were once beyond our sight. "This is an exciting time for biophotonics," he says. "Traditional barriers to observation are being pushed back and life scientists are learning about biomolecular processes with unprecedented detail, speed and physiological relevance."

IMAGING IS GETTING EVER MORE COMPLEX BUT HUMANS HAVE REACHED THE LIMIT OF WHAT THEY CAN PROCESS

French is developing two techniques known as fluorescence lifetime imaging (FLIM) and fluorescence resonance energy transfer (FRET), which allow researchers to watch molecules in time as well as space, and see different molecules interacting. Working with chemists and biologists, his group slowed how FLIM and FRET could be used to screen for inhibitors of the HIV virus. Today they are extending this approach to complex 3D cell cultures and live disease models such as zebrafish.

According to French: "If you're studying a disease mechanism, you ideally want to see how molecules are interacting in live organisms – or at least in 3D cultures – rather than in thin layers of cells on a glass coverslip. These may be easier to image but can often give 'false positive' indications, for example of the performance of a drug candidate." FLIM provides useful readouts of biomolecular interactions, even when the image quality is degraded. This can allow drug discovery to be done in realistic biological environments, which is important because many drugs that work in very artificial conditions can fail in the clinic. Testing them in a more realistic environment means that more drug candidates will fail, and weeding these out as early as possible is vital because clinical trials of new drugs are hugely expensive.

A key challenge in imaging science is that image data analysis is still dependent to a large degree on human interpretation, but two other projects currently being developed at Imperial are matching advances in imaging science with leaps in the technology to support it.

"Imaging is getting ever more complex, but humans have reached the limit of what they can process," says Dr Ben Glocker of the Department of Computing, who trains machines to detect patterns of disease in

medical images. “Although humans have an amazing ability to detect visual patterns and abnormalities, we find it difficult to analyse multi-dimensional, highly complex data, and to see changes over time.”

Which is where artificial intelligence comes in, he says: “Where machines really shine is making sense of large amounts of data and quantifying anything in that data, so we’re developing software to augment human skills by extracting clinically useful information from medical images that allows doctors to make the best decisions.”

As well as studying traumatic brain injuries and the potential to use machine learning to help us find imaging biomarkers for hard-to-diagnose neurodegenerative diseases such as Alzheimer’s, one of Dr Glocker’s main areas of research is teaching machines to spot brain tumours in MRI scans. But whereas humans can learn from prototypes – show us one bicycle and we can recognise any bike – computers need many examples from well-defined settings. “To teach them how to find brain tumours, we use lots of MRI images from patients with brain tumours, and then use pattern recognition techniques to analyse them automatically so the computer figures out what it is in the image that tells us it’s a brain tumour.”

But what happens once a tumour is identified? Alongside Dr Glocker’s work, Dr Stamatina Giannarou, an engineer and computer vision expert, recently began a Royal Society fellowship to use real-time multiscale imaging and robotics to help surgeons identify and remove those brain tumours more successfully. It is, she says, a hugely important area of research: “I picked neurosurgery because brain tumours still kill more children and adults under the age of 40 than any other cancer, so there’s a big space to help surgeons improve their outcomes.”

Cancer surgery’s main aim is to completely remove a tumour, at the same time as causing minimal damage to surrounding healthy tissue.

WHEN THE SURGEON OPENS THE SKULL THE BRAIN SHIFTS: WHAT WAS ON THE MRI ISN’T WHAT THE SURGEON SEES NOW

For cancers elsewhere in the body, surgeons can ensure they excise the whole tumour by removing a little healthy tissue too. In the brain, however, this isn’t an option because losing healthy brain tissue can have catastrophic results.

At the moment, surgeons use pre-operative scans like maps to guide them during surgery, but these snapshots have major limitations. According to Giannarou, who has watched many such operations: “Once the surgeon opens the skull, you get what’s called ‘brain shift’, the brain deforms and what you saw on the MRI isn’t the same as what you see now.” Instead of maps, she wants to give surgeons something more like the equivalent of GPS. “The idea is to use endomicroscopy and other imaging techniques during the operation, and combine this with robotic tools for accurate scanning,” she explains.

Robotics are vital because endomicroscopy probes are so small and bendy that even the steadiest surgeon’s hand would be unable to scan brain tissue with the necessary precision to collect optical biopsies and keep track of where the probe has been. The final element of the platform will be a database of images to help the surgeon make diagnoses in real time during the operation.

Giannarou believes the platform will benefit patients, surgeons and healthcare systems. “By resecting all the tumour and preserving all the healthy tissue you have better outcomes – increased survival and better quality of life. It also means you need fewer follow-up operations, which helps patients and the health service,” she says. “And by enhancing surgeons’ vision – giving them better navigational and cognitive cues – it will make brain surgery less stressful for surgeons.”

Finding real-world applications for advanced imaging techniques is what it’s all about. And it’s something that excites Gabrielle Thomas, who hopes her space laser system could be sitting on the launch pad in the next ten years. “It’ll be nerve-racking but super exciting,” she says. “And it could be so useful to so many people. That’s the most rewarding part. You spend so much of your life in the lab, it’s so abstract, but this could represent a step-change in the way we see the world and use those images to make a fundamental difference.”

