Imperial/47

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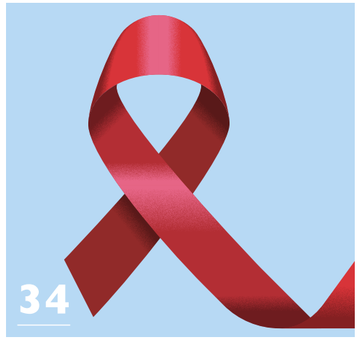
THE MAGAZINE FOR THE IMPERIAL COMMUNITY

WINTER 2019/20

£7.95 WHERE SOLD

TURNING GRAVITY UPSIDE DOWN

CONTENTS



Regulars

Features

Imperial/47

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Imperial is published by YBM Ltd on behalf of Imperial College London Communications and Public Affairs
www.imperial.ac.uk/communications
www.ybm.co.uk

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Fascinating read

As an alum of Imperial, I always read your magazine with interest, and issue 46 had a number of fascinating articles.

It was great to see Imperial starting to get involved in the future of batteries, for example. We need a real breakthrough in battery technology to enable our future in electric cars and solar/wind-based renewables. The comparison of a Tesla to 5,000-8,000 AA batteries puts the challenge into context. It would also be great to find out what Imperial is doing with the hydrogen economy, as I see this as a more practical way forward.

And having lived and worked in Africa for more than 12 years of my life, I really see the challenges the continent offers, and enjoyed the feature (albeit that the headline may have over-dramatised the situation slightly – Africa's GDP is only about 60 per cent that of the UK!). Africa needs an agricultural revolution to create jobs and empower its economy; it could become a breadbasket for the planet without destroying any more forest.

Imperial has a real role to play here to help improve agricultural productivity – indeed, the financial examples (EcoCash and Diamond Bank) will help people in trading and developing their economy, but the continent needs more grassroots investment into agriculture to help it leapfrog the rest of the world!

Thanks, and keep up the great work.

David Simmonds
(Chemical Engineering 1973)

Battery memories

I was fascinated by the feature on batteries in the last issue (*Imperial* 46), especially so because of a story passed down through my family.

At some time in the early part of the 20th century, my grandfather, Richard Alfred Hardway, along with a couple of other men, invented a battery that was a considerable advance on anything current at the time. They planned to put this into production, and a very substantial sum was raised to do just that.

Alas, one of the financial team members oversold the number of shares – leading to his prosecution – and the battery was never produced. However, that did not stop callers sometimes appearing at the door of my grandparents' house in Ilford with considerable sums of money, in guineas, to try to get details of the prototype from my grandmother – if she was the only person at home. She did not divulge!

As this all predates my birth I have not, so far, been able to establish any further details about the case, though I would love to do so (ideas welcome!). Your published article brought it all back to mind!

Dr Raymond Hardway
(Charing Cross Hospital Medical School 1952)

> *Keep up with the latest news from the College as it happens, and share your thoughts and news on our Imperial alumni Facebook page and LinkedIn group.*

facebook.com/alumni.imperialcollegelondon www.linkedin.com/groups/87488

Puzzling it out

We've had a great response to our new puzzle section, so thanks to everyone who has been in touch so far.

Some of you wrote to say that question three, relating to a house number and a PIN number, wasn't an entirely unknown quantity! "I first came across the 'magic number 1089' in a short little square book called *Oddities*," writes Simon Potter (PhD Chemistry 2000), while Ray Cook (PhD Metallurgy and Materials Science 1985) says that he has "known that trick for 66 years!"

In general, though, you seem to be enjoying the challenge: "It was pretty fun working through them! Please keep up the great stuff and hard work," says Yue Guan (Life Sciences 2013); "Those were some brilliant puzzles! I look forward to seeing more!" says Jack Fenton (Mathematics 2018); and "I was grateful for the distraction as the rain continues to fall without end!" says John T. Davies (Chemistry 1969).

Winner Graham Perry (Aeronautics 1965) says: "Thank you! You have made an old man very happy,", while fellow winner Rosco Paterson (Mathematics 1976) adds: "What a lovely surprise!"

Finally, thanks to Rob Stott (Mechanical Engineering 1968, MSc Management Science 1971) for pointing out that the correct address for the solutions to the puzzles in issue 46 should be www.imperial.ac.uk/be-inspired/magazine/issue-46/brain-power.

> *Are you receiving the alumni e-newsletters, containing information on the latest alumni benefits, events and how to get the most out of your Imperial connection? If not, it might be because we do not have your current email address. Visit www.imperial.ac.uk/alumni or use the form enclosed with this magazine to update your information.*

DIGEST

OPPOSITE PAGE ILLUSTRATION: MIKE LEMANSKI

GLOBAL HEALTH RESEARCH CENTRE

J-IDEA to transform international public health response

A new research institute based at Imperial will use state-of-the-art data analytics to identify and combat worldwide disease threats.

The Abdul Latif Jameel Institute for Disease and Emergency Analytics (J-IDEA), co-founded by Imperial College London and Community Jameel, will transform how the world responds to epidemics, chronic diseases, natural disasters and humanitarian crises.

The most advanced facility of its kind in the world, J-IDEA will draw together Imperial's world-leading expertise in epidemiology, biostatistics and data science to improve global health and wellbeing. Its findings will provide the evidence base for effective interventions in the fight against crises such as Ebola and MERS, alongside longer-term global priorities.

Researchers will use real-time analyses and intervention modelling to contain outbreaks, protect vulnerable communities and strengthen health systems with data analytics.

The institute will be led by world-leading epidemiologist Professor Neil Ferguson. He says: "Global crises need global solutions, and collaboration is at the core of J-IDEA. Over the last 20 years, we have seen an explosive growth in data, covering almost every dimension of human life and activity. For health researchers, this represents an unprecedented opportunity.

"The Jameel Institute for Disease and Emergency Analytics will cut through the noise," says Ferguson, "drawing out actionable information and driving effective and affordable policy responses that will transform the health of communities around the world."

Professor Nicholas Grassly, Professor of Infectious Disease and Vaccine Epidemiology, in Nigeria during a study to detect poliovirus in sewage, in collaboration with the World Health Organization.

FROM THE PRESIDENT / PROFESSOR ALICE GAST

"Imperial community full of new ideas, friends and interesting conversations"

Wherever I go, I greatly enjoy meeting friends and alumni of Imperial College London. Our alumni are smart, energetic and inspiring. They take well-justified pride in their scientific and technical expertise, their broad range of interests, and their significant accomplishments. They excel in whatever career they have chosen, be it in industry, academia, government or in a variety of other areas. They have fascinating stories of intellect, hard work and devotion. Graduating from Imperial College London seems to prepare one for almost anything.

It is rewarding to spend time with such impressive alumni, our stellar staff and outstanding students, and it is exciting and gratifying to welcome friends of the College who are eager to be involved with, and support, Imperial and its work.

Our common interests, our shared values and our growing numbers and reach make us a vital community. And community has never been more important.

With so much uncertainty and division in our society, we need the fellowship and support of one another now more than ever. In an age where we get much of our information from electronic sources, it is becoming ever harder to make the time to listen to, and understand, one another. But we must. The insight and warmth provided by a simple conversation while having a coffee or sharing a meal is too valuable to lose. To move from information to understanding, we need to look up from our phones and talk to each other. We need to recapture our sense of community.

Our alumni community is thriving. You are spending time with one another. You are finding warmth in a shared evening. You are giving your time to volunteering for our students and others in ever greater amounts. More alumni than ever are hosting and attending events all over the world and throughout the year. This past year, more than 7,000 alumni registered for one of our nearly 200 events. We are here for you; let us know what opportunities you would like to have to spend time with your Imperial community.

Imperial magazine is one way we communicate with our community. We send it to 123,000 alumni and another 2,600 friends and donors. We know that readers are interested in the science, excited about the impact of our research and curious about the educational experiences at Imperial today. We have filled the pages with cutting edge stories like the ones you find in this issue: the breakthroughs in understanding the "killer fungus" that are appearing worldwide and the discoveries turning our understanding of gravity on its head. We connect with the past, as in the history of *Felix*, and we look to the future with our announcement of the launch of the landmark Abdul Latif Jameel Institute for Disease and Emergency Analytics of J-IDEA. We want to hear from you about what you like and how we could do better.

> To move from information to understanding we need to talk to each other – recapture our sense of community

We have also improved our monthly e-newsletter to reach those who have given us their email address. Our new Plexus platform provides a virtual connection to our community and is an additional way to stay in touch with other alumni and keep informed of what is happening at Imperial. A growing number of you are using Plexus and we will continue to improve it to meet your needs.

Through all of these connections, we respect the privacy of our alumni and friends. If we are not reaching you and you would like to be in closer touch, please email alumni@imperial.ac.uk or call +44 (0) 207 594 6138 – our Alumni HelpDesk team will be delighted to help you to reconnect.

I like an analogy I recently heard in France comparing café culture and encyclopaedias. For both, "you enter with a purpose and then lose yourself to other things".

We all enjoy the opportunity to "lose ourselves" in unexpected conversations. Now, perhaps too often, the café is just a place to get a takeaway coffee (or to sit with our laptop and work alone) and the encyclopaedia is supplanted by the internet search. I hope that you will reconnect with the Imperial community and "lose yourself" in the new ideas, the friends old and new, and the always interesting conversations that you will find. ◆

> ***Professor Alice Gast*** *is President of Imperial College London and is an internationally renowned academic leader and researcher.*

DATA SCIENCE

Not so anonymous

Just how anonymous is the so-called 'anonymous' dataset? Not very, according to a new paper published in *Nature Communications* from Imperial and researchers at UCLouvain in Belgium. They set out to show that to truly anonymise data requires far more than just stripping out characteristics such as names and email addresses.

They harnessed machine learning to correctly re-identify 99.98 per cent of Americans in an anonymised dataset using 15 characteristics, including age, gender and marital status. And to demonstrate to the public how easy it is to hand over unique information, they've developed an online tool that shows you the characteristics that make you unique in datasets.

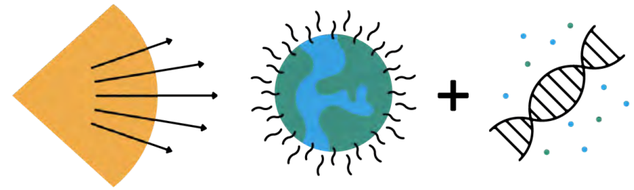
It asks for the first part of your postcode or ZIP code, gender and date of birth, before giving you a probability that your profile could be re-identified in any anonymised dataset. Then it asks for your marital status, number of vehicles, house ownership status and employment status, before recalculating. By adding more characteristics, the likelihood of a correct match dramatically increases.

Senior author Dr Yves-Alexandre de Montjoye, of Imperial's Department of Computing and Data Science Institute, points out that though companies are bound by GDPR guidelines, they're free to sell the data to anyone once it's anonymised. "Our research shows just how easily – and how accurately – individuals can be traced once this happens. Companies and governments downplay the risk of re-identification by arguing that the datasets they sell are always incomplete. Our findings show this might not help."

99.98%

The percentage of Americans correctly re-identified in an anonymised dataset using 15 characteristics.

PHOTOGRAPHY: IMPERIAL COLLEGE LONDON/THOMAS ANGUS. ILLUSTRATION: MIKE LEMANSKI



42

The Hitchhiker's Guide to the Galaxy declares 42 the answer. But what is the question? Dr Robert Endres talks theories of life.

The origins of life on Earth: it is a question that has vexed philosophers, theologians and scientists for centuries – but Dr Robert Endres is undeterred. As leader of the biological physics group and the Physics of Life Network at Imperial, Endres thinks that physics has a lot to offer in moving us closer to understanding our earliest beginnings. "I'd like to extend the successes of physics to living matter and see if we can develop fundamental overarching theories for life," he says.

How non-living matter became living has traditionally been studied by chemists such as Stanley Miller, known as the father of prebiotic chemistry. Miller replicated a lightning storm in his lab in 1953 to produce "primordial soup" – an amino acid mixture he claimed was the basis of early life. But Endres considers physics, particularly far-from-equilibrium thermodynamics, a more helpful tool for investigation because, unlike chemistry or biology, it also studies non-living matter, so could chart the moment life begins.

And he is getting closer. "We anticipated that far-from-equilibrium thermodynamics underpins the emergence of life – when matter is driven to the extreme by fluxes of molecules and energy – but we didn't know how. My student and I recently developed a theory that proves that, everything else being equal, dynamic states of matter emerge when maximum disorder is created in the surroundings. That might even be a precursor for Darwinian evolution, so it's a good starting point."

While he doesn't yet know what the practical applications of his theory might be, there is the potential to revolutionise our inner and outer worlds. "In evolution you ask how are things evolving? How are things dynamically going from one time point to the next and what can happen? What kind of structures can emerge? It's about calculating and predicting the evolution of complex systems. This may lead to new ways for the self-assembly of microscopic structures."

Gaining a better understanding of the rules and control mechanisms of self-assembly would allow the development of synthetic organisms that might, for example, deliver drugs that target a specific tumour. Understanding what conditions are sufficient for life to emerge could also allow governments to accurately assess the viability of missions to Mars and other planets – before spending billions of pounds to get there.

But it's the possibility of homing in on the truth that most inspires Endres. He says: "There's nothing more exciting than asking these fundamental questions: 'Where do we come from? Why and how?' The ideas are there, we just have to put them together like a puzzle."

> *For more on Dr Endres's theory, see bit.ly/Imperial47-42, or visit rgendres3.wixsite.com/biologicalphysics*

ADVENTURES IN ...

Deep time diversity

Looking back is the best way to look forward, says earth scientist Professor Peter Allison.

Words: **Megan Welford** / Photography: **Angela Moore**

Were the dinosaurs in decline before they became extinct? Our modelling tool was able to show they were not

Professor Peter Allison says uncovering the secrets of our ancient Earth is a "magical" feeling.

Professor Peter Allison found his passion for uncovering the Earth's secrets in a caravan on the north-east coast of England. "As a boy on holiday in the late 1960s and 70s I pretty much got to run feral!" he says. "I loved rock pools – turning things over and finding critters. Finding fossils."

These days, his passion for fossils has evolved. "I found classifying the rocks and fossils of one area was a bit dull," he says, "but then, in the 1980s, I read a paper where the researchers had used a computer model to look at how the whole Earth had responded to climate change over time and I thought, 'This is cool.' They were using fossils to answer the big questions."

