Horizons

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Pioneering research from the University of Cambridge

UNIVERSITY OF CAMBRIDGE

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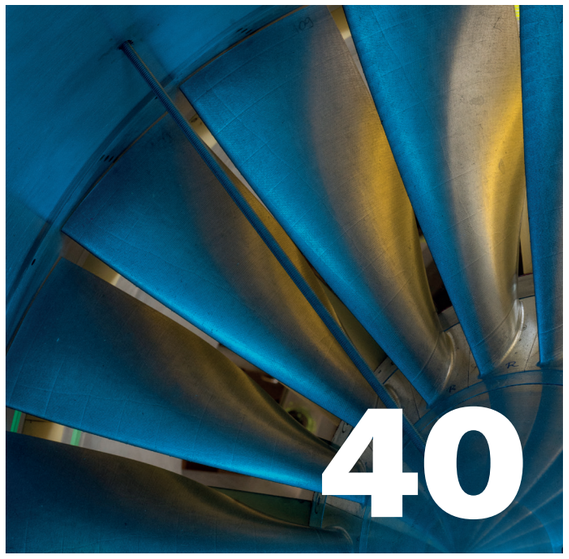

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The plant scientist with a practical vision for Africa (and who wasn't content to sit and drink tea).

This Cambridge Life

Carol Nkechi Ibe

Carol Nkechi Ibe discovered the hard way what it's like to be bright and educated, and yet feel like you know almost nothing. The life science foundation she started as a result has now helped hundreds of Africans prepare for the scientific career she could easily have given up on.

Africa is always in my heart, on my mind, anytime, every day. I was born in the USA where my father was studying, but we returned to Nigeria when I was two years old. It is a country that is deep within me.

I chose to study microbiology because the name sounded so cool. I'd always loved science and this was a subject that meant you could work in a lab and diagnose diseases like typhoid and malaria. I ended up being one of the top three students in my department.

Our school system taught us tenacity and the strength to keep pushing on but when I went on to do my Masters at Georgetown University in Washington DC, I had a shock. The curriculum we'd been taught at university in Nigeria was essentially obsolete and there were huge gaps in my knowledge of modern scientific principles. It just hadn't prepared me for the next step in a scientific career.

I pretty much had to start again. In fact it would have been easier to give up. People don't understand the struggle students coming from many African countries face. We have not had access to the level of opportunity people have elsewhere.

I knew what was needed because I'd been there myself. So during my studies at Georgetown, I had the vision to start JR Biotek, a not-for-profit life science foundation to help educate and train present and future Africa-based scientists. We want to build a powerful workforce of skilled innovative scientists and industry leaders who can contribute to the continent's sustainable development.

Agriculture in particular is crucial to sub-Saharan Africa's development. It's the small-scale farmers who face the most challenges. They don't have the training, education, funding or modern farming methods to help them improve their crop production.

I realised that nothing was changing, and in fact things were getting worse. Deteriorating soil conditions, climate change and diseases have put a strain on an industry that's badly needed to provide jobs and food. This inspired me to do a PhD in plant sciences in Cambridge with a Gates Cambridge Scholarship.

I study the interaction between rice plants and fungi. Some fungi help rice grow, others are detrimental – like the one that causes rice blast, which can destroy up to a third of the rice in a field. By understanding these interactions, we can optimise the beneficial and protect against the pathogenic. Rice has become a vital staple food in many African countries and so this research will contribute to food security.

When I came to Cambridge I had a choice. I could either focus on doing my PhD, work in a cool lab, cross my feet, sit and drink tea – or share the amazing opportunity I've been given and give back.

My motto is never give up – and never give up doing good. And so it's been during my time here at Cambridge that JR Biotek Foundation has really taken off. We've held workshops for hundreds of scientists and educators from African nations, providing them with new knowledge, resources and connections which they can take back to their own workplaces and pass on to many more people. My colleagues here have embraced the project with such enthusiasm, and I had the privilege of being awarded a 2019 Bill Gates Sr Prize for the work.

There are people in Africa who are relying on me even if they don't know me. I want to have an impact on what really matters. Providing knowledge and practical know-how to Africa-based students and early-career researchers will help the continent's agricultural sector to develop. It's this that inspires me every day. ●

Innovations, explorations, news, views, discovery and curious objects. Read the full stories at cam.ac.uk

Ad Hoc.

VIEWPOINT

“AI and machine learning have the potential to reshape almost every aspect of our lives, but we desperately need more machine learning specialists, or else the promise of AI will not be realised.”

Professor Neil Lawrence, Cambridge’s first DeepMind Professor of Machine Learning

RESEARCH

The butterflies are coming

Do you know your Postman from your Red Admiral? If not, perhaps it’s time to find out because lepidopterists expect climate change to drive many new species of butterfly to Britain.