Name: Matthew Lee
Prescription: Short-sighted: right eye -1.5, left eye -1.25
Research team: Biomedical image analysis (BioMedIA)
Research project: Developing machine learning algorithms to extract clinically useful information from biomedical images, to aid doctors in diagnosis or treatment planning

"Our goal is to integrate machine learning into everyday life. My daily routine would be pretty hard without my glasses – I never realised just how bad my vision was until I got them during my undergraduate degree. We're hoping people will think the same way about how machine learning helps us 'see' in the future."

<!DOCTYPE html>
<html>
<head>
<title> How to train your computer </title>
</head>
<body>

<h1> **Today, this is one of the ways we talk to computers.** </h1>

 The syntax of coding is so familiar that many of us use it in everyday written language without even thinking.

 But the rise of machine learning computers, which use input data to learn how to complete tasks without explicit programming, will require us to interact differently with machines.

 Because if they are learning, we will need to know how to train them.

</body>
</html>

Words: **Sooraj Shah**
Illustrations: **Matt Murphy**

And that is a change that is coming soon, as Murray Shanahan, Professor of Cognitive Robotics, acknowledges. "At the moment, I guess most Imperial people – staff, students and alumni – use coding or will have had to code at some point in their everyday lives," he says. "But in the future, you will need to know how to train computers onto relevant data. It may mean thinking in a different way – more in terms of data and statistics rather than algorithms."

Healthcare is one of the most exciting areas of machine-learning advances. For Professor of Visual Information Daniel Rueckert, whose team focuses on extracting information from imaging data to help clinicians make decisions about diagnoses of individuals, the reality of training, rather than coding, computers is already here.

"We are using machine learning developed in our group to detect very subtle changes in brain images to try to enable a more accurate diagnosis for patients who have dementia," he says. "The changes are often too challenging for the human eye to pick up, but we are starting to explore how to use our relationship with new technology routinely in the NHS."

Professor Rueckert's team, led by Dr Ben Glocker, is also applying deep-learning techniques to award-winning work on brain lesion segmentation, to more accurately detect brain damage from traumatic brain injuries such as those caused by car accidents. Their system provides automated, image-based assessments of traumatic brain injuries at speeds other systems can't match. "Doctors need to see what's happening to the organs and brain, and are making decisions based on what's in emergency room images," says Glocker. "What we're doing with computing technology is helping doctors make better informed decisions."

"We are replacing image analysis techniques with more general machine learning and artificial intelligence (AI) approaches, which attempt to mimic what a human might do when they look at images," says Professor Rueckert. "That means that the data becomes more and more important because the data is what we use to train the model, and the model effectively represents our knowledge base. As a result, I think the next generation of data scientists is going to become more AI focused, becoming very good at training, using the right data to solve specific problems, and building powerful models that can be used in healthcare and other domains."

As some level of machine learning becomes implicit in how all computers work – in the same way coding is today – academics, researchers and technologists across the world are turning their attention to what it means for those of us for whom the computer is the key tool. Are we going to have to change the way we think? If so, how? Are our brains changing already?

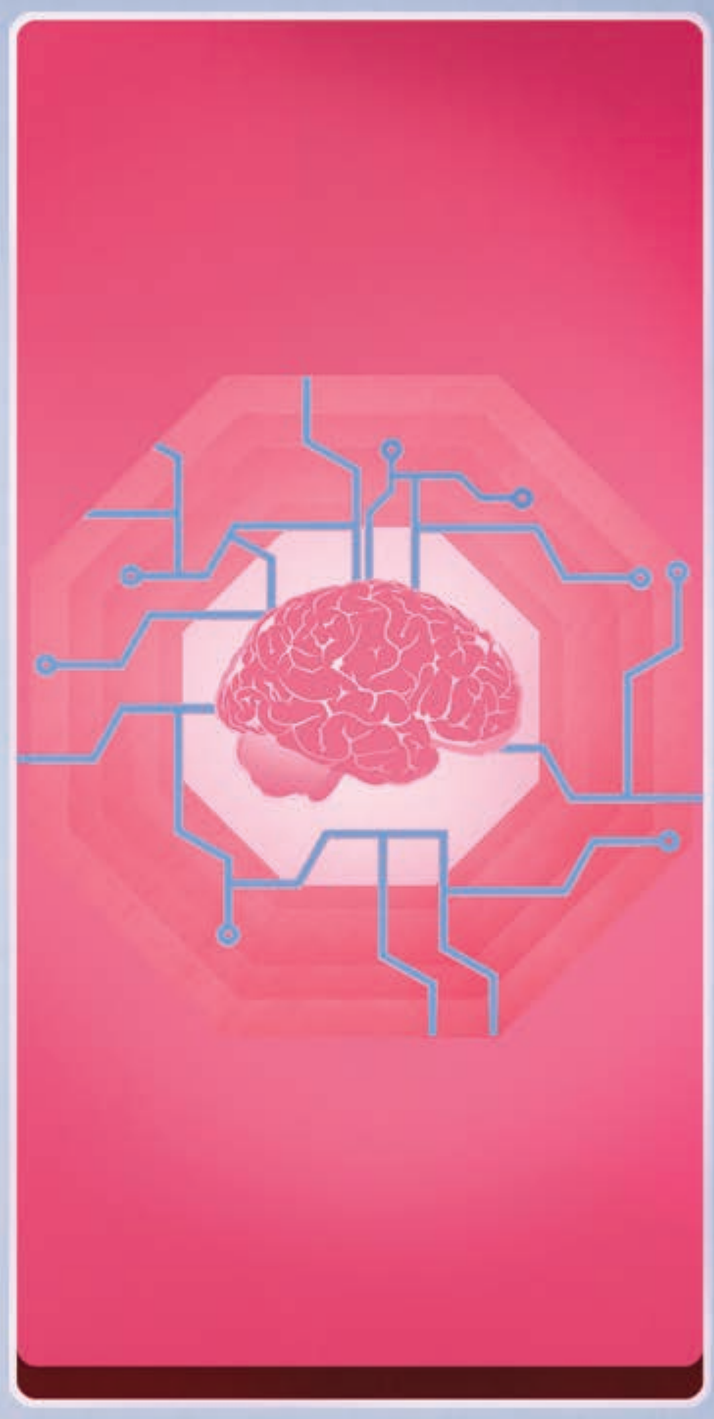
"It is something that people will need to learn, and it may not require low-level programming skills but you would need to know a little bit about what goes on under the bonnet," says Professor Shanahan, suggesting that some coding knowledge will still be useful. "The expertise that this person would need is in getting machines trained with relevant datasets and plugging in various parts of hardware in order to do this."