And so, he took the plunge into the world of deep time diversity, and now uses the oceans, tides and climate to model how the world was a very long time ago – or sometimes, how it wasn't. "Our work helps recognise the bias in exploring deep time," he explains. "If I want to look at the world 100 million years ago, there were rocks in some places and not in others. In the intervening period some of those rocks were buried, some lifted, some eroded. You maybe have a few per cent left. If, in 100 million years, someone wanted to look at the Earth today, and the only preserved bit was from the Sahara, they would get a biased picture. Our tools combine the rock with other data – climate, atmospheric, ocean, tidal – to add to the accuracy of the picture."

Indeed, the work of Allison and his students has recently settled a longstanding dinosaur debate. "Were the dinosaurs already in decline before they became extinct? Our modelling tool was able to show that their habitat was actually fantastic, and that previous work had been sampling the wrong parts of the system. So, they were not in decline before their sudden demise."

These tools can be used for things such as helping ecologists looking for butterflies in the Amazon, for example. "If you go to two or three spots and gather data on the slope, rainfall and plants there, and train a computer model to use these parameters across the whole of the Amazon basin, then you can ask the computer, 'Where shall I go and look next?' And then you can gather more information."

For Allison, there's an element of magic to it all. "It takes me back to fossil collecting with my dad. When you split a rock, and you're the first person to see the animal inside that hasn't seen the sun's rays for 200 million years, it's a magical feeling. Using these tools to see what the ancient Earth was like is the same feeling."

Understanding the world of deep time can also tell us much about future time. "We have good reason to think we are currently in the early stages of the sixth mass extinction," he says. This is the Holocene extinction, which will be the first where more than 75 per cent of species loss is caused by humans. "My tools allow us to recognise the bias in the data and tell us what questions we can't answer. Then other people – conservation ecologists and biologists – can use that to add to the picture of what the impact of global warming will be. Because looking at how rocks have responded to climate perturbations in the past can tell us how bad things could be in the future." ◆

> ***Professor Peter Allison*** *is Professor of Earth Science at the Department of Earth Science and Engineering.*

A working life

Dame Judith Hackitt led the independent review of regulations and safety following the Grenfell Tower fire in 2017, a typically high-profile role for this pioneer of the engineering world.

If the review of building regulations and fire safety I did for the government after the 2017 Grenfell Tower fire taught me anything, it's that you have to stay true to your principles. It was a major piece of work and, as an engineer, getting to the heart of why the system had failed rather than just dealing with the symptoms of that systemic failure was what drove me. It would have been easy to jump to the conclusions that people wanted me to. But I like a challenge. I take on controversial roles sometimes, and when you put yourself out there, you've got to be resilient.

A lot of my career has been about doing things differently, from balancing work and family to becoming an engineer in the first place, which was much harder for women in the 1970s than it is today. I loved science and maths at school, and originally planned to study engineering so I could be a teacher, but when I went into industry after graduation, I enjoyed it so much that I never looked back.

My roles included working at Exxon and the European Chemical Industry Council in Brussels, before chairing the Health and Safety Executive from 2007 to 2016. I have a portfolio career now; I'm constantly hopping from one subject to another, so retaining the key decision points is vital. Wherever I go, I carry a notebook, but to avoid getting it mixed up with someone else's, I bought a pack with the periodic table on the front which feels very "me".

Moving from corporate life, where I'd always had a PA, to managing my own diary came as something of a shock. I travel all over the country, so planning my time is more than just logistics, it's an essential skill. I might have missed a meeting or two in the early days, but I've got it down to a fine art now.

One of my proudest moments was getting my damehood in 2016, in part for being a role model for women. The industry is more willing to value diversity of thinking now than 40 years ago, but we've still got a long way to go. My dad was one of my strongest supporters, and he was a mechanical engineer who qualified through apprenticeships, so I feel passionate about seeing people get into engineering via a variety of routes.

I think we need to change the image of what the job involves in order to make it more accessible. It's not about people who think the same and act the same. It's about working in teams to solve the big problems the world faces – it's exciting.

> *Dame Judith Hackitt (BEng Chemical Engineering and Chemical Technology 1975) was the Chair of the 2018 Independent Review of Building Regulations and Fire Safety and chairs manufacturing trade body Make UK. She also holds non-executive positions at HS2 Ltd, Made Smarter Commission, City and Guilds Group and High Value Manufacturing Catapult.*

RESEARCH FOCUS / POLICY AGENDA
DR GBEMI OLULEYE
RESEARCH ASSOCIATE,
DEPARTMENT OF
CHEMICAL ENGINEERING

"We need net-zero carbon emissions in industry, on a global scale, to protect our future. But we're running out of time"

CONTEXT

The challenge of achieving net-zero carbon emissions in industry is not just about the scientific process surrounding technology development, it's about creating economic and policy frameworks to make it a viable proposition. The future of research in this area will lie at the interface of science, engineering, business and policy.

THE PROBLEM

Most people recognise that, to protect our future, we need to achieve net-zero carbon emissions in industry on a global scale. But to do that, we need to buy into a narrative that is efficient, secure and sustainable. "The world is already on the verge of change," says Dr Gbemi Oluleye, a researcher in the Department of Chemical Engineering. "But we need to do it much faster. We're running out of time."

MODELLING THE FUTURE

Oluleye develops optimisation-based decision-support frameworks for energy system design. These models show how industrial energy systems can be decarbonised, and she examines the possibilities within the wider context of policy creation, business models for accelerated technology adoption, affordability and creating value from decarbonisation to maintain industrial competitiveness.

"I am exploring how to integrate low-to-zero carbon technologies, and alternative fuel options such as hydrogen, biomethane or biogas," says Oluleye. "But the challenge is not just about the scientific element, it's about the adoption of these technologies in industry and achieving decision-support frameworks for decarbonisation. It's about exploring economic and policy frameworks to make it a viable proposition."

INDUSTRIAL EVOLUTION

So, for the past year, Oluleye has been collaborating with industry to better understand the business, technical and policy challenges of net-zero decarbonisation. "We need to create a business case that industries, particularly manufacturers, will adopt, to ensure they do not just move their sites to another country where emission regulations aren't as stringent.

"This means factoring in who will fund it. Energy is the mainstay of any economy. It impacts everything we do – if we're to achieve net-zero carbon emissions, particularly in industry, we have to work towards simultaneous innovations in business models and policy frameworks to drive adoption of the technical solutions and determine who bears the bulk cost of it.

The framework is able to explore new business models that prevent a situation where an increase in production costs is not shouldered by industry nor pass-through to customers, but a system is created to find byproducts that have value in other sectors of the economy, thereby promoting large-scale adoption.

"This model gives us a pathway to commercial viability. For example, my recent work on integration of biogas-fuelled solid oxide fuel cells in industry shows how to achieve market adoption in the short and medium term. Our mathematical optimisation models provide evidence to industry and to policymakers to speed up the process of adoption of greener technologies to reduce our carbon emissions and achieve the net-zero targets."

***Dr Gbemi Oluleye** is Research Associate in the Department of Chemical Engineering, and a recipient of the Imperial College Research Fellowship.*

OVERHEARD ON CAMPUS

***New World leaf-nosed bat:** A group of bats that have evolved to thrive on diets of anything from nectar to blood.*

***Imperial sustainability:** Professor Paul Lickiss has been appointed as Imperial's first ever leader in sustainability, building on initiatives such as Greening Imperial.*

***GOP hormones:** Three hormones originating from the bowel that have been found to aid weight loss in a small study led by Professor Tricia Tan.*

CLINICAL TRIAL

Chlamydia vaccine

The first ever early clinical trial for a chlamydia vaccine has shown it to be safe and effective at provoking an immune response.

Chlamydia is the most common bacterial sexually transmitted infection worldwide, and can in some cases lead to infertility. Around 131 million new cases occur every year.

Researchers who ran the randomised controlled trial of 35 women, led by Imperial and the Statens Serum Institut in Copenhagen, said that it was an important first step in the fight against the infection.

Professor Robin Shattock, Head of Mucosal Infection and Immunity within the Department of Infectious Disease, said: "The next step is to take the vaccine forward to further trials, but until that's done, we won't know whether it is truly protective or not."

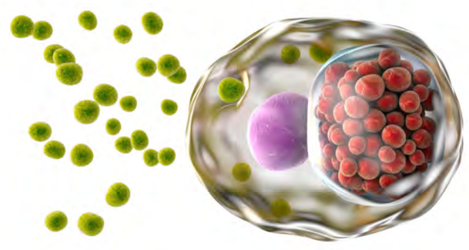


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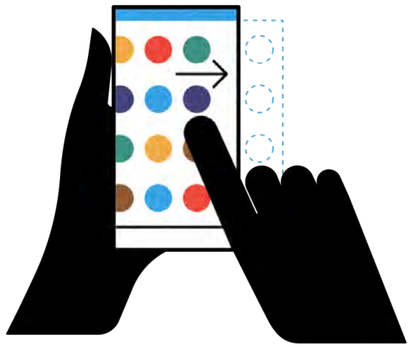
ILLUSTRATION: MIKE LEMANSKI



Test tube

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

WHO DR MILES PAYLING *(MBBS Medicine 2011)*

WHAT

C the Signs is a multi-platform tool that uses artificial intelligence to help doctors diagnose cancer at the earliest and most survivable stage of the disease. It's an integrated tool, so it can be accessed within a patients' electronic health records.

HOW

Cancer is often diagnosed based on late-stage features such as coughing up blood or significant weight loss. To pick it up sooner, you need to look at symptom combinations, but they can be difficult to tease out, as cancer can present in virtually any conceivable way. Our tool uses layers of artificial intelligence alongside a GP's assessment to calculate whether a patient is at risk and, if so, what the next step should be.

INSPIRATION

When my co-founder Dr Bhavagaya Bakshi (BSc Medical Sciences with Management 2009) was training to be a GP, she met a patient in A&E with terminal pancreatic cancer. He'd seen his doctor several times but been misdiagnosed, and Bhavagaya told me that she might have done the same thing because it was so difficult to spot. We decided to try to make something that would be more simple for a GP to use within a consultation.

MOTIVATION

We want as many patients to survive cancer as possible, which means catching it early. Our aim isn't to replace GPs but to help them make the best decisions for each patient in the relatively short amount of time they spend with them.

THE FUTURE

We're currently commissioned in the NHS, covering a population of more than 2.5 million patients, and will be expanding significantly by the end of the year – we're also looking at how the tool can be used in other countries. Cancer doesn't just affect the patient, it's also traumatic for their family, friends and work colleagues, so we think we can make a huge difference to patients' lives and society in general.

> *Dr Miles Payling and Dr Bhavagaya Bakshi are the founders of C the Signs, an artificial intelligence cancer diagnosis tool for GPs that won the Medilink UK Healthcare Business Award for Collaboration with the NHS 2019.*

IN BRIEF

Convergence Science Centre
The £13m Cancer Research UK Convergence Science Centre will "secure the future" of people with cancer. *Full details at bit.ly/Imperial47-CRUKConvergenceScienceCentre*

Be inspired
Check out Imperial's latest podcasts on all your favourite platforms or visit *www.imperial.ac.uk/be-inspired/social-and-multimedia/podcasts*

LKC Medicine students graduate
The second cohort of student doctors from the Lee Kong Chian School of Medicine in Singapore have received medical degrees from Imperial and Nanyang Technological University.

New chair of Council from January
From January 2020, business leader John Allan will be Imperial's new Chair of Council. Allan is currently President of the CBI and chairs two FTSE 100 companies, Tesco and Barratt Developments.

TRIBUTE

Sir Michael Uren 1923 – 2019

Distinguished engineer, philanthropist and businessman Sir Michael Uren (Mechanical Engineering and Motive Power 1943) has died, aged 95.

The man behind a £40m gift to create the Sir Michael Uren Biomedical Engineering Research Hub at Imperial's White City Campus, among other very significant support for medical research, was one of the UK's most generous philanthropists, supporting causes spanning medical research, education, the armed forces and the conservation of wildlife.

ILLUSTRATION: MIKE LEMANSKI

IMPERATIVE / DR ANA MIJIC
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

"The worst case is that people start fighting for the water they can't live without"

Water is an essential resource and it's endlessly replenishable – in theory. But if we look at how fast the climate has changed in the recent past and its impact on the water cycle, it's possible that in the future we may witness devastating floods and water scarcity. Long-term planning is essential, and it's this work that is my imperative.

As an engineer and hydrologist, my work looks at water within the bigger picture. I focus on long-term planning for physical systems, and what this means for policies on the ground.

In India, for instance, we've asked farmers directly how they irrigate their fields, and then incorporated their behaviour into a new water-management model. And in a year-long attachment to the Environment Agency, I've looked at the relationship between tourism, environmental pressures and water management in the Cumbria catchment, in a project to test new tools and methods to manage ecosystems. We're also looking at pressures on water management in London, where there's huge demand for further development.

What we are doing is new, and the government's 25-year environmental plan is a great starting point. We aim to change how we assess and incorporate the role of people in the water cycle. We draw on historical behaviour and try to build models that predict the future. If we want to manage water better, we need to understand the social element and how it interacts with the physical system.

Urban development alters our demand for water and also levels of flood risk, as well as creating pollution. Typically, models of physical water resources don't combine the human behavioural element, or the impact of our activities on the natural water cycle. Combining these different models is a technical as well as a conceptual challenge.

If we create models and tools that will ultimately be useful, we need to work with the people who make the policy decisions. It's important for me to know, for instance, how the Environment Agency operates and what knowledge it requires from the scientific community.

One fundamental problem is the mismatch of the needs of the global economy and the pressure that puts on natural resources. We experience the impact of global warming through our water.

In the last few decades, carbon emissions have soared, and the population continues to increase. Sustainable growth is one of our most difficult challenges. With water management, the spatial element becomes important – can we move water from regions with too much to those that have too little? Or when we are deciding where to build, do we look for a natural environment that supports that growth?

We're trying to see how we can co-ordinate the interests of the environment, land regulators and infrastructure – they're all connected, and we need to find solutions for all these interests. A systems-thinking approach would bring real innovation to our water management. It wouldn't work, for instance, if I proposed a new but energy-intensive solution to water management – it would just ship the problem elsewhere.

For me, success means we can create a new framework, and tools within it, to see water management in a much broader context – something that models physical systems but embeds human behaviour. If we could simulate 100 years into the future taking into account key interdependencies in the water management system, we'd have a better idea of any unintended consequences of development decisions we make today.

> **The greatest danger is that we will change and damage the natural environment beyond its regeneration capacity**

The greatest danger is that we will change and damage the natural environment beyond its regeneration capacity. If we don't change the underlying framework of assessing development to move towards systems approaches, we won't change what we do in practice. At the moment, we are at the theoretical stage – I really hope one day we will deliver science that has a real impact. ◆

> ***Dr Ana Mijic** is Senior Lecturer in Water Management.*

INTERVIEW: WILLIAM HAM BEVAN

THE CAT THAT GOT THE CREAM

AS *FELIX* TURNS 70, SOME OF ITS LEADING PLAYERS GIVE US THE STORIES BEHIND THE HEADLINES.