While global warming poses a major threat to butterfly populations across the globe, and will cause some species to decline in the UK, it will also create important new habitats here for species that are declining in mainland Europe.

Butterflies are well served at Cambridge, being the focus of three research groups examining their evolution, genetics and conservation. Among them, Dr Andrew Bladon is devising habitat ‘stepping stones’ to help butterflies disperse and extend their range as the climate warms. His work includes very gentle use of thermometers.

OBJECT

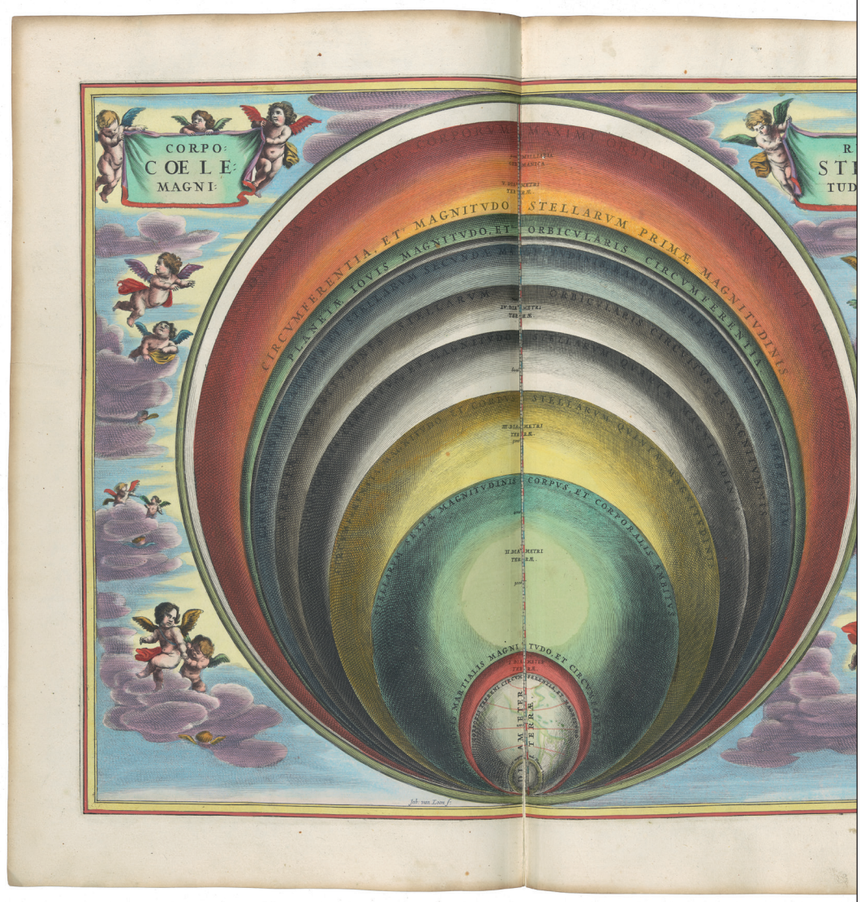
What colour is heaven?

Red and yellow and pink and green, purple and orange and blue... at least if you were a celestial cartographer in the 17th century.

This spectacular rainbow-coloured illustration is from a celestial atlas, the *Harmonia macrocosmica*, by Dutch star-mapper Andreas Cellarius. It forms part of an ambitious programme to map out the surface of the Earth, the cosmos and all its heavenly bodies, which started almost a hundred years earlier with the famous cartographer Gerard Mercator.

First published in Amsterdam in 1660, this sumptuously hand-decorated second issue printed a year later is one of the great treasures of Cambridge University Library’s extraordinary collection of early printed books.

The hand-colouring differs from one copy to another; in some copies, this one included, this plate has the continents drawn in by hand on the surface of the Earth.



Credit Cambridge University Library

Image *Harmonia macrocosmica*, 1st edn, 2nd issue

NUMBERS

Towering trees

The tallest tree in the Amazon recorded as 88.5 metres by Cambridge and Brazilian researchers using airborne 3D laser mapping of the Amazonian rainforest. And they climbed it!

88.5m

RESEARCH

Artificial chameleon skin powered by nanomachines

Chameleons and cuttlefish are able to change colour because of special skin cells called chromatophores, which provide important camouflage for protection.

Scientists from Cambridge’s Cavendish Laboratory have developed artificial versions of chromatophores using tiny particles of gold in a rubbery coating, squeezed into water droplets and suspended in oil. When heated, they collapse and cluster together, changing the colour of the material.

While still in a prototype stage, the colour-changing material could be used for active camouflage and large-scale dynamic displays.