INTERROGATING THE BLACK BOX

As to computers that train themselves, or which obviate the need for the human altogether, Professor Rueckert is sceptical, arguing that regardless of the state of the technology, machines that work with humans are simply more useful than ones that don't – and machines that don't work with humans may not be usable at all. "I think self-programming computers are very far-fetched. The machine can't make a decision on its own. That's why we call our technology computer-aided diagnosis, not computer-controlled diagnosis. The computer is there to aid the human, not replace them."

This approach can throw up some interesting challenges for those training – and coding – the machines, as Professor Rueckert observes. "The biggest challenge for us working with clinicians is ensuring they do not feel the technology is like a black box – something they can't interrogate. The machine might not get it completely right or it might give a different answer to the clinician," he says. "In that situation with a colleague, the clinician would be asking: 'Why do you think this is the right answer for this particular diagnosis?' But it is quite challenging to extract from a computer reasoning that can then be explained to a human observer."

It makes sense to Professor Guang-Zhong Yang, Director and Co-founder of the Hamlyn Centre for Robotic Surgery, which was established in 2008 to develop advanced surgical robots. "The systems we develop tend to be what we call the 'robot assistant



solution', focusing on tasks that require the kind of precision that can't be done freehand or which will lighten the surgeon's cognitive load, leaving them free to deal with unexpected events and high-level planning," he says.

In practice, this means matching a surgeon's experience and understanding with a machine's precision, to execute surgical tasks that require both a high level of dexterity and the ability to respond instantly. "So rather than saying that the robot will run autonomously, we are developing robots that can understand the human better. We call the concept 'perceptual docking', where the machine will understand human perceptual capabilities, and will in fact rely on human cognition, with the two working together."

ADAPTED TO HUMANITY

Of course the advances are not confined to the world of medicine, and the question of how machine learning can positively affect human outcomes is something that has an impact on everyone, including the commercial world. Charlie Muirhead (Computing 1996) founder of CognitionX – a networking platform for the world's leading AI innovators – says that machines that can 'learn' are already on the market and these will commoditise quickly, meaning that affordable off-the-shelf solutions will be readily available shortly. "The challenge will be having the right datasets to train it up in order to solve a problem, so that aspect will be less about coding and more about coming up with an algorithm itself." And the future is already here, he says. "You can already sign up to a cloud service and get online access to state-of-the-art machine learning at a relatively low cost."

"Everything is becoming more – not less – involved with the human," says Professor Yang. "We are working with reinforcement learning, so the system learns from false positive and negative reinforcement, from which the internal reasoning process starts to evolve," he says – clearly, this will become ever more essential if AI is to be really useful. "The ethical and legal challenges of an autonomous robot are huge," he says. "If, as a patient, I am treated by a robot and something goes wrong, how do you deal with the legal process? Who is responsible? The future of coding will become a lot more sophisticated and closer to the way we reason and communicate and also how we learn, but the human mind will always be there."

COULD THIS BE THE END OF 'COMPUTER SAYS NO'? IT MAY WELL DEPEND ON THE TRAINER

The increased interaction with computers has enabled people to become empowered, and AI is likely to continue that trend, but the downside of the use of machines is an overreliance which has encouraged a measure of laziness, whereby people aren't learning their car journeys and are instead relying on mapping applications to get them to their destination, which doesn't bode well for a future where technology gets more sophisticated.

And maybe that is why many experts believe that the need to train computers represents an opportunity to make them not so much more human, but more adapted to supporting humans than ever before. "We may be offloading a lot of our cognitive effort to machines in the future and become somewhat dependent on them to make increasingly complex decisions on our behalf," Professor Shanahan says.

Self-programming computers that require no human input are still far from becoming a reality – they're more likely to be seen in a sci-fi film in the years to come. But this means that there will still be a huge need for people who can code, as the artificial intelligence techniques get increasingly complicated, and for a new breed of engineers who are interested in training machines. Could this be the end of 'computer says no'? It may well depend on the trainer.

"I am pleased to be able to support this unique institution."