Words: **William Ham Bevan** / Photography: **Angela Moore**

Henry Alman
Current editor
Just a few months into the role, Henry is looking forward to taking a considered approach and giving as broad a view as possible.

Some cats have far more than nine lives. As *Felix* approaches its 70th birthday, a look through the archives reveals a taste for regeneration that would give pause to a Time Lord. Imperial's student journal has been by turns a roughly typed newsletter with smudgy headlines, a glossy A4 magazine, a business-like *Economist*-style weekly and a full-colour tabloid.

In his corner of the front page, the mascot himself has likewise gone through numerous incarnations, including cartoon kittycat, sabre-toothed tabby, roaring lion and caped crusader. Today, *Felix* appears as the mischievous, tip-toeing feline who graced the cover of the very first edition on 9 December 1949.

The name was a cheeky reference to *Phoenix*, the Imperial magazine that had been founded by HG Wells as the Science Schools Journal in 1887. The first editorial explained: "The need has been felt for some time for a frequently published journal to comment on the affairs of the College while they are still topical ... Any contribution will be welcomed, whether it be a full article on the marital customs of the Watussi or a chance remark heard in the bar."

When Sir Les Ebdon (BSc Chemistry 1968, PhD 1971) took over *Felix* in 1969, controversies included racism at a student lodgings bureau, a proposed collar-and-tie rule in the Beit refectory and the quality of the bands at Carnival. Some coverage was contentious in itself, such as a report on College lavatories smashed up after a rugby dinner. But the biggest spat was around the issue of "double jeopardy" – that misbehaving students could be disciplined by the College after being dealt with by the courts. After *Felix* reported that a committee convened by the College authorities was planning to institute this policy, Sir Les was summoned to the Rector, Lord Penney. ▶

He says: "The Rector rapped the paper and said, 'I don't know where you got this story. Even I don't know what this committee is recommending. You're a terrible journalist.' I said, 'If I know a story that you don't know, I might be a better journalist than you think.' That didn't improve his temper. We agreed to print his letter of rebuttal in the next issue, but we set his name in a creepy gothic typeface. My supervisor thought I was done for."

Under Sir Les's watch, the price of *Felix* rose from fourpence to sixpence, though the honesty-box system for gathering payment was widely abused. (The newspaper would finally abolish its cover charge in 1971; the famous "Keep the Cat Free" slogan dates from three years later.) It was an issue brought up when the Duke of Edinburgh visited Imperial and dined with Student Union officials. Sir Les recalls: "Prince Philip asked me, 'Do many people take your newspaper?' Thinking of his famous wit, I said, 'Far too many. They're supposed to pay sixpence.' It took him a while to get the joke."

In 1987, Judith Hackney (BSc Physics 1989) became one of the last editors of the pre-computer era. By then, Imperial had the facilities to print the newspaper on campus. But when the *Felix* offices were moved from near the Beit Quad entrance to a windowless cellar at the back end of the quad, a large area of the building was subjected to the intoxicating stench of Cow Gum – the adhesive used to attach articles and artwork to layout sheets.

She says: "We were still producing the newspaper by writing longhand on pieces of paper and handing the copy to a paid employee who would typeset on a very large machine. It would come out of this machine in galleys, which were then cut up with scalpels and pasted on to A3 sheets of paper with this potent glue. There were lots of fumes as we carried the pages through to the printing area."

The *Felix* of the late 1980s offers a glimpse into a febrile time, with heated arguments about abortion and gay rights played out in its pages. It also represents one of the periodic lows in the uneasy relationship between the newspaper and Imperial College Union. "They felt that because they funded the newspaper, it should be a Union mouthpiece and publicity machine," says Hackney. "Whereas we, thinking ourselves very much as student journalists, felt the reason for the newspaper was to hold the Union to account."

Under Rupert Neate (BSc Biology 2005), editor in 2005-06, *Felix* took its campaigning role seriously. One of his actions was to bring back the "Page Three" pictures of students posing in various states of undress; these had been trialled a few years earlier and have survived in various forms to the present day ("We had complaints, but we did a poll and basically everybody wanted it," he told *Felix* in 2013). But it was his investigative scoops – many picked up by the national media – that led to *Felix* becoming Newspaper of the Year at the Guardian Student Media Awards for the first time, where Neate also won the Journalist of the Year award.

Stories with the biggest impact included an exposé of fly-tipping at Charing Cross Hospital and a look into the sharp increase in thefts from halls. "We also did a campaign about a major London nightclub that had banned R&B music," he says. "We thought that was a sideways ban on letting black people into the venue. That story got a lot of publicity and we got them to reverse the ban. Stories like this made me realise you could actually change things as a journalist."

By the time Jovan Nedić (MEng Aeronautics 2008, PhD 2013) was elected editor in 2008, the paper's masthead was sporting some subtle changes. Since the previous February, the cat crusader had been shown wearing a gag, with the slogan amended to "Student 'news'paper of Imperial College", in protest at alleged censorship by the Union.

The main plank of Nedić's manifesto was to "ungag the cat", but his other big plan – and a first for a UK student newspaper – was to digitise the entire *Felix* archive, making it free for anyone to view online. "I'd realised *Felix*'s 60th birthday was coming up," says Nedić. "And I thought, wouldn't it be great if we could also get the archive uploaded in time for the anniversary?"

An invitation was extended to all former editors and sub-editors to attend a formal dinner in the Union dining room, with a tour of the current *Felix* offices. And, thanks to funding from the Union and the IC Trust, the archive went live in time for the celebrations – though it caused consternation with some alumni who weren't keen to see their College indiscretions made available in a searchable format. Nedić says: "I do remember getting emails from a few people, going, 'Oh my God, no – I didn't think this was going to appear online. Could you remove it?'" ▶

They thought it should be a Union mouthpiece, but we felt the point of it was to hold the Union to account

Judith Hackney

Judith Hackney
Editor, 1987
One of the last editors to produce *Felix* without computers, Judith remembers an uneasy relationship between the paper and the Imperial College Union.

As Fred Fyles (MBBS Medicine 2019) was voted into the editor's chair in 2017, big topics included nationwide strike action among academics and the campaign to have universities divest from fossil fuels. An investigation into the College's Counselling Service earned him a shortlisting in the 2018 Mind Media Awards, which recognise exceptional reporting of mental health issues.

However, it was the annual sex survey that provided the biggest headache. "We'd never imagined that a survey about sex at Imperial would result in too much data," he says. "We tried to collate the results into a big set of data visualisations, and it was one of those things that ended up being way more work than we thought. We had to pull a couple of all-nighters, and things got pretty hairy: we ran out of time and almost missed the print deadline."

It's the camaraderie of the office, Fyles believes, that he'll recall most about *Felix* in years to come. "The strong bond we had between team members sticks with me. It can be difficult to recruit journalists at an all-STEM university, but it means the people who do get involved are there because they really, really enjoy it, not as a CV exercise."

In September 2019, *Felix*'s latest editor took the reins. So, does Henry Alman (BSc Physics 2019) feel the pressures of upholding a 70-year tradition? "Absolutely," he says. "*Felix* is a high-quality publication. But I'd say it's exciting rather than nerve-racking to pick up that mantle after so many good editors in the past."

Alman believes there's much to be learned from the editorial values of *Felix*'s past. "Today, you can do incredible things such as live reporting on Twitter, but I don't think that sort of immediacy is entirely positive for news quality," he says. "I want to take a more considered approach and include as broad a view as possible of the different people and demographics that exist here at Imperial. To do that, you have to give your writers time." ◆

We had complaints about Page Three but we did a poll – and everybody wanted it

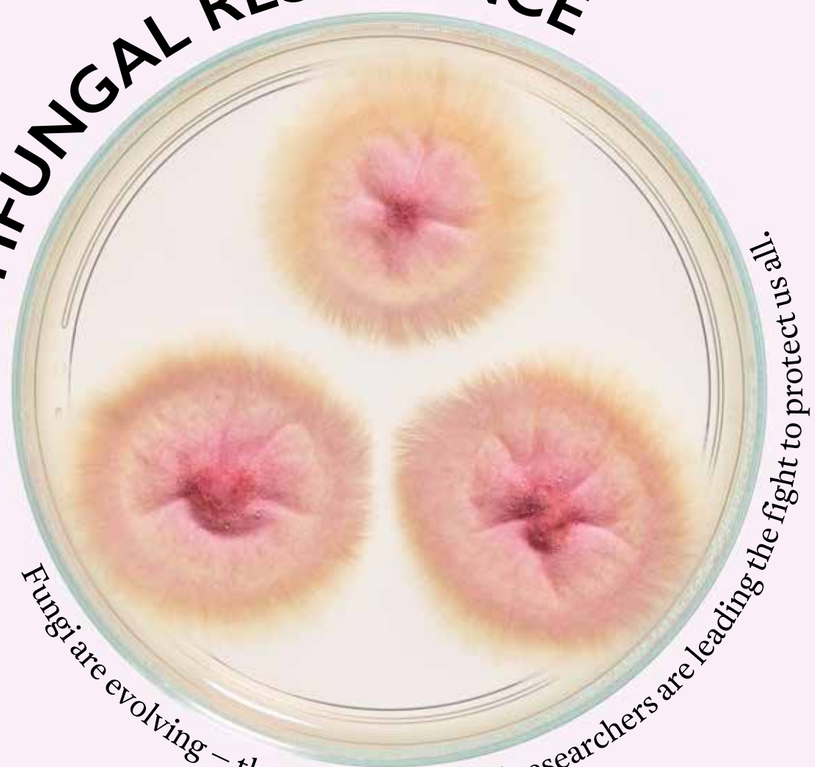
Rupert Neate

> *To see the digital archive, visit felixonline.co.uk/publications/felix*

Rupert Neate
Editor, 2005
Named Journalist of the Year at the Guardian Student Media Awards, Rupert says that he took the campaigning role of *Felix* seriously, running stories on fly-tipping and thefts.

Words: **Becky Allen** / Photography: **Wilson Hennessey**

ANTIFUNGAL RESISTANCE



Fungi are evolving – thankfully, Imperial researchers are leading the fight to protect us all.

Opposite:
Fusarium proliferatum
Source: Human eye infection.
Growth conditions: Potato dextrose agar at 28°C for one week.
Cause: This mould can cause fungal keratitis (corneal infection and scaring) and displays resistance to several common antifungal agents.

Above: Trichophyton rubrum
Source: Human nail infection.
Growth conditions: Potato dextrose agar at 28°C for three weeks.
Cause: Common cause of tinea pedis (athlete's foot) worldwide, infecting both nail and skin.

Left: Candida auris
Source: Human skin.
Growth conditions: Candida Chromogenic agar at 37°C for three days.
Cause: Multi-drug-resistant yeast emerging as a cause of healthcare-associated infections. ▶

According to Dr Johanna Rhodes, one of the most dangerous fungi on the planet is like a comic-book supervillain. "It seems able to withstand everything," says Rhodes. "It's almost as if it was designed: it's too good at surviving, too good at evolving – it's like nothing we've ever seen in a fungal pathogen."

Clearly, *Candida auris* is far from your average fungus. Named because it was discovered in the ear of a hospital patient in Japan in 2009, *C. auris* has since emerged on every continent except Antarctica, infecting hundreds of vulnerable patients in dozens of healthcare facilities across more than 30 countries. Without prompt diagnosis, mortality rates are high. Even more worrying for researchers like Rhodes is how hard it is to kill – and how little we know about it.

"It popped up simultaneously on three continents, with three different mechanisms of resistance to the same drug, causing all these infections in the space of a couple of years – that's unheard of," she explains. Rhodes began working on *C. auris* in 2015, when the Royal Brompton Hospital asked her to help control a major outbreak among cardiothoracic patients in intensive care. Using the latest genome-sequencing techniques and old-fashioned sleuthing (Rhodes' parents were both detectives in the Staffordshire Police) she, together with colleagues from Imperial and the Royal Brompton, traced the source of infection to a contaminated ear thermometer. Impervious to traditional disinfectants, the fungus had spread silently between patients as their temperatures were taken.

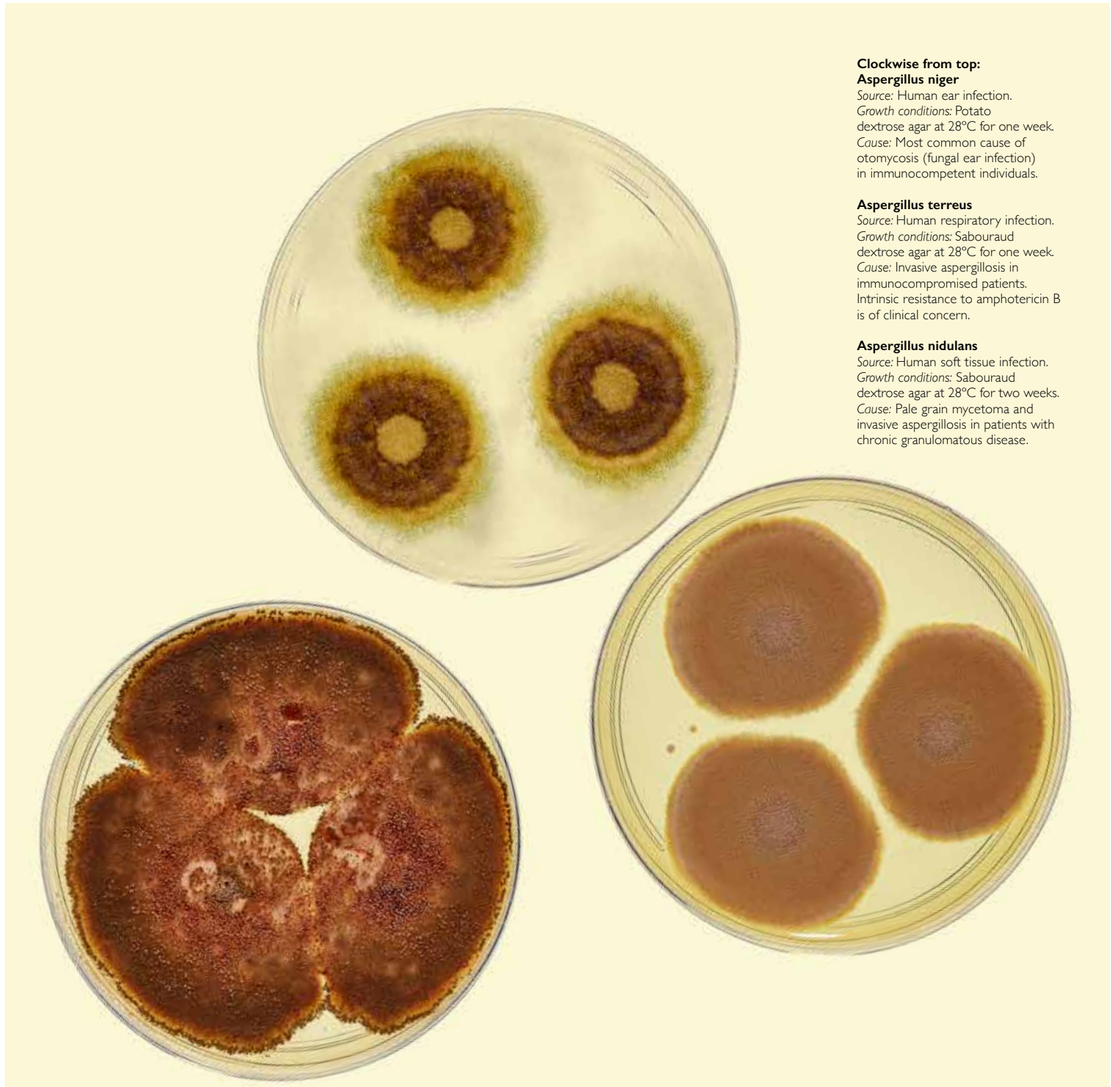
Fungal infections are common throughout much of the natural world and, in humans, they occur when an invading fungus takes over an area of the body and is too much for the immune system to handle. Around 300 fungi are known to be pathogenic to humans – capable of causing disease – but antifungal measures try to control their impact. However, estimates suggest fungal diseases kill more than one million people every year – more than breast cancer or malaria.