RESEARCH

Lost Irish words

Researchers from Cambridge and Queen’s University Belfast have identified and defined 500 medieval Irish words, including many long-forgotten terms that offer extraordinary details about the everyday lives of the people who used them. The findings can now be freely accessed in an online dictionary (www.dil.ie), but in the meantime here are a few to improve your *fis* (knowledge) of a fascinating *foclóracht* (vocabulary).

ogach meant ‘eggy’ or ‘abounding in eggs’, but in reference to a fertile land.

rímaire referred to a person who calculated the date of Easter, among other things. In modern Irish, it means ‘computer’.

galar na rig literally meant the ‘king’s disease’, a term for scrofula, which is known in English as king’s evil.

VIEWPOINT

“We hope to illustrate an all-encompassing picture of the incredible fight for gender equality within the University, while portraying the fascinating journeys of some of the militant, cussed and determined women of our institution too.”

Dr Lucy Delap, co-curator of a new exhibition, *The Rising Tide: Women at Cambridge*, in the University Library until March 2020

TECH

Fishy tails in virtual reality

Ever been inside a fish-processing factory? How about inside a 3D printer inside a fish-processing factory?

Well, now’s your chance thanks to a newly developed virtual reality (VR) experience that places you right where the 3D fish action is happening. As you watch, less than a virtual arm’s-length away, layer upon layer of a fish-shaped fish is 3D printed from the edible pieces that are too small to make it out through the factory gates.

The VR Future Kitchen series is funded by EIT Food – Europe’s leading food innovation initiative. The immersive ‘infotainment’ series is now being trialled as an educational tool by the University of Cambridge to show how technological advances can help achieve a more sustainable food system.

Oh and when you’ve seen enough of the fish factory, there’s a vertical greenhouse to ascend...

NUMBERS

Long in the tooth

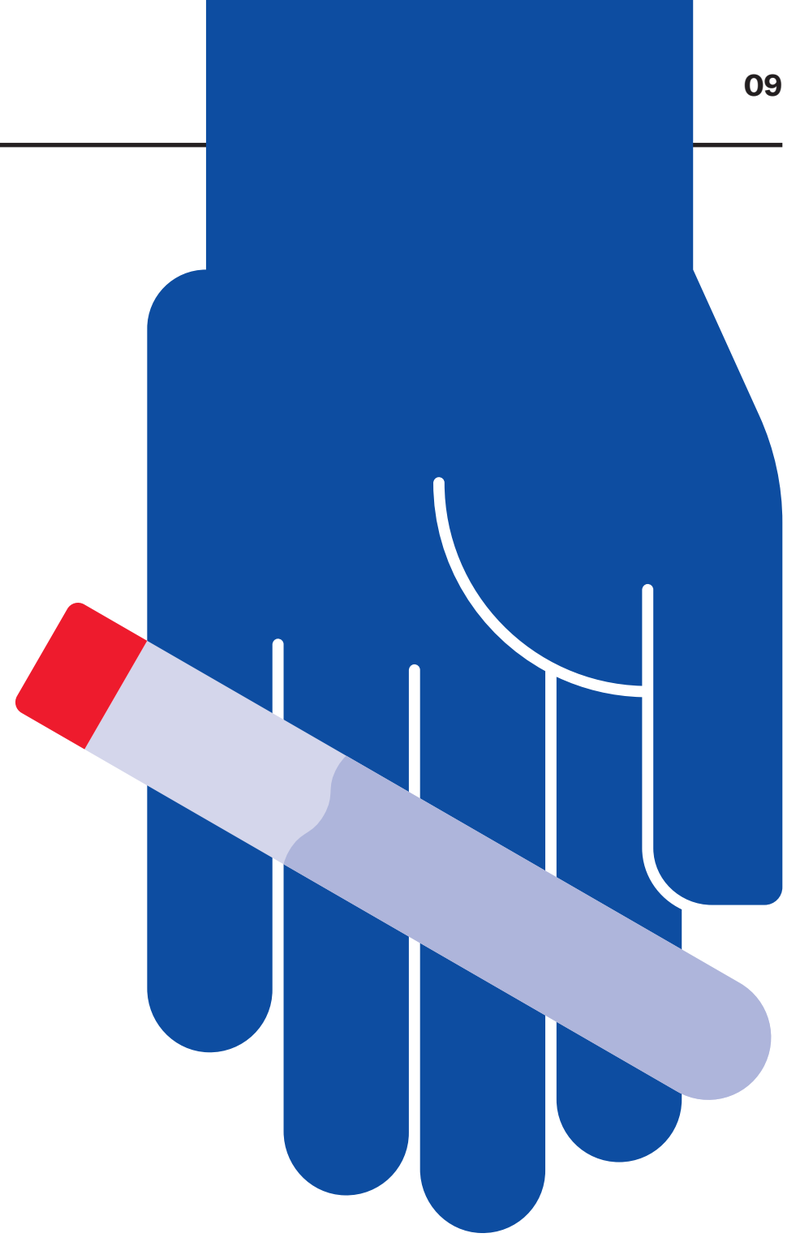
Genetic information extracted from the dental enamel of a 1.77 million-year-old rhino tooth by researchers from Cambridge and Copenhagen is the oldest genetic data ever recorded.