DR MARTIN COLE, LEGACY PLEDGER
(PhD BOTANY AND PLANT TECHNOLOGY 1958)

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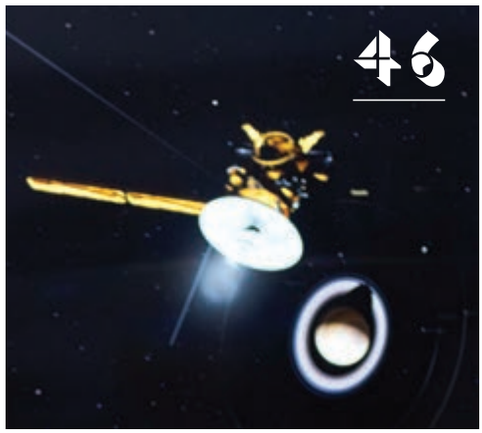
“AS PRESIDENT, ONE OF MY BIG TASKS WAS TO MAKE SURE MASCOTRY STEALING DIDN’T GET OUT OF HAND. WHICH, OF COURSE, IT DID.”

Lord Chris Fox
Students’ Union President 1979-80



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DISRUPTOR

A good use of energy

Economist Dr Mirabelle Muûls is disrupting the way consumers and businesses think about climate change.

> **We wanted to find out if people would use less energy for reasons other than making savings on their bills**

Everyone wants to save the planet – in theory. But as an economist working on climate change, I'm interested in what might make you take positive action. Would you let an app on your smartphone tell you when to start your washing machine cycle? How about using an integrated 'smart energy' system which automatically turns your appliance on and off at optimum times?

These are the kinds of questions I'm exploring as I work on understanding how both firms and individuals react to different policies, incentives and information they're presented with to help protect the environment.

With individuals, this mainly involves analysing just how ready consumers are to shift their practices around energy consumption, as a result of innovative approaches like the app or smart energy system. After all, a future where 80 per cent or more of our energy is produced by renewables would require dramatic efficiency improvements – something that could be achieved if we reduced our consumption during demand peaks or supply troughs.

One of our most recent published studies on the topic, which was reported in *The Washington Post*, involved looking at the energy consumption of students in halls of residence. We wanted to find out if people would use less energy at home for reasons other than making savings on their electricity bills. By testing students, who don't pay for their energy use in halls, we were able to focus on these other incentives.

So we informed these students once a week, over seven weeks, about how much energy they were using in their dorm rooms and how that compared with the energy usage of other students, with the goal of invoking a new norm of using less energy. Interestingly, just knowing this led to a 22 per cent decrease in overall usage.

We also wanted to see if a competition-based incentive would work, so we created a prize for the student using the least energy. The surprising effect was that those students that realised they weren't close to winning after a few weeks stopped making any effort, showing how carefully incentives need to be designed. This research has been recently extended to social housing, where on top of climate change and renewable energy comes the issue of fuel poverty. Here, we're trying to understand how people can be both better informed and rewarded to manage their energy in the long-term.

Of course, once we know what works we want to be able to put it into practice. Working with Scottish Power and a number of startups, we're looking at how to tackle these different areas among the wider population and we are bidding for a whole new research centre on energy, economics and energy consumption behaviour.

Businesses have also begun to understand the importance of their impact on climate change. We've been looking at how effective current EU policies are when it comes to the carbon market, as well as how carbon markets are being adopted across the world. For example, we're working on a new project that is looking at the Chinese emissions market.

We've also just introduced a new MSc in Climate Change, Management and Finance, with academics from the Faculties of Natural Sciences and Engineering and the Business School leading the curriculum. The programme will produce graduates with a combination of expertise in the science behind climate change (including all the new technologies and the innovative solutions being developed) and in business needs. Imperial is the ideal setting because our strength lies across both areas and the MSc fits perfectly with Imperial's strategy of tackling big global issues through interdisciplinary expertise to deliver world-class teaching.

Our aim is to build an alumni body who will not only go on to transform businesses, but who, in the future, will also be able to collaborate to come up with further solutions to lead to a low-carbon society. Close to 40 students will embark on the programme this autumn. I'm excited, not only because climate change is such a lively topic, but because – as with my research – I know we'll also learn as much from their different experiences.

Dr Mirabelle Muûls is a lecturer in the Faculty of Natural Sciences at the Grantham Institute for Climate Change, and an Assistant Professor in Economics at the Imperial College Business School. To find out more about the MSc in Climate Change, Management and Finance, visit www.imperial.ac.uk/study

ILLUSTRATION: DAVID SPARSHOTT

DATASET

CHILD OBESITY

Dr Sonia Saxena is investigating the link between childhood obesity and related medical issues.

Words: **Victoria James**

Obesity on the rise

From 2000-2009 hospital admission rates in those aged 5 to19 for total obesity-related diagnoses increased more than fourfold.

The most common reasons for admission where obesity was a comorbid condition were sleep apnoea, asthma and complications of pregnancy.

Where obesity was mentioned as a comorbidity

The median age of admission to hospital over the study period was 14.0 years.

5,566 (26.7%) admissions for obesity.

15,319 (73.3%) mentioned obesity as a comorbidity.

56.2% GIRLS

V

43.8% BOYS

Obesity surgery

The number of bariatric surgery procedures per year rose from

1 in 2000

to

31 in 2009

– the majority were performed on obese girls (75.6%) aged 13 to 19.