And, worryingly, *C. auris* is just one of an increasing number of emerging pathogenic fungi that are becoming resistant to our limited arsenal of antifungal agents. But it's work on another fungus – *Aspergillus fumigatus* – by Imperial researchers that is truly revealing how fungi are evolving into such formidable foes. The big difference between *C. auris* and the drug-resistant *A. fumigatus* is that we know more about the latter. With a library of 600 isolates, Imperial has the world's largest collection of genome-sequenced *A. fumigatus*, a fungus found in soils and decaying vegetation that infects humans when our defences are down. But that knowledge makes its growth no less alarming.

"It's one of the most numerous organisms on the planet; it's in almost every breath you take," explains evolutionary ecologist Professor Matthew Fisher. "It's an extraordinary organism. It thrives at high temperatures and secretes chemicals that can rot proteins, which allow it to grow in this nutrient-rich soup of the human being. But because we've lived with *A. fumigatus* for millions of years, a whole arm of our immune system is devoted to killing it. Without that, *A. fumigatus* would rot us down in a flash."

While healthy people have nothing to fear, the trouble comes for those with cystic fibrosis, COPD and other chronic lung conditions, and people whose immune systems have been compromised by cancer treatment or organ transplants. Among these groups, the fungus causes aspergillosis, a potentially fatal infection that affects millions of people worldwide. Antifungal drugs worked to keep things in check – until those drugs started to fail.

In the mid-1990s, doctors in the Netherlands noticed rising death rates among patients with aspergillosis. *A. fumigatus* had developed resistance to previously effective triazole drugs. Worst of all, the failures occurred in patients who had never taken the drugs, meaning the resistance must have arisen in the environment, and researchers urgently needed to find out how. "That's where we came in," says Fisher. "We started looking at patterns and processes underlying the evolution of azole resistance through the lens of genomic epidemiology." ▶



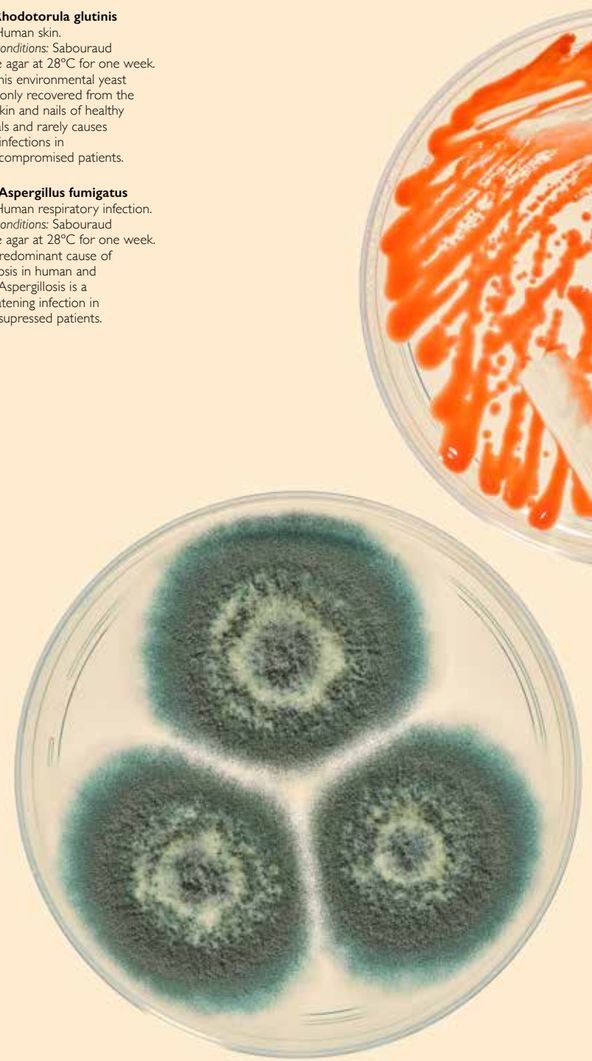
Clockwise from top:
Aspergillus niger
Source: Human ear infection.
Growth conditions: Potato dextrose agar at 28°C for one week.
Cause: Most common cause of otomycosis (fungal ear infection) in immunocompetent individuals.

Aspergillus terreus
Source: Human respiratory infection.
Growth conditions: Sabouraud dextrose agar at 28°C for one week.
Cause: Invasive aspergillosis in immunocompromised patients. Intrinsic resistance to amphotericin B is of clinical concern.

Aspergillus nidulans
Source: Human soft tissue infection.
Growth conditions: Sabouraud dextrose agar at 28°C for two weeks.
Cause: Pale grain mycetoma and invasive aspergillosis in patients with chronic granulomatous disease.

Right: Rhodotorula glutinis
Source: Human skin.
Growth conditions: Sabouraud dextrose agar at 28°C for one week.
Cause: This environmental yeast is commonly recovered from the human skin and nails of healthy individuals and rarely causes invasive infections in immunocompromised patients.

Below: Aspergillus fumigatus
Source: Human respiratory infection.
Growth conditions: Sabouraud dextrose agar at 28°C for one week.
Cause: Predominant cause of aspergillosis in human and animals. Aspergillosis is a life-threatening infection in immunosupressed patients.



In his diagnostic mycology laboratory, **Dr Ali Reza Abdolrasouli** studies medically important fungi recovered from human clinical specimens. While yeast cultures are often streaked on agar plates, filamentous fungi are inoculated into three spots per plate. Then, the fungal cultures are examined at different times depending on the growth rate of each organism advanced technologies including mass spectrometry and genome sequencing are used to assist identification of fungal pathogens.

THE AZOLE FUNGICIDES USED IN AGRICULTURE AND HORTICULTURE ARE ALSO USED TO TREAT HUMAN FUNGAL INFECTIONS

If Fisher's lab has a strapline, it's from US biologist Theodosius Dobzhansky who wrote: "Nothing in biology makes sense except in the light of evolution." According to Fisher: "We cannot understand biological patterns without understanding their evolutionary underpinning – it's like driving without a map, you'd be lost. Sequencing the fungi's genome from across the planet lets us see the underlying patterns and make sense of what we are seeing," he says.

The genomic evidence is revealing that industrial-scale use of azole fungicides in agriculture and horticulture has driven *A. fumigatus* to evolve resistance to azoles – the same class of chemicals doctors rely on to treat human fungal infections – and this resistance is spreading around the world on wind-blown fungal spores and the horticultural trade. "Dutch flower bulbs, for example, contain up to ten times more azole than a heavily sprayed field, and the Netherlands exports five billion bulbs a year around the world," says Fisher. "That's the smoking gun that encouraged us to look for resistance closer to home."

In 2018, Dr Thomas Sewell of the School of Public Health and MSc student Yuyi Zhang tested 200 soils across southern England – from Cambridgeshire farmland and the New Forest to Hampstead Heath and Kensal Green Cemetery – for azole-resistant *A. fumigatus*. Finding it was not a problem, but where they found it was surprising and worrying.

"In places where we expected to find resistance – we found hardly any *A. fumigatus* and no resistant strains. But flower beds in London and Bath, including flower beds outside two large London hospitals, were hotbeds of azole-resistant strains," says Sewell. "It shows that urban environments are an important part of the epidemiology of azole-resistant *A. fumigatus*, and bringing contaminated soils into cities through the horticultural trade could increase the spread of resistance."

CHINKS IN THE DEFENCE

With the genie long gone from the bottle, what can we do to mitigate the problem? According to Dr Nina Jiayue Zhu, a modeller using a whole-systems approach to antimicrobial resistance, everyone has a role to play. "We can't stop fungi evolving, but we can try to change human behaviour," she says. "We know that inappropriate use of antifungal drugs in healthcare and over-the-counter creams is a key driver of resistance, so we need better policies and much more awareness of the issue."

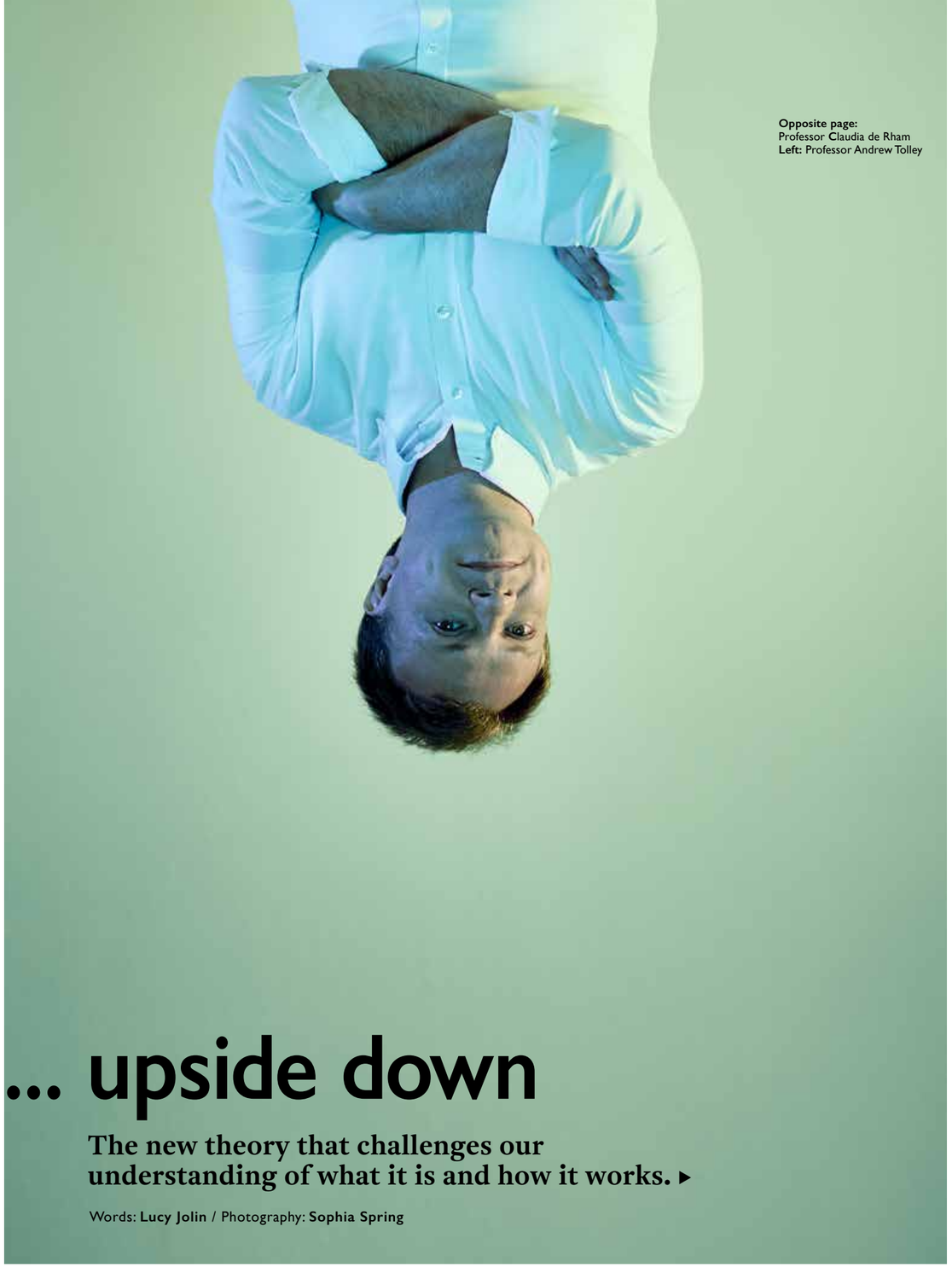
As a medical mycologist and infectious diseases physician, Dr Darius Armstrong-James (PhD Investigative Science 2005) helps treat patients with severe fungal diseases every day, but admits that the fungal diseases have been "underfunded, underappreciated and generally neglected" for too long. And, as a researcher, Armstrong-James is trying to get to the bottom of why patients with weakened immune systems or chronic lung conditions suffer so many severe fungal infections.

"The big issue is that our existing treatments don't work very well," he explains. A chronic fungal chest infection needs three months' treatment, and many patients need lifelong drugs, which is fuelling resistance. And designing new drugs is challenging because, biologically, fungal cells are so similar to those of animals. "There aren't many drug targets in fungi that don't have a very similar target in humans, so they often have toxic side-effects."

Today, there are 11 new drugs in development, from new classes of chemical and repurposed drugs, to compounds that have been reformulated so that they can be delivered to the site of infection without causing unwanted side-effects. One such treatment is an inhalable drug developed by the Imperial startup Pulmocide, which is currently in trials at the Royal Brompton Hospital.

It's why Imperial's work on *A. fumigatus* offers huge hope. "We have groups like the Fisher lab focused on the fungi – mapping why outbreaks occur and which isolates are pathogenic in humans – and researchers like me focused on the human host, understanding why certain individuals get fungal diseases," he says. "We're starting to close the circle, because it's only by getting a holistic view of these diseases that can we hope to mitigate them." ◆

Turning gravity...