1.77m

START-UP, SPIN-OUT

A homegrown success story in the growth factor industry

Words Catherine Aman



How a DIY approach solved a technical hitch for one protein biochemist – and now potentially the global stem cell research community.

When Dr Marko Hyvönen started his postdoc research in the Department of Biochemistry in 1998, his assignment was straightforward: determine the structure of Activin A and Activin B with their receptors. These growth factor proteins are master regulators that instruct cells to grow, differentiate, proliferate, heal and expire.

His task was to analyse them using X-ray crystallography and figure out how they were built. To do that, he needed large quantities of highly pure protein. “Large quantities are milligrams, or tens of milligrams, which doesn’t sound like a lot,” he says, “but for protein people, it is.”

The hitch? Growth factors have complex 3D structures and are notoriously difficult to work with. The existing purification methods using animal cells were simply not able to produce sufficient pure protein for this work.

To Marko, the obvious solution was DIY: invent a way to produce activins in sufficient quantity and quality to carry out his research. It took over three years. “For an early-career researcher, that’s close to career suicide. I wasn’t producing many papers in that time,” he says. “But I was just determined to find a way.”

His tenacity paid off in 2001. Using the bacteria *Escherichia coli*, he found he could reliably produce human growth factors in far greater yield and purity than had been done using animal cells.

Soon after nailing the prototype, he spotted a research paper from another Cambridge lab on activin’s part in maintaining stem cells in a state that can develop into any cell of the human body. He emailed the authors, Professors Ludovic Vallier and Roger Pedersen: “I’ve got a freezer full of Activin A, would you like to try it?” An affirmative reply shot back. Marko pocketed a vial of the almost-invisible substance and cycled to the Laboratory of Regenerative Medicine to deliver it.

The stem cell researchers approved. Their tests showed that Marko’s protein was highly active and as good as, if not better than, commercially available activins. Before long, Marko and his team were supplying Activin A, at cost, across the growing stem cell community in Cambridge.

In 2008, Cambridge Enterprise licensed the technology to a leading growth factor producer based in the USA. Spurred on, Marko was determined to be able to provide high-purity growth factors and other proteins to the international stem cell community, driven in part by requests from researchers who’d trained in Cambridge.

Cambridge Enterprise introduced him to biochemist Dr Catherine Elton and they co-founded Qkine Ltd, which spun out of the University in 2016. After a couple of years as an embedded company in the Biochemistry Department, Qkine gained investment from a team of business angels and Cambridge University, and now has established laboratories on the Cambridge Science Park.

The team continues Marko’s mission to tackle the production of some of the trickiest proteins in the field using clever protein engineering and the same laser focus on quality.

“With the rapid growth in stem-cell-based medicine and the emergence of new and exciting markets such as stem-cell-derived meat, there’s a vital need for solving problems in the growth factor supply chain so that we can make reliable reagents in bulk,” adds Catherine. “Marko’s unwillingness to settle for second best and desire to have real international impact has certainly set Qkine on an exciting path.”

NUMBERS

Boosting heart and lung research

A £30 million award announced by the government will support the new Cambridge Heart and Lung Research Institute on the Cambridge Biomedical Campus, complementing £10 million of funding committed by the British Heart Foundation.
The Institute brings together the expertise in cardiovascular and respiratory science at Cambridge University with the clinical excellence at the Royal Papworth Hospital.

£30m

RESEARCH

Immersive 3D head-display developed for in-car use

No, we still don't have flying cars, but driving is starting to get positively futuristic.

A collaboration between Jaguar Land Rover and researchers at Cambridge's Centre for Advanced Photonics and Electronics is developing next-generation head-up display technology that could beam real-time safety information in front of the driver, and allow passengers to stream 3D movies directly from their seats.

Recent tests showed that stereoscopic 3D displays can improve reaction times and depth judgment while driving. The aim of the collaboration is to develop an immersive display that allows drivers to react more naturally to hazards and prompts.

The programme forms part of Jaguar Land Rover's 'Smart Cabin' vision to create a personalised space inside the vehicle for the driver and passengers. It's at the forefront of development in the virtual reality space and will set the scene for the connected, shared and autonomous cars of the future.

RESEARCH

Ancient East Anglians were riddled with tapeworm thanks to marshy diets

The fossilised faeces of Fen folk living in the Bronze Age have revealed the consequences of feasting on undercooked fish and frogs: parasitic worms.

Prehistoric poo preserved in the mud of a settlement near Peterborough that burned down around 3,000 years ago contained the earliest evidence for fish tapeworm and giant kidney worm in the UK.