Jones Nielsen JD, Laverty AA, Millett C, Mainous III AG, Majeed A, Saxena S (2013) Rising Obesity-Related Hospital Admissions among Children and Young People in England: National Time Trends Study. PLoS ONE 8(6)

The statistics are startling. One in ten British children starting primary school are overweight or obese – and by the time they leave in Year Six, that's doubled to one in five. But equally startling is the fact that parents just don't see it. When notified, more than three-quarters of parents did not recognise their child's weight status.

These worrying facts underpin the work of Imperial's Dr Sonia Saxena, Reader in Primary Care, whose research is shaping government policy on the ever-worsening rates of child obesity in the UK. Saxena's inspiration comes not only from data, but also from the children and parents who attend her general practice surgery in Putney. And from frustration at the way these children are currently being served by the NHS.

"GPs are prescribing them anti-obesity drugs, on repeat prescription, which goes against what NICE guidelines say we should do," she explains. "Bariatric surgery is being performed on children as young as 13. It's a desperate situation."

Saxena's detailed research established the link between observed rates of obesity in children and the explosion in medical problems now being experienced on the NHS frontline: a 30-fold increase in bariatric surgery, a fourfold increase in hospital admissions for obesity-linked conditions such as asthma and sleep apnea, a surge in prescribing for high cholesterol and high blood pressure, and rocketing rates of diabetes.

To unearth these deeply concerning trends, Saxena analysed a decade's-worth of 'hospital episodes' data from 2000 institutions, when there was either a primary (directly causal) or secondary diagnosis of obesity in an admitted child. And her GP experience reveals the human stories behind the statistics.

"Children are coming in depressed, for instance, or needing knee replacements," she says. "There is a very large rise in teenage girls admitted to hospital during pregnancy. Obviously there are social challenges related to pregnancy at that age, but from a biological point of view, up to age 25 is pretty much the best time to have a baby. Yet we're seeing life-threatening complications in mother and child due to obesity."

A second strand of her work relates to the disproportionate incidence of obesity in certain ethnic groups. "It's the 'thrifty gene' theory," she explains. "When you take people with efficient Asian genes and put them into an environment of abundance, their bodies store fat efficiently – but too efficiently."

It's a phenomenon that Kolkata-born Saxena has seen, she notes sadly, among her own family members. But she has tracked it extensively in Britain's child population, finding that girls of Pakistani origin and Afro-Caribbean boys are disproportionately overweight.

This in turn creates hotspots of childhood obesity in areas with large ethnic populations. Her groundbreaking research identified locations "such as Birmingham and parts of London where, by age 11, nearly two-thirds of children are overweight or obese."

Having documented the scale of the problem in the UK, Saxena now aims to achieve the best solutions. And as with everything in this controversial field – there was uproar in mid-August, for example, when ambitious targets that many campaigners fought for were omitted from the government's draft childhood obesity plan – data is driving her forward.

She is focusing on that phenomenon of parental blindness to their child's weight. The goal is twofold: how to ensure parents recognise that their child's weight is problematic, and how then to help both child and family tackle it.

The National Childhood Measurement Programme weighs and measures all children when they enter and leave primary school. This is how we know that overweight or obese measurements double from one in ten children to one in five during those years. Parents are informed by letter of their child's status: underweight, normal, overweight or obese. And here is where things get both worrying, and interesting.

"We followed up on 18,000 of those letters," Saxena explains. "Eighty per cent of parents who were told their child was overweight hadn't known that was the case. Perception is really important here."

> **"Eighty per cent of parents who were told their child was overweight hadn't known it was the case"**

So what did the parents do next? "More than half put the letter straight in the bin. The majority took no action, often pointing to the fact that their child wasn't as bad as others in the playground. We're seeing a normalisation of obesity perception."

Some parents, though, took action. One in twenty went to their GP surgeries. What happened there also shocked Saxena. "Often they were told it was just puppy fat. Their child would grow out of it."

Here, then, are several openings for intervention. Improving parental recognition of their child's weight status. Increasing the number of families who go to a GP after receiving such a notification. And medical practitioners offering a more robust response once families are there.

Saxena and her collaborators on a £2m grant-funded project are now focusing on those openings. They have designed an online tool to improve parental understanding and get them seeking intervention. And the best interventions, she believes, are ten-week programmes of 90 minutes after school, which provide physical activity for the child, and dietary and psychological support for the whole family.

She's also launching a new project with Westminster Council that aims to provide evidence that this joined-up approach can work. "British children are on a trajectory that's going up. We've got to get it going down," says Saxena. The dataset shows just how urgent the task is.

OUR IMPERIAL

UNITED WE STAND

From politics to mascots, and from budgets to fish guts, the role of the Students' Union President has seen a few changes over the years. Here, three past presidents recall the highs and lows.

Words: **Sarah Woodward**
Illustrations: **Sarah Tanat-Jones**

JUDITH WALKER
(Material Sciences 1969)
President 1970-71

I was the first woman President and as such I think my election to the post was quite a surprise to a lot of people, although I won convincingly. Of course, there weren't nearly so many women at the College back then.

I stood as a Socialist Society candidate – I had joined the society at the Freshers' Fair and was able to benefit from the groundwork set by my predecessor, Piers Corbyn [Jeremy's brother, Physics 1968, MSc 1972], who was the first sabbatical President.