Opposite page:
Professor **C**laudia de Rham
Left: Professor Andrew Tolley

... upside down

The new theory that challenges our understanding of what it is and how it works. ▸

Words: **Lucy Jolin** / Photography: **Sophia Spring**

Back in the 1930s, theoretical physicist Wolfgang Pauli and physicist Markus Fierz came up with a radical idea.

What if gravity had a mass? And what if there was a theoretical particle called a massive graviton? Could this simple theory help to explain one of the universe's biggest mysteries – why gravity, in many instances, simply doesn't act as Einstein's and Newton's theories suggest it should?

The answer, at the time, was: maybe. However, their theory never really caught on. By the 1970s, physicists had found numerous problems with it. But it turns out that this idea wasn't dead – just waiting to be revived by new thinking and new frontiers in cosmological and theoretical physics. In short, it was waiting for the de Rham-Gabadadze-Tolley (dRGT) theory, the result of work by theoretical physicist Professor Claudia de Rham and theoretical cosmologist Professor Andrew Tolley at Imperial, and Professor Gregory Gabadadze at New York University.

"The beautiful thing about Einstein's theory of general relativity is that the red flags are built in – we know that, at some point, it will stop working," says De Rham. "It tells us exactly when it's breaking down, and when new physics is needed. That doesn't happen very often in science. So, our big question is: 'How can we explain the things that Einstein's theory can't explain?'"

And there is a lot to explain. The more we discover about our universe, the more it has become clear that neither Einstein's or Newton's theories explain everything we need to know about how it began, how it works and how it's behaving now. Newton's theory, for example, breaks down in areas with a very strong gravitational field, such as black holes. And, as recently as 2015, the discovery of gravitational waves has opened up a whole new world of questions and anomalies around gravity.

Hence, the dRGT theory, which, in its simplest form, posits a theoretical particle called a graviton, that has a mass. It aims to explain one of the biggest problems confounding cosmologists and physicists today: our universe is expanding, much faster than predicted, and galaxies are moving away from each other, faster and faster. This is precisely where new physics is needed to explain that accelerated expansion. In response, cosmologists have hypothesised 'dark components': fluids or substances that affect gravity, but the actual identity of which is unknown. These could explain why galaxies are receding from each other, despite having an attractive force between them.

But then you come up against another big issue: the so-called cosmological constant problem. Around 22 per cent of these dark components is dark matter, which behaves more or less the same from a gravitational point of view as normal matter. But 74 per cent is 'dark energy', which, as Tolley points out, is "really just a name for 'lack of knowledge". Nobody has been able to actually find any dark energy. And when you try to calculate the amount of theoretical dark energy in the universe according to Einstein's theory, it ends up being far more than what has been observed – around 10^{120}, according to some expectations. "If we use general relativity in order to describe this cosmological expansion, it breaks down, at cosmological scales," says Tolley. "General relativity works at smaller scales – I mean galactic – but not on this scale."

A new approach was needed, and De Rham and Tolley were ideally placed to find a new way in. They first met in Cambridge, where they were both independently working on the concept of 'braneworlds' – the theoretical existence of extra dimensions, and 'branes', membranes or surfaces that exist in these dimensions. And their familiarity with these concepts helped them find a new way to think about massive gravity.

"When we started, there were many very famous physicists who had proved that it was simply not possible for gravity to have a mass," says De Rham. "There were lots of no-goes. So, the way we dealt with that was to initially work with extra dimensions, in addition to the usual four. We looked into the extradimensional models that we came up with – and then we realised that the way we were evading the no-goes had nothing to do with working in extra dimensions. We could evade them in four dimensions as well, in ways that hadn't been accounted for. Working in ▶

We still get papers saying it's either wrong, not new or useless. It's not the ultimate theory, but it remains the best we've got

the extradimensional gave us guidance in how to deal with the problem in a much simpler way that we had anticipated."

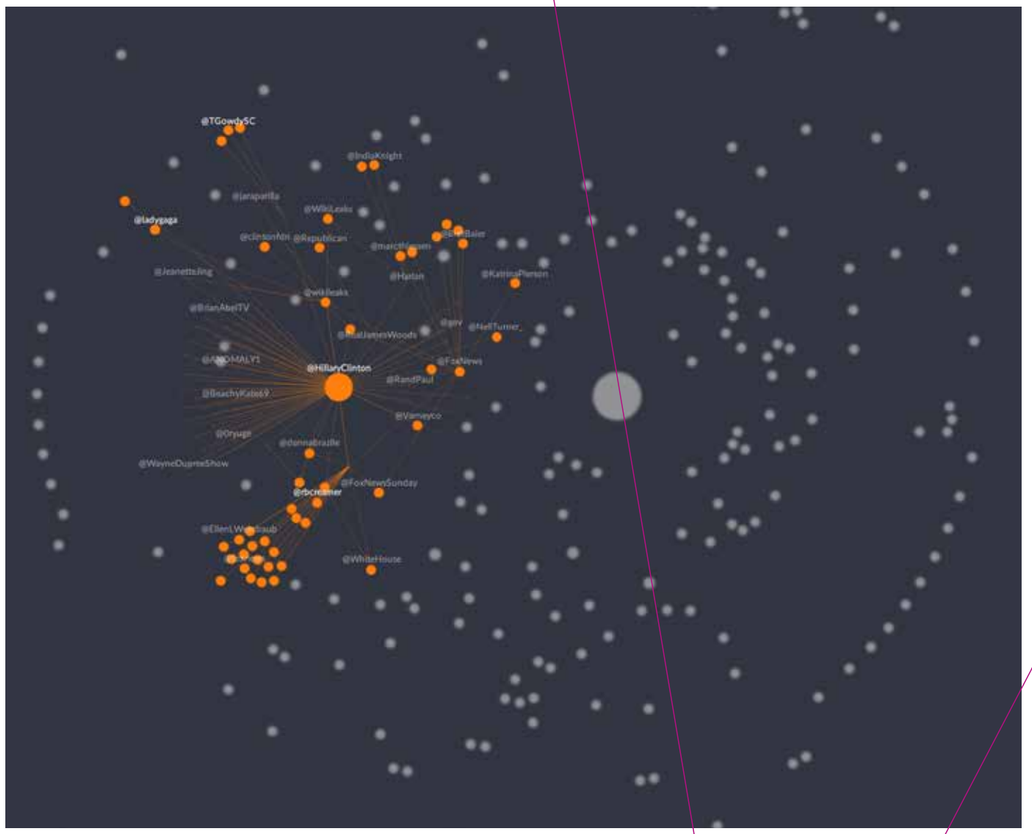
According to Einstein's theory of relativity, gravity is a distortion of spacetime. An object (such as a planet) has a mass, which creates a gravitational field that can be warped and changed. "The simplest way to change any force at large distances is to give a mass to the particle that propagates that force," says Tolley. "The more mass you give to the particle that propagates the force, the harder it is for it to propagate over large distances. In practice, the force decays exponentially through what's called Yukawa suppression. This means gravity becomes weaker over large distances." So, when gravity is given a mass, it can explain the universe's acceleration without the need for dark energy.

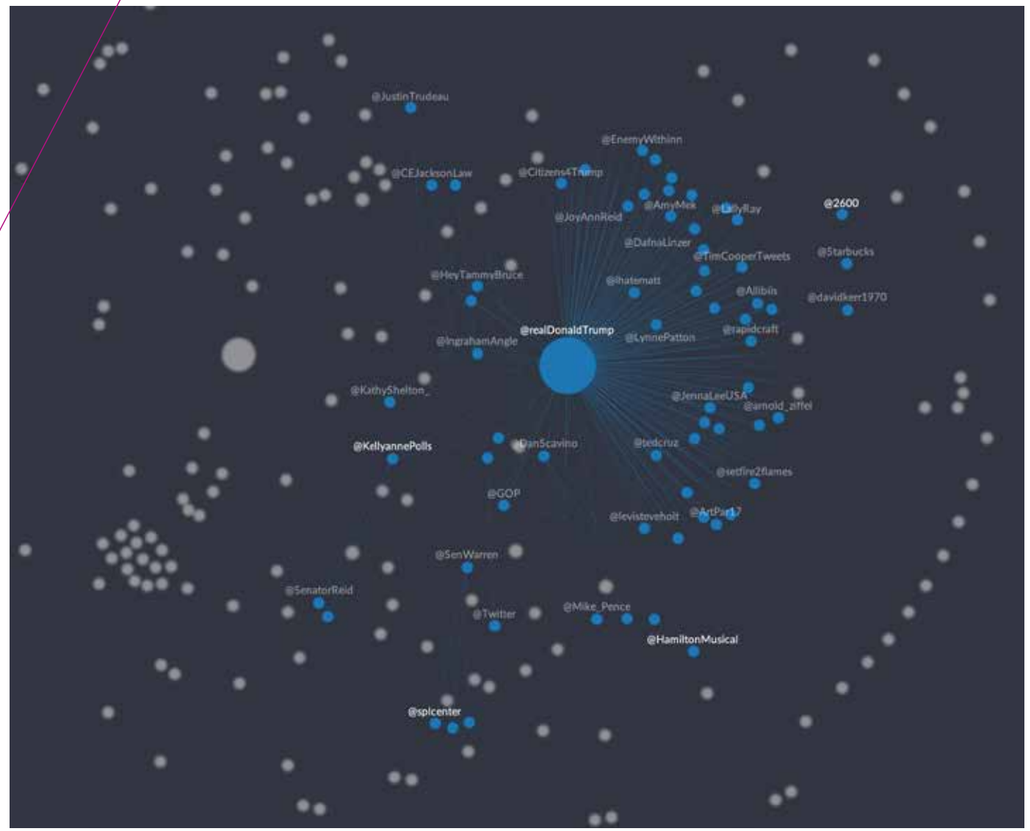
They're at pains to point out that not everybody agrees with them. "We still get papers saying it's either wrong, not new or useless – or even all three at the same time," says De Rham, co-recipient of the Adams Prize for contributions to mathematics in 2018, and Blavatnik Physical Sciences and Engineering finalist for the inaugural Blavatnik Awards in the UK. "It's been killed so many times! And just like general relativity, we know it will fail at some point, but it's still a very good description of what's going on. Our theory is not the ultimate theory. No one ever thought it would be the ultimate theory. But it's still the best we have got."

And it's opened the door to even more questions and research, alongside the Laser Interferometer Gravitational-Wave Observatory's detection of gravitational waves in 2015. "That's surely the discovery of our scientific lifetime," says De Rham. "Cosmology is the new way of doing particle physics from phenomenology, because it's getting harder and harder to crank up energies on Earth in accelerators. More and more, it's giving us the opportunity to test particle physics not in the lab, but by just observing."

So, does this mean they are close to the fabled Theory of Everything? Not quite, they emphasise, but they're moving in the right direction. "By understanding how gravity interacts with other fields and how other fields react to it, we are getting closer and closer to having a completion of what the graviton particle content is as a whole, even if we can't observe it," says De Rham. "Gravity interacts with everything, and as gravitational waves propagate, we will get signatures of their interactions with everything. It's the start of something. We don't yet know where that will go. And that's the exciting part." ◆

GROOMING: CHARLIE OSBORN





Do bots help to spread fake news? No, but they could be part of the answer

Words: **William Ham Bevan** / Graphics: **Dr Julio Amador**

Web of lies
Hillary Clinton (above left) and Donald Trump (above right), on 6 November 2016. Julio Amador uses a piece of software called GraphicExt to study the spread of word-of-mouth stories via social media. In the visualisation above, the research group mapped out the source and proliferation of fake (as determined by professional fact-checkers) news on the two presidential candidates.

"A lie can travel halfway around the world while the truth is still putting on its shoes," wrote Mark Twain – and never has a maxim seemed truer. Indeed, last year, a study examining the spread of true and false news online suggested that falsehood spreads further and faster than truth across every topic, and that the effect was magnified when it came to political stories. Against prevailing wisdom, it also found that this was mostly down to humans – not the automated "bots" that many believed were largely responsible for disseminating the material. And this makes sense: take that quote from Mark Twain. It seems plausible. It has been quoted in countless news stories on the subject of fake news. But there is almost no evidence that Twain actually said it.

Clearly, combatting fake news is a huge task. And if bots aren't responsible for spreading fake news, could automated systems actually form part of the solution, helping to identify false stories ▶

and check their spread? It's a question being investigated by several groups at Imperial, straddling a range of different disciplines.

The first task is to come up with a working definition of fake news, which means making an important distinction between misinformation – a neutral term for material that is untrue – and disinformation, a subset that is deliberately intended to mislead people.

It's recognised that people may create and spread disinformation for a wide variety of reasons. "In some cases, it's just to sell more advertising," says Dr Julio Amador Diaz Lopez, a Research Associate at Imperial Business Analytics – a centre that connects the Data Science Institute and the Business School – with an interest in misinformation. "There was a news story about some people in Macedonia who were spreading sensational stories to get clicks through their Facebook stories and earn money. They didn't have an interest in modifying public opinion. But, on the other hand, there are state actors who are trying to generate influence and swing elections."

For Dr Mark Thomas Kennedy, Associate Professor at Imperial College Business School, getting a handle on the phenomenon means understanding people who are "differently informed" and receptive to dubious information from online sources, favouring it over evidence-driven orthodoxy. "Sometimes it's about people trying to deceive us, but other times it is people genuinely believing what they are saying and finding others who believe it with them," says Kennedy. "And rather than trying to understand those who, for example, go in for the idea that vaccines are dangerous, there's a tendency for people like me to say, 'Well, they're just ignorant.'

"However, from a scientific perspective it's more useful to say, 'They're differently informed' than 'How can we prove to them that they're wrong?' We need to find out about the gaps in their background that lead them to these conclusions. Unless you understand how they consume information and learn, you're not going to be able to have anything more than a conversation in which you're shouted down or dismissed."

This was well illustrated in 2016 when Facebook began to include warning icons next to stories that had been disputed by third-party fact-checking websites. It stopped doing so a year later, after research revealed that the red flags were causing readers to become further entrenched in their beliefs. "People just got angry and tried to rationalise why Facebook was lying to them, rather than saying, 'OK, this is a piece of information that's not real'," says Amador.

Kennedy stresses the importance of a cross-disciplinary approach to the problem – bringing in expertise from the spheres of the social sciences and philosophy of science, as is taking place at Imperial. "Facebook had been approaching this with the idea of 'Oh well, we'll just figure out what fake news is and isn't'," he says. "They're perhaps an example of very smart computer scientists who were themselves differently informed, in that they weren't so good at realising that these things are not always black and white."