Dumping excrement from stilt houses into the surrounding channels, then consuming infected fauna from the same stagnant waters, created an "ideal nexus for infection", according to study author Marissa Ledger, a PhD student in biological anthropology.

The findings come from Must Farm, an exceptionally well-preserved Bronze Age settlement dating to 900–800 BC excavated by the Cambridge Archaeological Unit. The site is so rich in archaeology it has been dubbed Britain's Pompeii.

RESEARCH

The curious tale of the cancer 'parasite' that sailed the seas

Around 6,000 years ago, a dog in Asia developed a tumour that had a very unusual property: it was contagious.

'Canine transmissible venereal tumour' can now be found in almost every corner of the globe and, remarkably, the tumour cells are those of the original dog in which the cancer arose, not the carrier dog.

As a result, it's possible to read changes in the tumour's DNA over time like a historical travel journal and trace its spread to where dogs accompanied man on the high seas, says PhD student Adrian Baez-Ortega from the Department of Veterinary Medicine.

The cancer first spread from Europe to the Americas around 500 years ago and from there to North, Central and South America, to Africa and into the Indian subcontinent – almost all places that were, at the time, European colonies.

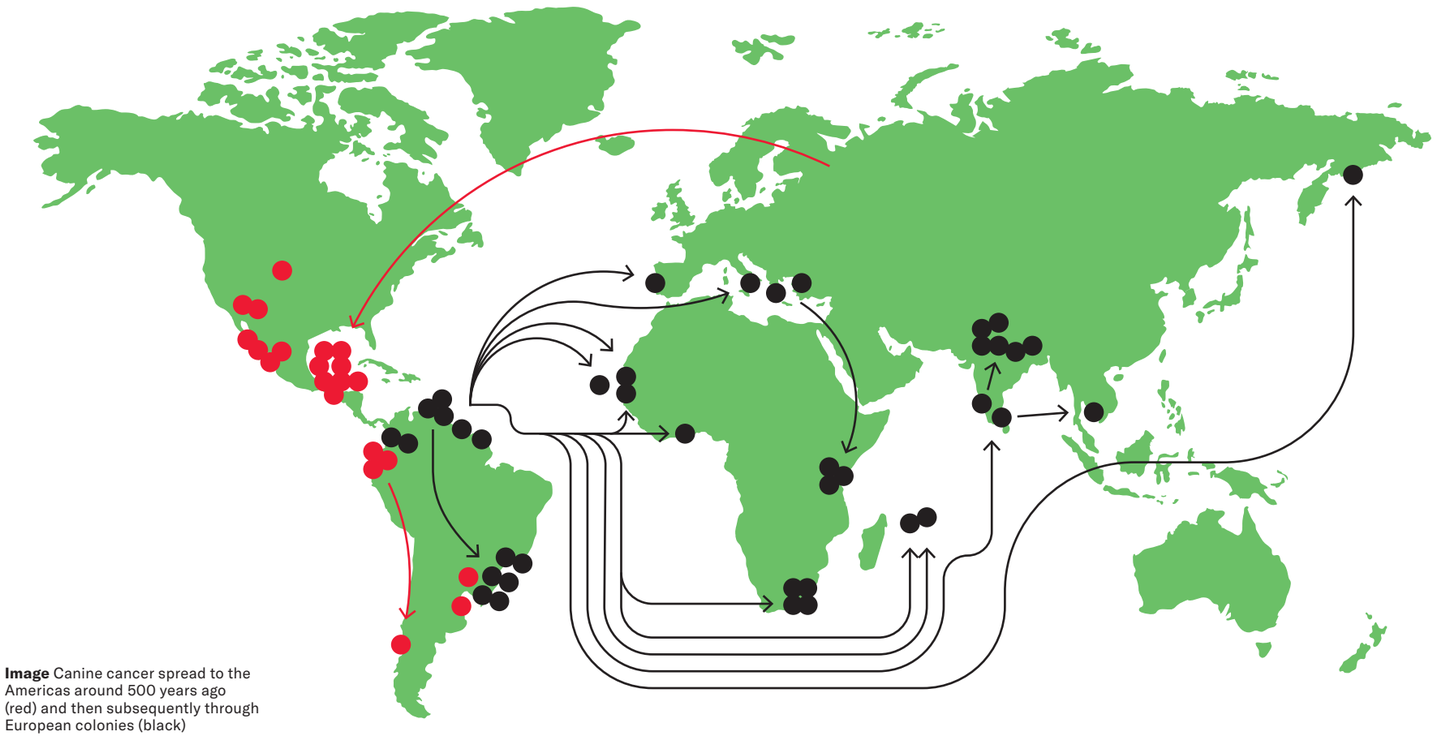
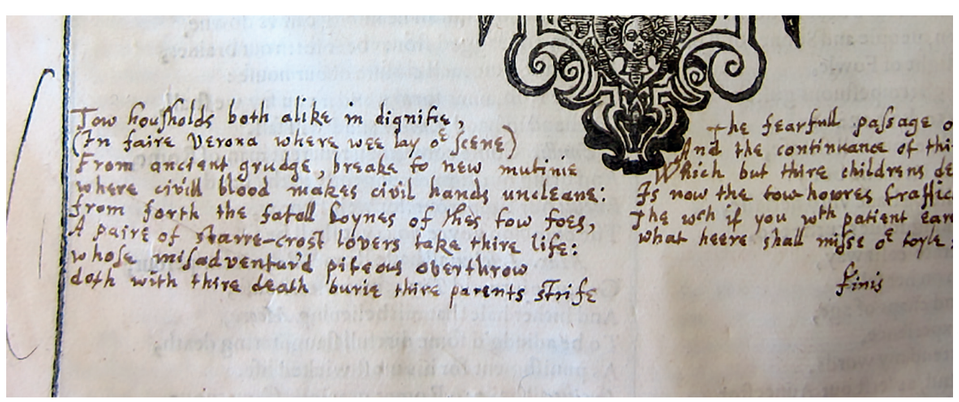