We didn't have much money during my time as there weren't all the businesses to run that are now associated with the Union, nor did we have such a strong student welfare role. But it was a lively political scene with a significant stream of student unrest, which I was happy to lead.

In the early Seventies, apartheid in South Africa was the big issue for students. Then there were local protests. Our main concern was to enhance the student voice in university affairs – to make ourselves heard. We had a sit-in at the canteen about the quality of the food, we occupied the Senior Common Room to stop the freemasons meeting there and we campaigned for better student accommodation.

I loved the student agit prop life but my time as President also taught me how to organise a political movement, how to write a leaflet and the best way to communicate my thoughts. My main regret is that I failed to come up with a successor to carry on the socialist agenda I had inherited from Piers. The momentum went out of the student movement at Imperial in the 1970s and we ended up leaving the NUS – again!

» *Judith is Chief Executive Officer of her own strategic consultancy, Judith Walker Enterprises.*

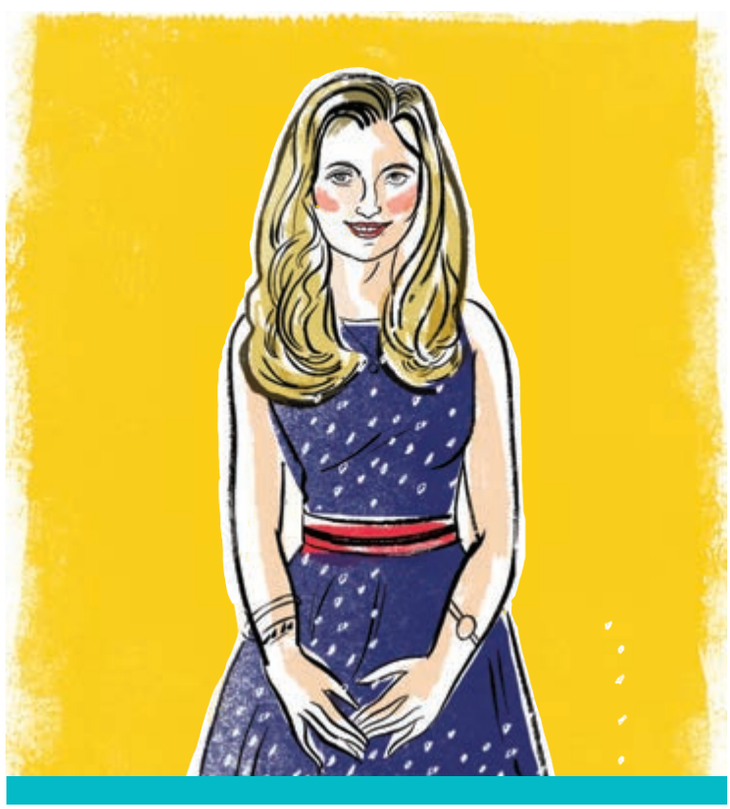
CHRIS FOX, now Lord Fox of Leominster *(Chemistry 1979)* President 1979-80

In the final year of my chemistry degree I served as President of the Royal College of Science Union – standing for the Presidency of the Student Union as a sabbatical officer was in some ways a natural next step. I found I enjoyed campaigning.

I started the process whereby the College's bars came under the control of the Students' Union, one of the reasons the President today has a lot more money to play with. But in those days, we were much less accountable. The Treasurer would occasionally drift into my office and ask: "Are you sure?" about some expense but that was about it. I am not sure I would want the job with the level of governance that there is now. In my day I could pretty much do what I liked, but then again I carried the can if something went wrong. I did have lots of people reporting to me, both student colleagues and union employees, so they stopped me making too many mistakes. I learnt to be resourceful and acquired a sense of responsibility.

I wasn't a hugely political President. Abortion was a big issue at the time and there were lots of debates about the protection of the unborn child. There were also the challenges of managing international students whose nations were in conflict. And the imposition by government of full-cost fees for overseas students led to an occupation by students of the Senior Common Room in Sherfield. But one of my biggest tasks was to make sure mascotry stealing didn't get out of hand. Which of course it did. At the interconstituent college rowing there was a huge fight for the Morphy Oar, which included collecting tubs full of offal and fish-guts to hurl at the opposition. As President I was meant to rise above the fray. I am not sure I did, but I had a huge amount of fun.

Chris is Communications Director for global engineering group GKN.



LUCINDA SANDON-ALLUM *(Biology 2015)* President 2015-16

On my second day at Imperial I went to a welcome talk where the President of the Students' Union gave a talk and I said to my friend: "I'd like to do that." I really thought I could make a difference, but I don't think I fully understood what I was getting into.

It's a huge role these days – the Union had a turnover of just under £8m last year with 50 full-time staff members and a Managing Director to report to, who has been a great mentor to me. It's been an amazing experience, with no two days the same.

> **"Gender equality has been a big issue. And I'm proud to have introduced Week Zero"**

Gender equality has been a big issue for me during my year, not least because of the ways in which social media affects women leaders. I was delighted to get representatives from UN Women and associated guests to host a panel discussion on campus, based around their HeForShe campaign for gender equality. And I am also proud to have introduced Week Zero, an academic-free welcome week. From 2018, just like in many other universities, freshers will have a week to adjust to life at Imperial before they start studying.