When done by humans, identifying fake news and working out how it spreads can be hugely labour intensive. Harnessing machine learning and artificial intelligence to help is a holy grail for both academics and the social-media platforms. In one measure of this, Twitter recently acquired Fabula AI – a startup helmed by Michael Bronstein, Chair in Machine Learning and Pattern Recognition at Imperial, which uses a new class of algorithms to detect misinformation.

Some of the most promising approaches start with a premise that may seem surprising: that AI systems don't necessarily need to decode or understand a piece of information to work out whether it's true or false. Instead of looking at the "what" – the content of the tweet or post – it may be more profitable to examine the "who" (the person spreading it) and the "how" (the way it propagates).

'Language leakages' have nothing to do with the message but could signal if something is suspicious

Miguel Molina-Solana is a Marie Curie Research Fellow at the Data Science Institute, who specialises in data mining and knowledge representation. He says: "Analysing the content of tweets is very, very difficult. You need to do things such as identifying when someone is just being ironic or is really convinced of the facts – or whether something is simply a typo, or if it's an intended error to mislead you.

"After some thinking, what we decided was rather than analysing the text, why don't we analyse features around the tweet? How many followers do you have, how many capital letters are you using, and how many emojis are you putting on the tweet? All these things have nothing to do with the actual message, but there could be signals there for identifying or at least giving a hint if something is suspicious."

Amador, who has been leading this strand of research, says: "These 'language leakages' are able to be detected by a computer but not by a human. And machine learning is also very good at looking how people are diffusing the information."

If, as the MIT study suggests, misinformation spreads in a different way from accurate material – rather as cancer cells can be distinguished from healthy ones by the way they divide – then this "signature" could be the key to finding and stopping it.

Machine-learning researchers at Michael Bronstein's group at Imperial have been looking at a technique called "geometric deep learning", which is capable of dealing with the messy datasets generated by social media to achieve this. They showed that fake stories (as determined by professional fact-checkers) could be differentiated with high accuracy from true ones after just a few hours of diffusion on Twitter, by learning their spreading patterns.

An advantage of this approach is that it is language independent: it's possible to apply the same techniques to stories in English, Russian or Chinese. It can even offer judgments on the provenance of a piece of information where its content is not available, as in the case of social networks that offer end-to-end encryption. However, almost all researchers agree that removing humans entirely from the detection process is neither practicable nor desirable. "Machine learning as we use it is very dependent on human decisions," says Amador, "and fake news is a human activity, so humans should be involved."

And beyond this, dealing with the what, who and how of online misinformation still leaves the biggest question – why? For the foreseeable future, it's not one that machines will be in a position to answer. Kennedy says: "Fake news is an applied problem for information theorists, computer scientists and intelligence researchers, but it's also a basic-level social science question.

"Understanding what makes a social group, and what makes a set of people coherent as a culture, is incredibly relevant to understanding why some people want to believe the world is flat. We have to look at how our interactions on these new platforms are revealing new aspects to the way we construct our social world." ◆

1994-95 was the worst year for AIDS deaths in the hospital – there was one death every working day. When the drugs arrived, the death rate fell by 90 per cent within a year. It was a penicillin-like moment in history.

For the past 25 years Imperial has been at the heart of the hunt for a cure for HIV. This is the story of that search – of the highs, the lows, the setbacks – and the breakthroughs.

It's 30 years since Professor Sarah Fidler (PhD Medicine 1997) was a house officer at King's College Hospital in chest medicine and infectious diseases, but she still has vivid memories of those shocking days. "We were seeing so many young patients. I was in my mid-20s, and they were the same age as me. Some were haemophiliacs, some were gay men, and they were all dying, but there wasn't any treatment," she recalls.

This was eight years after the US Centers for Disease Control first reported five cases of a rare pneumonia affecting young gay men in Los Angeles, and the AIDS epidemic began. "By 1989, the average time between coming into hospital with an AIDS diagnosis and death was two years, and there was this huge stigma," say Fidler, now a Professor in the Department of Infectious Diseases at Imperial and a consultant physician at the Imperial College Healthcare NHS Trust. "I remember caring for patients in side rooms. Nurses and porters were too frightened to wheel patients to x-ray or change sheets, so we just did it."

Alongside the stigma, AIDS also presented Fidler and her colleagues with a medical mystery they were determined to unravel. "It was very interesting medicine, because nobody knew what to do, so it was hugely challenging," she says. "And I worked with consultants who were very inspiring and creative – we had to be, because none of us knew what to try."

One of those inspiring figures was Professor Jonathan Weber, Dean of the Faculty of Medicine, who entered the field in 1982 – before HIV/AIDS even had a name – and set up a clinic for AIDS patients at St Mary's Hospital. He also conducted the first UK study into the natural history of this troublingly strange new disease. "I recruited 400 volunteer gay men who I thought were at risk of AIDS because they had swollen lymph nodes, and followed them up for two years. It gave us some idea of the time course of the disease and its manifestations," he says. "Between 1982 and the end of 1984, big inner-city hospitals across Europe and North America began filling up with AIDS patients. It was a very frightening time."

The first signs of hope emerged from France in May 1983, where the virus that caused AIDS was discovered. "Nailing the virus was a breakthrough," says Weber. "It opened up this extraordinary area of research because it meant we could now identify infected patients and start looking for both a vaccine and a treatment."

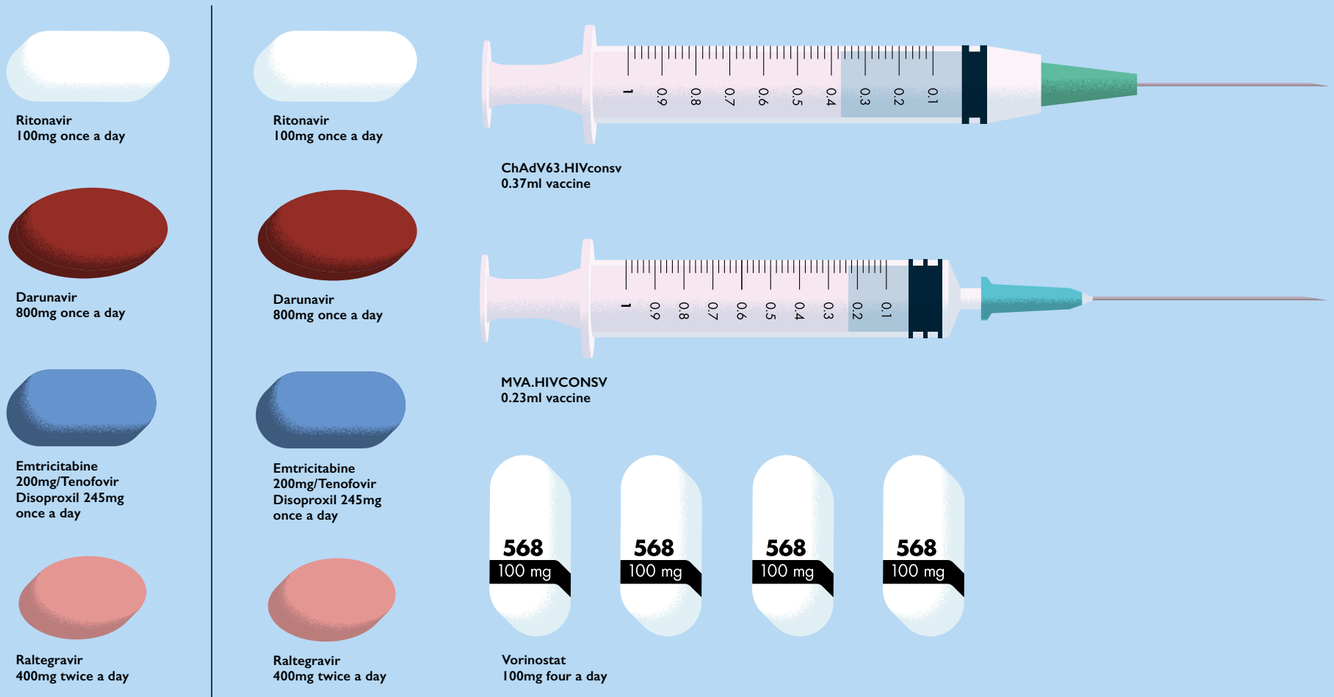
But neither looked easy. Only one specific antiviral drug – acyclovir – had ever been invented, and developing a vaccine with no viable animal model would prove an even bigger ask. But when AZT, the world's first antiretroviral, burst on to the scene in 1987, everything changed. ▶

Words: **Becky Allen**
Illustration: **Deanna Halsall**

The RIVER medical trial (2015-18)

Antiretroviral therapy (ART) has been the mainstay of HIV treatment since 1995. ART is highly effective, but taking several tablets every day for life is stressful, costly and can cause side-effects. The Imperial-led RIVER trial (RIVER stands for Research in Viral Eradication of HIV Reservoirs) tested the 'kick and kill' approach in 60 men recently diagnosed with HIV and who had the virus under control by taking ART.

The 'kick and kill' was a randomised controlled trial: participants were enrolled and then randomly selected (like the roll of a dice) to one of two groups. All participants received a four-drug ART; the 'control' half continued on ART alone, the 'active' half also received a drug that would force the virus to reveal itself, plus a vaccine.



ART reduces viral load to undetectable levels, but HIV remains hidden in people's immune cells, in what are called 'reservoirs'. If ART is stopped, these cells wake up and HIV quickly becomes detectable again. In the trial, 30 men received just the standard ART treatment, delivered in four tablets.

For half the group, RIVER used two medicines on top of the standard ART treatment. First, a drug called vorinostat that would 'wake up' the reservoir cells that HIV is hiding in and force the virus to reveal itself and face the immune system, and, second, two vaccines to coach the body's immune system to recognise and destroy HIV. The 'kick' is delivered from vorinostat and the 'kill' comes from the body's own immune system killer cells that have been trained by the vaccines.

What did RIVER find out?

'Kick and kill' proved no better at reducing the size of HIV-infected cells than ART alone, but the vaccine was very effective at boosting the immune system – to be explored in future trials.

As the Anglo-French Concorde study began in October 1988, AZT was already being used by 200,000 people with HIV/AIDS for whom the drug represented their only hope. Weber worked on Concorde, a randomised control trial of 1,750 HIV-infected patients, half of whom took AZT and half a placebo. Reporting in *The Lancet* in 1993, the results showed that AZT neither halted the progress of the disease nor lengthened people's lives.

'Miracle AIDS drug has flopped' screamed British tabloids, and the news was devastating for patients and researchers. For Weber, however, the trial meant something else. "Concorde was a negative study, but it was invaluable," he explains. "It showed the emergence of antiviral resistance to the drug over time, and it focused our attention on the hopelessness of using a single drug to treat the disease, but, as with TB treatment 40 years earlier, a combination of drugs might work."

From that nadir, the only way was up. Building on Concorde's results and an explosion of drug development and clinical trials, Weber worked on Delta, a landmark UK, French and Dutch study that posed the question: if AZT alone won't work, what happens if we combine it with a second drug? Reporting at the end of 1995, Delta revealed that two drugs were dramatically more effective than one, reducing mortality by up to 42 per cent. By the end of 1996, three drug combinations were licensed and became rapidly available on the NHS, where they had an astonishing impact at a terrible time.

"I can't begin to tell you what that time was like," says Weber. "1994-95 was the worst year for AIDS deaths in the hospital – there was one death every working day. When the drugs arrived, the death rate fell by 90 per cent within a year. It was a penicillin-like moment in history. From an invariably fatal disease that inflicted miserable, terrible deaths, suddenly we saw these drugs having this powerful impact. It was the most extraordinary period."

Great strides have been made in treating HIV, but what worries experts such as Timothy Hallett (MSc Epidemiology 2004, PhD 2007), Professor of Global Health, is that we have not yet succeeded in driving down the incidence of HIV, which in 2018 still stood at 1.7 million new cases. As a modelling expert, Hallett has built the increasingly sophisticated mathematical models that have become central for HIV researchers and policymakers. "Modelling is particularly important in HIV because it's a long-term, slow-moving disease. That means you can't track it in real time," he explains.

By taking into account the huge complexity of the real world – from poverty and geopolitics to age and gender – Hallett's modelling has made it possible to get the most out of HIV programmes by tailoring them to local conditions. "There are many tools to prevent HIV, but they need to be used in the right combinations to maximise their impact," he says. "Modelling helps you fit your epidemic response to local epidemic contexts and use resources wisely by investing them in the most effective interventions."

It is new interventions, however, that are preoccupying Fidler and Weber, because both believe that only a vaccine or a cure will finally bring the epidemic under control and improve the lives of the millions living with HIV. "Although treatment has dramatically altered survival, one of the challenges for patients is taking a tablet every day. Because, as soon as people stop treatment, the virus comes back," Fidler explains. "That's because there's a reservoir of hidden HIV that's not detected by the immune system and not affected by the treatment."

Fidler and her team decided on a new line of attack, dubbed 'kick and kill'. She used one drug to wake up the silent virus hiding in the reservoir cells plus a pair of vaccines to enable the immune system to recognise and destroy the HIV. But when she tested them in a randomised control trial, RIVER, between 2015 and 2018, they proved no more effective than existing treatments. ▶

IMPERIAL AND HIV: THE SEARCH FOR A CURE

Although treatment has dramatically altered survival, one of the challenges for patients is taking a tablet every day. Because, as soon as people stop treatment, the virus comes back.

Despite the disappointment, RIVER confirmed that, individually, each element worked and was safe, and Fidler will soon be testing drugs that work against HIV in a completely novel way. Known as monoclonal antibodies, they have been shown to control virus in small pilot studies, but RIO will be the first large, randomised trial to test whether this new approach works to control virus off traditional therapy.

For Weber, 2020 marks an even bigger milestone, as the HIV vaccines he first began work on in 1999 finally enter field trials. The European project, PrEPVacc, is based on a complex protocol involving a series of three vaccines – a DNA prime, a boost based on a modified pox virus, followed by a protein that mimics the virus's envelope – and is a true testament to HIV researchers' tenacity and optimism.

Holding on to one small success amid a series of five failed HIV vaccines, and relying on public funding alone as industry lost confidence in HIV vaccine development, Weber pressed on. "Whatever immunologists tell you, it's not possible to design a vaccine from first principles, all you can do is try, try and try again," he concludes. "I'm an incurable optimist, otherwise I'd never have gone into this field in the first place." ◆

SOCIETY

SOUP RUN

Hot food and a chat: how one student society's simple actions are making an impact.

Words: **Megan Welford**
Photography: **Hannah Maule-ffinch**

Right: Shatha Khalil, team lead at Children of Adam.

With thanks to members of the Soup Run Society: Josephine Akoro, Jonathan Davies, Ali Farzanehfar, Julia Lin, Emily Naish, Alec Raines (centre photo) and Felix von Cossel.