Image Canine cancer spread to the Americas around 500 years ago (red) and then subsequently through European colonies (black)

VIEWPOINT

> **"Back then, exoplanet research was a very small field. I think there were about 50 of us and we were seen as weirdos."**
>
> Professor Didier Queloz, co-winner of the 2019 Nobel Prize in Physics, speaking about the early days of his research



Credit Claire Bourne/Free Library of Philadelphia

RESEARCH

Shakespeare's mystery annotator identified

When the right foot of an 'h' missed the ground before it headed up into an 'e', a mystery began to be solved.

Thanks to his painstaking analysis of handwritten notes, literary scholar Dr Jason Scott-Warren from Cambridge's English Faculty believes he has identified tangible evidence of a crucial encounter between two of the world's great writers: Shakespeare and *Paradise Lost* poet John Milton.

The telltale palaeographical clues – a neat italic hand with little sense of flow, two kinds of 'e', a distinctive 'R' and so on – were lying hidden in what have, until now, been anonymous annotations in the margins of a Shakespeare First Folio housed in the Free Library of Philadelphia's Rare Book Department. The First Folio was published in 1623, when Milton was 15 years old.

Although further work is needed to prove Scott-Warren's theory beyond doubt, several Milton experts have already expressed their enthusiastic support and offered further evidence. Some scholars have called it one of the most important literary discoveries of modern times.

SHAPING SENUA'S INNER DEMONS

Senua is the central character in the award-winning video game Hellblade. She's troubled by voices in her head. A unique collaboration between games developers, a Cambridge psychiatrist and people who hear imaginary voices helped bring these hallucinations to life.

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Words Craig Brierley

A mist hangs over the water as a Pict warrior paddles her canoe towards the silhouetted shape of a Viking ship, half submerged ahead. Around her, voices, whispers, linger in the air.
What's happening?
It's breathing.
Up ahead.
He knows she's getting closer.
He can feel her getting closer.
They're watching ahead.

This is Senua, the central character of the video game Hellblade. She has begun a quest to save the soul of her lover from the Norse underworld of Helheim. The voices that accompany Senua, in equal measures encouraging, aiding, mocking and belittling, result from her psychosis, brought on by traumatic events earlier in her life.

As the opening titles begin to roll, the first credit to appear is Mental Health Advisor Paul Fletcher.

Fletcher is a psychiatrist at the University of Cambridge with a particular interest in psychosis. The condition is defined as a separation from reality, whereby someone's perceptions and beliefs do not agree with the reality that people around them recognise. Most commonly, it involves hallucinations and delusions, and can arise as a symptom of any number of conditions, from severe depression to schizophrenia to dementia and even stress.

In 2013, Fletcher received an email from Dominic Matthews, Commercial Director at Cambridge-based video games company Ninja Theory, asking for his help. They had an idea for a game whose central character experiences psychosis, and wanted to get it right.

Ninja Theory had received a starter grant to develop their ideas from the charity Wellcome, which had recently taken an interest in how video games might be used to engage the public with science. Wellcome would later provide additional funding towards production costs.

"Entertainment hasn't always handled issues around mental health particularly well," says Dr Iain Dodgeon, then Head of Broadcast & Games at Wellcome. "But with Ninja Theory, we felt that they were interested in approaching [the portrayal of mental health] in the right way to be able to more authentically and sensitively depict the experience of psychosis in a way that wasn't exploitative, but was really engaging."

At the start, Fletcher's work with Ninja Theory was simply informative: this is what psychosis is, this is where you find it, here are some examples. But this quickly turned into a broader conversation around the question of what it's like to have psychosis and what sort of people might experience it.