As for me now, I plan to use the confidence and experience I've gained as President to help in women's education projects.

Lucinda is currently on a post-degree gap year, travelling and getting involved with wildlife conservation projects.

ADVENTURES IN...

SPACE PHYSICS

Professor Michele Dougherty is focused on understanding where and how life could be sustained on other planets.

Words: **Pamela Evans** / Photograph: **Joe McGorty**

"You need a lot of patience to work in outer planetary spacecraft," observes Professor Michele Dougherty. "When you're planning missions to the outer planets, it often takes 20 to 25 years from when you first start thinking about a mission to when you start getting the data back."

Dougherty is no stranger to the decades-long timeframe of space physics research. As Principal Investigator for the magnetometer aboard NASA's Cassini spacecraft, she will soon see the project, first mooted in the mid-1980s, finally complete. Cassini began its journey to Saturn from Cape Canaveral in October 1997, reaching the planet's orbit in 2004. Since then, it has found everything from ice-crystal-spewing jets on the surface of Saturn's moon Enceladus to evidence of rain on Titan. In September 2017 it will plunge itself into Saturn's atmosphere and vaporise.

Recently, she spearheaded another project that won't start producing data until it reaches Jupiter and its moons in 2030. The JUpiter ICy moons Explorer (JUICE), funded by the European Space Agency, will carry 11 instruments, including Professor Dougherty's magnetometer. Her team began designing and building the instrument, which measures magnetic fields, a year ago, with launch scheduled for 2022. Its mission: to study the liquid water which, it's believed, lurks under the surfaces of three of gas giant Jupiter's moons, Ganymede, Europa and Callisto.

"All three moons have icy surfaces," Professor Dougherty explains. "As well as having liquid water under those surfaces, we also believe they have organic material and a heat source. But we're not going looking for life. We're looking to see whether the conditions are right for life to form."

Once JUICE reaches Ganymede's orbit, the magnetometer will measure the size of the magnetic field produced by the currents that flow in the subterranean ocean. By analysing that data, Professor Dougherty and her team will be able to work out how deep the ocean is, how salty it is and the thickness of the ice crust. This last calculation is particularly vital for future missions: if another mission is sent out, will it be able to get underneath that ocean to study the water directly?

JUICE will send back information once a day, every day, for three years – before it, too, burns itself up in Ganymede's atmosphere. Data will go to a ground station network, then to the European Space Astronomy data centre in Madrid, and finally to all the teams involved in the project: currently, around 2,000 people from countries including the UK, Italy, Sweden, Germany, the Netherlands, France and the USA.

Right now, Professor Dougherty and her team are focusing on designing their instrument to withstand the rigours of both space travel and Jupiter's particular conditions. It's a challenge. Stand anywhere on Earth with a compass and that needle will point to the North Pole, because of the planetary field generated beneath the surface. Jupiter's largest moon, Ganymede has its own planetary field – the only one of the moons to have one – and that could interfere with the magnetometer's readings of the signature from the liquid ocean.

Professor Dougherty's team will have to come up with ways of separating and subtracting this effect from the effect of the magnetic field generated by the ocean currents, so they can pinpoint its size. "You measure magnetic flux in units called nanoteslas. We're trying to find changes in the magnetic field of 0.2 nanotesla, in a background field of about 1,000 nanotesla," she says. They'll only be able to do this once the spacecraft is orbiting around the moon and sending back information they can use.

The spacecraft itself will also need to be as magnetically 'clean' as possible to avoid disrupting readings, as will the other instruments. There's an elegantly simple solution to this problem: a long stick. "Our magnetometer will be on a ten-and-a-half-metre-long boom, sticking out from the side of the spacecraft," explains Professor Dougherty. "This will get us as far from the spacecraft as we can, so the field that we measure is from Ganymede itself and not anything of ours or the spacecraft's."

The effort will be worth the wait, says Professor Dougherty. "I won't tell you how old I'll be in 2030!" she says. "I hope I'll be working on the data it sends back. But the people who will be really crunching the numbers will be the younger ones who are training on the team right now. It's very satisfying, knowing that. It's a way of paying back."

» *To hear more about Cassini and the magnetometer, watch The Final Frontier, a resource for primary school educators, at www.youtube.com/watch?v=I8auHTiN8AA*

Opposite page: Professor Michele Dougherty is lead scientist on the project to study Jupiter's moons.

“We’re not looking for life. We’re looking to see if the conditions are right for life”

PIED PIPER

Alice in Wonderland

CAN YOU COMPRESS YOUR IMPERIAL EXPERIENCE INTO ONE MEMORY? FOURTH-YEAR MEDICAL STUDENT ALICE LEE SAYS THAT, FOR HER, IT IS ALL ABOUT THE REYNOLDS BAR.

Words: **Lucy Jolin**
Photograph: **Hannah Maule-ffinch**

Hidden behind Charing Cross Hospital is probably the most low-key nightspot in the West End: the Reynolds Bar in the Students' Union. Café by day, bar and disco by night – made possible simply by moving the tables to make space for the dancefloor and turning on the disco lights.

But though it may not be flashy, for me, the Reynolds is at the heart of Imperial's medic family. Wednesday is Sports Night, when all the different teams play. It's traditional for us all to go back to the Reynolds and either celebrate our wins or commiserate over our losses. Then the tables go away, and the disco lights go on.