It's 5.30pm on Sunday, and there's an orderly queue of around 170 homeless people snaking through London's Lincoln's Inn Fields. Imperial's Soup Run Society is delivering much-needed food – and conversation – and there's no shortage of takers, many who come each week.

"There's one wonderful guy who has a posh accent, wears a high-vis jacket over a dishevelled suit and tie, and is a ray of sunshine," says co-ordinator Alec Raines (Medicine, fourth year). "He holds up the line because he always wants to talk to everybody. He loves music and always has a miscellaneous fact about absolutely everything up his sleeve.

"Or there's the woman who shares her meal with her adorable dog, who does tricks. Almost all the interactions are lovely, like the time I spilled hot chocolate down my shirt and a man gave me his packet of wipes, and when I tried to give it back, he'd gone."

The society, which has between 100 and 200 members at any one time, began life gathering leftover sandwiches from food chains and doing its own soup run. But, more recently, the student team has teamed up with Children of Adam, an established local charity, whose volunteers source fresh hot meals each week that Imperial students help serve.

"People don't come and talk to you at first," says Raines, "but after you've been there a few months they recognise you, and they'll come over and say hello. Some know I'm studying medicine now and will ask how that's going. We'll have a chat about the weather or about Brexit. Some will tell you you're the first person they've spoken to all day. They chat to each other too, and share information."

The queue is mostly made up of men, but all ages and ethnicities are represented. Some people need a bed for the night, others just can't afford a meal. "Homeless people can come from 'normal' backgrounds," says Raines, "but maybe they lost their job, or perhaps their family doesn't talk to them any more. One guy I spoke to had been in the medical profession, like me. Others come from backgrounds of abuse and addiction. It's easy to think that people are homeless through their own fault, but I have never found that to be the case.

"I first went along on the offchance after Freshers' Week, and I'm so glad I did. It's changed my perspective. I feel like the luckiest person alive – to have my family and friends and the life I have. You feel weird and uncomfortable at first; it's tough being around people who aren't doing well, but that's how it feels to burst out of your bubble. Doing medicine, my whole job will revolve around being able to speak to people from different backgrounds. Working with homeless people has helped build my compassion and empathy, as well as my communication skills. I did Soup Run because I wanted to help people – but it's helped me a lot too." ◆

TEST YOUR BRAIN POWER

Ready to test your little grey cells? Imperial's best minds set the ultimate puzzle challenge.

1: HARD

I have nine coins in my pocket. Some of these are 2p pieces and the others are 5p pieces. I am contemplating buying some buns. I notice that I can buy four buns without requiring any change but, although I can afford them, I do not have the coins to buy five buns without needing to get change. How much does a bun cost and how many coins are there of each type?
Dr Lynda White, Principal Teaching Fellow in Experimental Design, Department of Mathematics

2: VERY HARD

I keep all my worldly wealth in a numbered Swiss bank account. Recently, the bank decided that all account numbers must have between 30 and 80 digits and may not start with a zero. It's complicated, but I can work mine out each time I need it. If I multiply my number by nine I get the same number with the last digit shifted to the front (so that, for example, 134689 would become 913468). Can you help me work out my account number?
Professor Jonathan Mestel, Professor of Applied Mathematics, Department of Mathematics

3: FIENDISH

A medieval farmer is in their house and needs to get water from a river and then take the water to animals in a barn. The farmer would like to take the shortest route to the barn, but doesn't know about calculus (as it hasn't yet been invented). The farmer's house is 400 yards west of the river, which runs north-south, and the barn is 200 yards west of the river, but 800 yards further north than the house. How can the farmer work out the shortest path, and how long will that path be?
Dr Daniel Mortlock, Lecturer in Astro-Statistics, Department of Physics

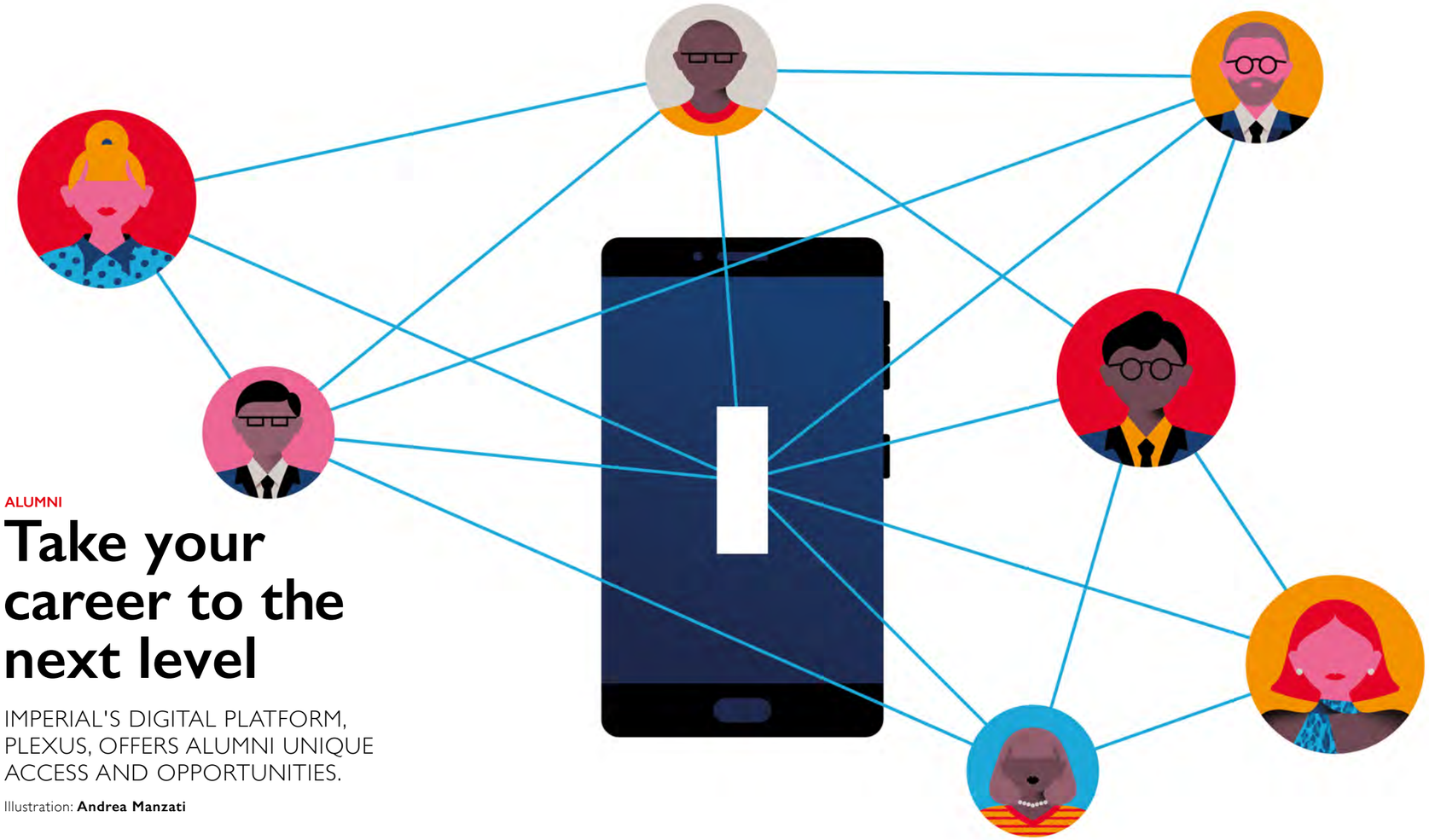
HOW TO ENTER:

Senders of correct solutions for two or more of the puzzles will be entered into a prize draw to receive a copy of *Superior: The Return of Race Science* by Angela Saini. Winners' names will be in *Imperial* 48 in May 2020, and solutions published at www.imperial.ac.uk/be-inspired/magazine/issue-47/brain-power. Entries close 31 January 2020. To enter, please email **imperialmagazine@imperial.ac.uk**

FOR ISSUE 46 SOLUTIONS:
www.imperial.ac.uk/be-inspired/magazine/issue-46/brain-power
ISSUE 46 WINNERS: Congratulations to:

***Casper da Costa-Luis** (Physics 2014, MSc Computing 2015), **Siddharth Amrat** (MSci Physics 2016), **James Craggs** (St Mary's Hospital Medical School 1983), **Philip Fisher** (PhD Mechanical Engineering 1986), **Nicholas Grogan** (MSc Mathematics 1978), **John Hilbourne** (Mathematics 1983), **Karen McGuigan** (MEng Chemical Engineering & Chemical Technology 1997), **John Nunn** (Physics 1986, PhD 1991), **Rosco Paterson** (Mathematics 1976), **Graham Perry** (Aeronautics 1965).*

ILLUSTRATIONS: MIKE LEMANSKI



ALUMNI

Take your career to the next level

IMPERIAL'S DIGITAL PLATFORM, PLEXUS, OFFERS ALUMNI UNIQUE ACCESS AND OPPORTUNITIES.

Illustration: **Andrea Manzati**

Looking to get that dream job, make an international role work, grow professional connections or become a better boss? Whatever rung you're at on the career ladder – and even if you're planning to step off it entirely – Imperial's bespoke online platform Imperial Plexus can help you move in the right direction.

Join and you'll have access to an exclusive community of around 11,000 Imperial alumni with expertise in all sectors, at all levels, all over the world. As well as offering you the chance to build your professional and social networks, you can search for and connect with fellow alumni, explore job and volunteering opportunities, and find events in your area.

To help you stay right up to date with the very latest developments in your field and keep your expertise fresh, you'll have access to a huge range of online databases, journals, talks and e-books, including JSTOR, Karger Medical and Scientific Journals, and Henry Stewart Talks.

And if you're looking for career advice, or just want to improve your understanding and resilience, check out our webinar series hosted by career experts at the cutting edge of their field. For instance, marketing and strategy consultant Dorie Clark is on hand to show how you can leverage your skills to differentiate yourself in a current or new role – or even re-invent yourself professionally; and international consultant Nicolas Constantinesco offers insights to job applicants on how to stand out, as well as how to understand better what recruiters want and to learn to tell stories that engage them. The panel of experts covers everything from avoiding burnout to mastering the art of informational interviews – with plenty more on the way.

Joanne Gardner in Imperial's Alumni Relations team says: "As an Imperial graduate, we know your thirst for knowledge continues throughout your life, so we ensure a wide variety of online resources remain open to you after you leave. Plexus is your remote gateway to continue accessing valuable information and to connect directly with other alumni." ◆

> *Already signed up? Great! Make the most of what's on offer with a regular check-in. If you haven't yet joined Plexus, visit imperial.ac.uk/alumni/imperial-plexus to sign up.*

A life in politics

Imperial has long been a training ground for would-be politicians. Here, three leading figures in politics and policy – and alumni – share their motivations.

LUKE REYNOLDS
MSci Chemistry 2008, PhD 2012,
Senior Private Secretary to the Gov't Chief Scientific Advisor

Q. Were your ten years at Imperial politically charged?
I was generally apolitical as a student – useful now that I am a non-political civil servant. I had a low belief in student politics and the Imperial College Union reinforced that by the way it flip-flopped on its membership of the NUS. I wasn't tempted to join – I thought if anyone was going to give me discounted cinema tickets it should be because I was a student, not because I was a member of a specific union.

Q. What led you to eventually join the civil service?
Through my year at Pfizer during my incredibly extended five-year undergraduate course, I began to appreciate the value of moving away from blue-sky research to working on things that have the direct potential to improve society – which is what a pharmaceutical company does. My Grantham-funded PhD on novel solar cells allowed me to learn to think outside the box. I did collaborative work with multiple institutions in India, which helped me put my work in the global perspective and work out what is important to me, using my scientific knowledge to make a tangible benefit to society. After a brief spell in renewable energy finance, I joined the civil service to be able to do just that.

Q. How did your time at Imperial help prepare you?
My training in scientific method – to gather, interpret and assess the value of evidence – is vital to my current role. Giving clear, robust and timely scientific advice is crucial to getting better decisions from politicians. Did I go on a course to learn how to shake hands? No, and I didn't need to! But I was in a research group dominated by overseas students and learning to work across cultures and countries is an undervalued experience that is hard to articulate, but essential to my job now.

> *Before working in the Government Office for Science, Dr Luke Reynolds was Assistant Director at the Department for Business, Energy and Industrial Strategy.*

CHI ONWURAH
BEng Electrical Engineering 1987,
Shadow Minister for Industrial Strategy, Science and Innovation

Q. Was Imperial the driver for your future career?
Imperial did inspire me politically – but not in the way you might expect. Growing up in the north-east of England, I had solid working-class roots and an inherent sense of social justice. When I joined, Imperial College Union was not a member of the National Union of Students (NUS) and the prevailing attitudes of my fellow students put me off getting involved in student politics. Nonetheless, I knew I had to stand up for what I believed in. So, I started writing articles for *The Guardian* about some of the sexism and racism I had encountered, and that did result in some policy-changing.

Q. What skills did you acquire at Imperial?
It was the first time I encountered how to unpick a problem by working from first principles. I learned to take a rigorous, ruthless, rational approach to problem-solving, which has stood me in good stead both in business and in politics. And, as long as I have some two-pence copper pieces, if it all goes wrong and I'm cast away on a desert island, I can always make my own electrical board!

Q. What advice would you pass on?
I wanted to change the world through engineering and am proud of my achievements, whether it be establishing Nigeria's first GSM network or setting communications standards for business during my time at Ofcom. I truly believe that engineering and politics are the twin engines of progress, and I would tell today's ethnic minority students, in particular, to be active in student politics. Your voice matters because you are less heard. Join your professional institution at an early stage and if you encounter barriers based on race or gender, go to them for help. And if they don't give it to you, write to me!