Fletcher introduced the team to Recovery College East, at Cambridgeshire and Peterborough NHS Foundation Trust, where a group of individuals who have experienced mental illness now run a college for people who are recovering. Together, they helped shape the development of Senua's experience and the manifestation of her psychosis.

The voices that surround Senua were recorded using a technique known as binaural audio, which captures the sense described by some people that their voices would move about them, sometimes in front, sometimes behind. The voices feel real, with characters and personalities, just as they appear in psychoses.

"Someone would say 'I have this experience where everything goes wobbly in the world' and our artists would say okay, how could we realise that in the game," explains Matthews.

"They'd have a go and take it back to the group, who'd say 'Wow, that's really close, it's really weird to see it, because now everyone else can see exactly what I'm talking about."

Hellblade was released in the summer of 2017 to widespread acclaim. *Forbes* magazine said it was "probably the most realistic portrayal of mental illness I've yet seen in a video game, and it works its magic without being patronizing, without stooping to exploitation or condescension."

The game broke even within three months, and within a year of its release had sold more than a million copies. It has won more than 20 awards and been nominated for dozens more.

"It's always been a bit of a dream [to win a video game BAFTA], and I thought maybe we'd have a chance on this project," says Matthews. "But to walk away with five BAFTAs, that was just phenomenal."

And yet, he says, it has been the impact the game has had on people's lives that has left the biggest impression on him. "We still get letters from people and emails and Tweets telling us how the game has helped them and given them a platform on which they are able to talk about their own experiences with friends and family members. I met a girl recently who said that she felt like Senua was the only person who really understood her."

Dodgeon is optimistic that Hellblade will have a positive lasting effect on the games industry. "From having conversations with people within the industry, I'd say it has certainly inspired a lot of people," he says. "It's made them appreciate better that serious issues can be tackled sensitively within games and can draw and engage a large audience."

For Fletcher, the game has transformed how he is able to communicate his research. "I used to read quotes from early 1960s papers about the perceptual disturbances that people with psychosis describe. I now have a whole load of clips created by Ninja Theory that I can just show. It's an amazing resource for teaching students."

Matthews and Fletcher see an exciting future for the relationship between gaming technology and mental illness, one that moves beyond games merely allowing players to experience simulations of mental illness and towards promoting mental health.

People already use games for their mental health, says Fletcher – perhaps picking up the phone and playing Candy Crush for 15 minutes of relaxation. But by combining physiological measures of anxiety – heart and respiratory rates, for example – with the feedback from virtual reality, it could allow them to take this to a whole new level.

"Imagine mindfulness with a virtual reality headset on, where you're being rewarded for controlling your physiology, because the environment becomes more beautiful. The sun comes out from behind the clouds or the wave starts to lap against the shore."

All this seems worlds away from the battles that Senua fights with the monsters in her world and in her head. But perhaps ultimately, authenticity in video games might help both Senua and us find peace in a turbulent world. ●

Credit Ninja Theory

Mîńd ŷøůr långüåġe(ş)

In many parts of the world, multilingualism is the norm and an essential life skill, while in others it is viewed as a luxury or even a waste of effort. At the same time, language learning appears to be increasingly politically loaded, not least in debates about immigration and social cohesion.

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Words Tom Almeroth-Williams

A major interdisciplinary research project based in Cambridge is seeking to understand the roles that languages play in societies, to inspire uptake at the grassroots and to embed multilingualism in policymaking.

MEITS (Multilingualism: Empowering Individuals, Transforming Societies), funded by the Arts and Humanities Research Council, is attempting to compare the role and status of languages across the world, but at its heart lies a very British problem.

The UK is a richly multilingual country. In England, about one in five children starting primary school and about 16% of secondary school children have a home language other than English. Yet language learning in the UK is in free fall. Since 2000, entries for GCSE modern foreign languages have dropped by 44%, with French and German each suffering declines of over 60%. At undergraduate level, the situation is even worse: between 2008 and 2018, the number of modern language undergraduates fell by 54%.

For Professor Wendy Ayres-Bennett, Principal Investigator of MEITS, bringing languages back from the brink in the UK requires a pincer movement of top-down and grassroots action. "We're battling to bring languages higher up the political agenda, to bust myths about them being difficult and elitist, and to raise awareness of the benefits of multilingualism."

Ayres-Bennett, an expert on language policy in 17th-century France, explains that the UK never having had a language Academy or a joined-up language policy remains one of the big differences between the two countries. It seemed a natural transition to think about how languages could be made more central to UK government thinking in the 21st century.

"British policymakers need to adopt a much broader concept of why languages are important," she says. "That means accepting that languages are central to the key issues of our time.