Freshers' Fortnight is held there, and it's where I met many of my friends and my College 'mum and dad'. I still remember walking into the Reynolds to meet them for the first time. I was nervous, but they bought me a drink and then sat me down and told me all about the course and what to expect. I'm still in touch with my 'medic mum', Helen-Cara Younan (Medicine 5th Year) today.

Because all the medics go there and it's a medics' place, we all know each other and all the year groups mix. Lots of us will go after lectures to have a pizza. It's our place. For me, it epitomises the community feel. Whenever I think about my best memories of Imperial, they are always inside those four walls. It's a symbol of our supportive community. Oh, and the snakebite and black is pretty reasonably priced, as well – though I tend to steer clear of it these days.

Alice Lee is in her fourth year of the MBBS/BSc Medicine. Share your memories by emailing imperialmagazine@imperial.ac.uk or using #ourimperial to contact us on social media.

> **"On Sports Night it's traditional to go back to the Reynolds and celebrate – or commiserate"**

Calendar

Imperial invites you to connect with world-leading researchers, inspiring students and the College's senior leadership at events throughout the year, in London and around the world.

8 / DECEMBER

Imperial Fringe: all around the world

From Antarctica to the desert, take a scientific trip of discovery around the globe.

College Main Entrance,
South Kensington Campus, London

1 / FEBRUARY

Schrödinger Lecture

Professor David Hand (Mathematics) delivers the annual Schrödinger Lecture.

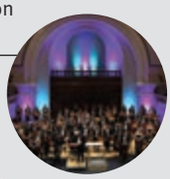
South Kensington Campus, London

15 / FEBRUARY

Peter Lindsay Memorial Lecture

A public lecture from Sir Paul Nurse, Chief Executive and Director of the Francis Crick Institute.

South Kensington Campus, London



4 / MARCH

Imperial College Symphony Orchestra Concert

A performance of Weber's Der Freischutz Overture, *Bernstein's* Symphonic Dances from West Side Story *and Ravel's* Daphnis and Chloe Suite No 2.

Cadogan Hall, London
www.union.ic.ac.uk/arts/orchestra

MARCH

Legacy Afternoon Tea

Join us to learn more about leaving a gift to Imperial in your will.

South Kensington Campus, London

22 / MARCH

President's Address

President Gast will deliver her third annual address.

Great Hall, South Kensington Campus, London

23 / MARCH

Ernst Chain Lecture

A public lecture from Nobel Laureate Professor Ada Yonath (Weismann Institute).

South Kensington Campus, London

7 / JUNE

Donor Reception

An annual event to thank donors to Imperial for their support.

South Kensington Campus, London

21 / JUNE

Friends of Imperial Summer Party

170 Queen's Gate,
South Kensington Campus, London

→ www.imperial.ac.uk/whats-on

"Fascinating event"
THE GUARDIAN

6–7 / MAY

Imperial Festival and Alumni Weekend

Save the date for a packed weekend programme of hands-on activities, talks and performances for all ages. Register for the Alumni Weekend at **www.imperial.ac.uk/alumni-weekend**

South Kensington Campus, London

Imperial around the world

Receptions for alumni and friends will be held around the world so you can hear the latest from the College and expand your network.

Check the website for more details as they are confirmed: **www.imperial.ac.uk/alumni/events**

The events listed here are just a small selection of what's on offer. Sign up to receive the e-Bulletin: **bit.ly/events_sign-up**

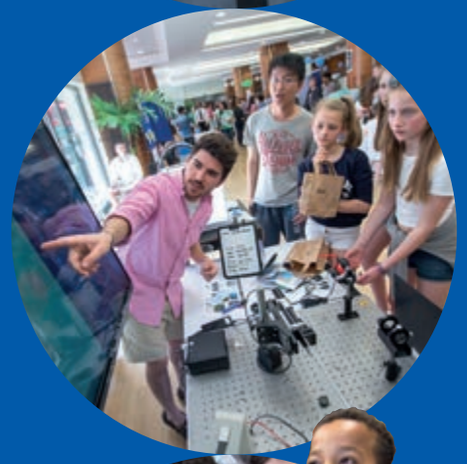
Email: **events@imperial.ac.uk**

Can't make it to campus?
Don't panic – many of our events are now live-streamed or filmed so you can enjoy them anywhere.

www.youtube.com/imperialcollegevideo

IMPERIAL FESTIVAL

6–7 MAY 2017



Make a date with discovery in 2017 at the Imperial Festival, a FREE event for all ages celebrating the livelier side of science.

Whether you are an alumnus, staff, student or member of the public, join us to enjoy a packed programme of talks, hands-on research demos, workshops, and performances.

"A brilliant day out"

ALUMNI WEEKEND at the IMPERIAL FESTIVAL

Register for the alumni weekend for exclusive activities:

- Preview Festival exhibits before the crowds and access an alumni-only zone
- Go behind-the-scenes on exclusive tours
- Catch up with old friends, reconnect with your department and the College and rediscover old haunts
- Reunite with your classmates and celebrate a milestone anniversary (for those who graduated in years ending in 2 or 7)

For more information:
alumni.weekend@imperial.ac.uk

#impfest and #OurImperial
imperialcollegelondon
@imperialcollege

For the latest updates and more information

www.imperial.ac.uk/festival