> *After a career in engineering, Chi Onwurah was elected at the 2010 general election as Member of Parliament for Newcastle upon Tyne Central.*

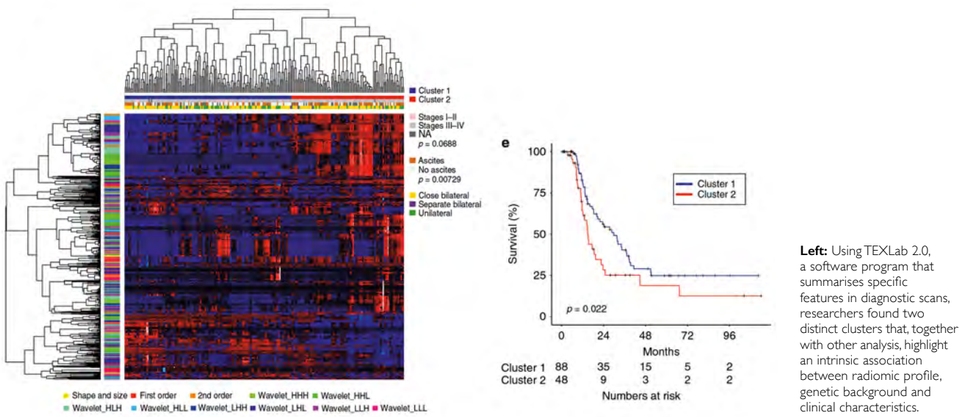
KONSTANTIN ARAVOSSIS
MSc Management Science 1987,
Greek Ministry of the Environment and Energy

Q. What are your memories of Imperial?
My time at Imperial was one of the most interesting periods of my life so far. I was a good student, and I was also very sociable. I had already spent five years studying in Germany and found Imperial much more international in its outlook. I loved the multicultural life London offered and I became very good at organising my time so I could spend as much of it as possible getting to know the city.

Q. How did your time at Imperial influence your career?
When I left Imperial, I was not aiming at politics at all and I couldn't have imagined I would become a specialist in environmental issues. Yet now I see my whole career has been heading in that direction. The shift from mechanical engineering to studying management and economic issues at Imperial changed my life and was vital for both my future professional and academic careers. I went on to set up the first recycling programmes for municipalities in Greece and, in 1996, I founded the Imperial College Alumni Association of Greece, and a separate alumni association for the Business School. Imperial gave me the skills to initiate in business and the contacts to make things happen. There are four Imperial alumni in the Greek government today, including the Minister for Finance.

Q. What impact does Imperial have in the world?
I believe politicians should be technocrats – it is not enough to have good ideas, you need to know how to implement them. It helps to have worked in business and it also helps to have a good brand like Imperial behind you. Going to the Business School opened a window for me in my thinking, but I also made friends for life and I continue to meet new people through the alumni associations. Wherever I go in the world, everyone knows Imperial!

> *Professor Aravossis is General Secretary for Natural Environment and Water and a visiting professor at Imperial.*



Left: Using TEXLab 2.0, a software program that summarises specific features in diagnostic scans, researchers found two distinct clusters that, together with other analysis, highlight an intrinsic association between radiomic profile, genetic background and clinical characteristics.

DATASET/ PROFESSOR ERIC ABOAGYE
PROFESSOR OF CANCER PHARMACOLOGY AND MOLECULAR IMAGING

Ovarian cancer: fighting a silent killer

Words: **Sarah Woodward**

Context

Ovarian cancer is the sixth most common cancer in females, usually affecting women after the menopause or those with a family history of the disease. There are 6,000 new cases a year in the UK alone, but the long-term survival rate is just 35-40 per cent. Often called "the silent killer" due to the fact that many patients are diagnosed too late for effective treatment, there is an urgent need to find new ways to treat the disease.

Background

"With masses of data in our healthcare system, medical researchers are beginning to ask how such data can benefit patients through artificial intelligence (AI), while protecting patient privacy," says Eric Aboagye, Professor of Cancer Pharmacology and Molecular Imaging. "It is against this background that a team of scientists at Imperial created an algorithm for predicting the prognosis of ovarian cancer patients."

Methodology

In a study believed to be the largest in the world, Imperial researchers used a mathematical software tool known as TEXLab to discover patterns in routine diagnostic scans. They analysed CT scans and tissue samples taken between 2004 and 2015 from 364 women with ovarian cancer, to identify the aggressiveness of tumours. Using machine-learning techniques, the software examined more than 660 features and chose four that describe biological characteristics of the tumours – structure, shape, size and genetic makeup – to assess the patients' prognoses. Patients were then given a score known as Radiomic Prognostic Vector (RPV), ranging from mild to severe, to indicate how advanced the disease is.

Findings

The software was up to four times more accurate in predicting deaths from ovarian cancer than the standard methods of blood tests – which look for a substance called CA125, an indication of cancer – and CT scans. The team found that five per cent of patients with high RPV scores had a survival rate of less than two years. High RPV was also associated with chemotherapy resistance and poor surgical outcomes, suggesting that RPV can be used as a potential biomarker to predict how patients will respond to treatments.

Outcomes

In conjunction with the pharmaceutical industry, the team is working on how AI can be used to predict which patients will benefit from specific drugs, including immunotherapy. "Although each patient's experience is unique, surgery and chemotherapy for late-stage ovarian cancer can have significant side-effects," says Aboagye. "However, we can now identify those patients unlikely to benefit from such standard treatments and offer them alternatives. Our technology is able to give clinicians more accurate information on how patients are likely to respond to treatments, which could enable them to make better and more targeted treatment decisions."

The next step is to further appraise the RPV test to make it usable in the NHS environment, necessitating a larger study to see how accurately the software can predict the outcomes of surgery and/or drug therapies for individual patients. But Aboagye has wider ambitions. He says: "In the future we hope to be able to apply similar methodology to other diseases, including lung and brain cancers, as well as Alzheimer's disease." ◆

> ***Professor Eric Aboagye** is Professor of Cancer Pharmacology and Molecular Imaging in the Department of Surgery and Cancer.*

DISRUPTOR / DR FREDDIE PAGE
DYSON SCHOOL OF DESIGN ENGINEERING

"Success shouldn't just be measured in grades. We want to create a growth mindset"

What does a successful student look like? According to our new intake of undergraduates, students should be innovative, creative, eager to learn – and they should get enough sleep.

This ability to see the bigger picture and not just focus on pure success is gratifying – so much of education has become about getting grades and passing exams. All our students will have done exceptionally well at school but, at the Dyson School of Design Engineering, exams account for just ten to 15 per cent of our degree and most marks come from coursework and group projects, so performance in exams will only take you so far. That's why, here at Imperial, we have developed a new programme that offers something a little different, putting creativity and innovation at the heart of what we do.

Our Master's in Design Engineering focuses on experiential, project-based learning. Sometimes students can get hung up on what they need to do to get a First, but this is looking at it the wrong way around. The grade should reflect what kind of a student they are. We want them to be self-directed, and not scared to explore or experiment – because they love the subject and not because they want to pass an exam.

A lot of what we do is just taking a different view of things. Take the work we ask our students to do independently, for example. Once they've submitted their coursework and received feedback, students sometimes forget all about it. So, with the help of a substantial grant, we've developed a new visualising collaborative projects (VCP) platform to enhance how and what students learn. Students will be able to see a record of previous work in the field and find academic experts both within and beyond the university. It will all enhance the learning experience and, hopefully, improve outcomes.

It also means that the time we spend marking that coursework is more effective: software we are writing for the VCP will capture projects, track feedback and put them in context, so generations of students can refer back when they cover a similar subject. We want this to drive best practice in learning and teaching, and we'll be piloting early stages next year.

We're also developing a feature to help students gain more from tutorials. Tutors believe students don't always make the most of their weekly catch-up – but if a student activity tracker updates a tutor before they meet, tutors can prompt students to look forward rather than back. This automatically trains them in industrial best practice.

Of course, everything we do has an eye on the real world – we stress that student projects must tackle existing problems. One of my students looked at how augmented reality could support and improve how students experience the traditional lecture – she interviewed experts and produced a set of guidelines for digital learning developers. Another student from mainland China created a virtual reality experience to familiarise overseas students with the daunting prospect of long-haul flights and UK security procedures.

All this is proof that you can't stand still in education. Although my background is theoretical physics, I'm always keen to make the most of digital learning innovations, and I love teaching the creative and intuitive elements of maths. I've built a range of visual tools to help engineers visualise and understand the equations on the page – the physical laws of how two masses on springs can interact with one another, for instance. Another looks at how light rays interact with solid objects, allowing lighting, shadows and reflections to be calculated to help create a realistic image. These are interactive and in line with the ethos

> Performance in exams will only take you so far; we put creativity and innovation at the heart of what we do

that you can explore, innovate and be creative. I've also helped write a MOOC (massive open online course) – a first for Imperial – on maths for machine learning.

Ultimately, everything we do is about creating a growth mindset; we want students to develop a healthy attitude to learning – a willingness to explore and to go deep into a subject. We want them to think that nothing is beyond them. This subject is fascinating, mixing engineering rigour, which comes naturally to me, with creativity and context. But always, it is the human factor that is critical. ◆

> ***Dr Freddie Page** is Strategic Teaching Fellow at the Dyson School of Design Engineering.*

INTERVIEW: WILLIAM HAM BEVAN

MY IMPERIAL

A walk in the park

Arian Arjomandi Rad (Medicine, fourth year) finds balance among the light and shade of Hyde Park.

Interview: **Lucy Jolin**
Photography: **Joe McGorty**

I'm originally from Iran but I was born and grew up in Italy, and it's been a lifelong ambition of mine to study at Imperial. Cardiothoracic surgery excites me the most – it's challenging and has a very observable impact on a patient's quality of life that only few professions can provide. But it can also be stressful; Hyde Park is my escape from academia and work.

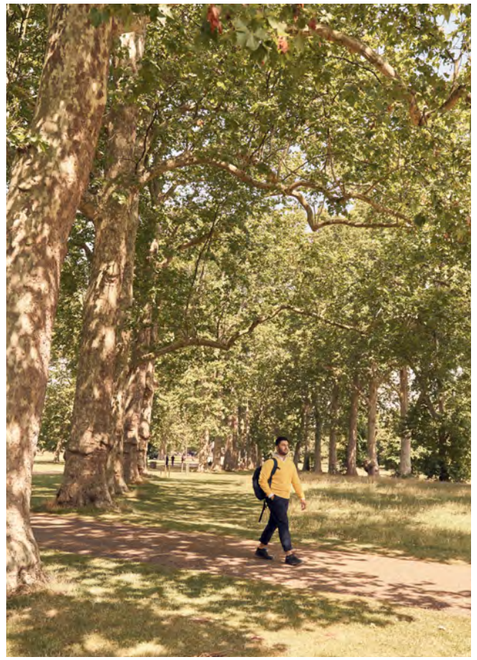
During term time, it can be intense. I spend long hours in the Central Library almost every day of the week – so I try to add balance by spending at least an hour or so in Hyde Park. It's the only truly green area near Imperial and, as much London air is polluted, I find the air there refreshing and stimulating. And its beauty and tranquility helps me to reflect.

My favourite times are early in the morning as the sun comes up – and when it gets dark. I love the lake, with the swans that you pass when you get off the tube at Queensway. I'll often get off the tube early on my way to College, even though it takes longer, just so I can have a walk to get my blood flowing and to think about something other than my studies.

It can be inspiring, too: last summer, I was walking through the park and thinking about how I could actively contribute to the Imperial teaching material available. Imperial had introduced a brand new type of practical examination for second-year medical students, with very few resources to use in preparation for the exam. So, I had an idea: why not produce a new medical textbook to help students through this exam? I went on to collaborate with five of my fellow students, and we created The Essential Guide to the OSPE Assessments.

I've also enjoyed the peace and tranquility of Hyde Park while on summer placement. I am in the heart surgery unit at Hammersmith Hospital, which I found out about when I met consultant cardiothoracic surgeon Professor Prakash Punjabi at a careers fair organised by the Imperial College Surgical Society. I've been a member of the society since my first year and actively involved in the committee since my second year.

Like studying, it is hard work, but I don't mind that: I'm usually in the hospital from 8am to 5.30pm, either assisting or observing operations and getting involved with research. There isn't much time for breaks, which is why, when I finish, and if the weather is good, I'll lie on the grass in Hyde Park. I'll think and I'll write in my notebook all the things I want to achieve and what I need to do next in order to achieve them. ◆



I'll often get off the tube early, just to have a walk and get my blood flowing

WHAT'S ON AT IMPERIAL

NOVEMBER 2019–MAY 2020

You are invited to connect with world leading researchers, inspiring students and the College's leaders at events throughout the year, in London and around the world.

13/NOV
Computers and spies: the rise of technology and death of secrets

Gordon Corera, BBC Security Correspondent, will chart the intertwining history of technology and espionage over the last century in the annual Vincent Briscoe Security Lecture from the Institute of Security Science and Technology.
South Kensington Campus

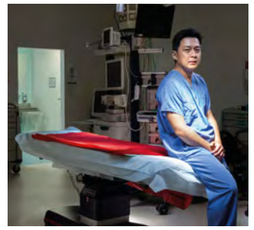
20/NOV
Can knowledge-based AI aid human-machine collaboration?

Alessandra Russo, Professor in Applied Computational Logic, explains why a knowledge-based approach is key to holding AI to account.
South Kensington Campus

22/NOV
A bright blue world

Professor Sandrine Heutz demonstrates that controlling and understanding molecules could be the key to a bright blue, and green world.
South Kensington Campus

28/NOV
Surgery, statistics and science



Eric Lim, Professor of Thoracic Surgery in the National Heart and Lung Institute, will share how mathematics transformed his career from bewildered medical student to international clinical opinion leader.
South *Kensington Campus*

05/DEC
Imperial Lates: Winter wonderlab

In the festive period as the nights draw in, we celebrate the chillier side of science via all manner of sub-zero chemistry and festive fun, embrace the cold in our Winter wonderlab.
South Kensington Campus

15/JAN
Imperial Inaugural: Roberto Trotta

Roberto Trotta, Professor of Astrostatistics and Centre for Languages, Culture and Communication Director, discusses dark matter, dark energy and the big bang.
South Kensington Campus

04/FEB
The Schrödinger Lecture 2020

Dame Georgina Mace, Professor of Biodiversity and Ecosystems, University College London, presents the annual Schrödinger Lecture from the Faculty of Natural Sciences.
South Kensington Campus

13/FEB
Imperial Lates: Future commuter

Travel over to Imperial in February to meet the scientists and engineers exploring the probabilities of our future mobility.
South Kensington Campus

19/FEB
Imperial Inaugural: Markus Perkmann

Markus Perkmann, Professor of Innovation and Entrepreneurship and academic director of the Enterprise Lab discusses his work in the Imperial College Business School.
South Kensington Campus

11/MARCH
President's Address 2020

Professor Alice P. Gast, President of Imperial College London, presents her sixth address to the Imperial community.
White City Campus

12/MARCH
Imperial Lates: Beautiful data

Data, data everywhere but perhaps we should stop and think? Explore both sides of the (bit)coin at Imperial Lates.
South Kensington Campus

Alumni and Friends Receptions 2019–2020

Every year we host a series of special events around the world, giving you the chance to meet members of our senior leadership team and to get to know local alumni. In the coming months, we'll be visiting Ghana, the USA, Switzerland and the UAE.

View a full list of public events at:
www.imperial.ac.uk/whats-on
Find out about Imperial alumni events around the world at:
www.imperial.ac.uk/alumni/events