"If you consider the government's industrial strategy, it's astonishing that language learning is hardly mentioned. But the importance of languages is also undervalued in health and wellbeing, immigration, social cohesion and community relations – policy areas in which they should be central. We want it to become a reflex to ask 'does this policy have a language dimension?'"

She adds: "The UK needs a high-level champion – a Chief Government Linguist – who can advise on policy and facilitate communication on pressing language-related issues."

In the meantime, MEITS has briefed officials from government departments including the Home Office and Foreign Office, as well as the Civil Service in Northern Ireland. The team has also urged the UK Statistics Authority to rework the language question in the 2021 Census to gain a more accurate picture of the nation's language skills.

A lack of foreign language skills costs the UK up to:

£48bn
a year or

3.5%
of GDP

Source bit.ly/2AxNvFv

The project has secured the backing of business leaders. The CBI's 2018 *Educating for the Modern World* report identified a lack of language skills as a major obstacle to the government's ambition for a 'Global Britain'.

"When I first spoke to the British Chambers of Commerce," Ayres-Bennett reflects, "I gave my spiel about international trade but it was only when I spoke about the cognitive benefits and transferable skills associated with learning languages that they got really interested because that spoke to all of their members not just those who traded overseas."

A raft of evidence has been published to show that learning a language hones analytical and problem-solving skills, cultural awareness and mental agility, as well as communication skills. "Language learning also helps you to see things from someone else's viewpoint and breaks down barriers," she says. "Whichever part of the workforce you're entering, these are all important assets."

MEITS examines the dangers of being 'locked out' by monolingualism and also the benefits of 'holding the key'. "You can only truly understand how people think and how other cultures work if you know their language," explains Ayres-Bennett. "And instinctively knowing how to behave and how things will be interpreted is vital not just for business but also in diplomacy."

One of the project's priorities is to explore the roles that languages play in conflict and conflict resolution. As part of this work, researchers are comparing developments in Catalonia, Ukraine and Northern Ireland. Disagreement over the question of an Irish Language Act was one of the key factors leading to the suspension of the Northern Ireland Assembly in January 2017. Behind the scenes, MEITS is offering insights by drawing on examples of what has worked in other parts of the world.

Within MEITS' 35-strong team, researchers from Queen's University Belfast have been working with a charity that is teaching the Irish language to former loyalist paramilitaries. "It's about building bridges with small but important gestures," says Ayres-Bennett, who has argued for similar efforts to be made to build better community relations across the UK.

As well as recommending that anyone wanting to live and work in the UK should learn English, Ayres-Bennett has also advised that it would be beneficial if English-speaking British people took more of an interest in the languages spoken by others in their local community and learnt even a few words of them.

"Just knowing the word for hello can help to make someone feel more welcome and more accepted," she says. "Integration has to involve equal partners, and even modest efforts can mean a huge amount."

The research team recognises that changing the perceptions of languages is a huge challenge, not least because of inequalities in language education provision. As well as working directly with schools, MEITS has launched its 'Pop-Up World of Languages', the first museum of its kind in the UK.

These interactive pop-ups will take place in Cambridge, Belfast, Edinburgh, Nottingham and London, using shopping centres, theatres and libraries as accessible host venues. They will challenge myths and prejudices, including the idea that 'the British aren't good at languages'. Ayres-Bennett points out that more people in the world are bilingual than are not, and the idea that learning languages is elitist and difficult is 'cultural baggage' that needs to be shaken off.

"We didn't want this to appear overly educational or threatening," she adds, "it has to be a fun space that you want to drop into. Many people think of learning languages as a chore but we want to show that it can be fun and open up so many exciting opportunities." ●

Cambridge volcanologist Dr Emma Liu travels to some of the world's most active volcanoes to understand what makes them erupt. Her latest work is helping a Pacific island community to monitor the restless mountain they live beneath.

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Words Louise Walsh

Fieldnotes

A walk less ordinary

Standing on the rim of the volcano with her research partner and a local guide, Dr Emma Liu listened to the low roar of the crater's belly and watched as it spewed its incendiary gobbets of lava and noxious volcanic gases. A moment later they launched their 'eye in the sky', a drone that can fly high above the volcano collecting gas chemistry data from directly inside the plume.

The geochemical measurements the team made that day would add another piece of the puzzle as to how volcanic 'signatures' on the ground and in the air can be used to understand what is happening deep beneath the volcanoes themselves.

"Volcanoes are always going to erupt. Remote gas sensing – 'breathalysing' volcanoes, if you like – to assess hazard is an important defence to build resilience in communities who live nearby," explains Liu.

She's pictured here standing on the rim of Volcán de Pacaya in Guatemala – one of the many active volcanoes she visits for fieldwork. Her recent work has been in Manam, Papua New Guinea, where she leads the international Aerial-Based Observations of Volcanic Emissions (ABOVE) programme, funded by the Alfred P. Sloan Foundation. Five major explosions have occurred here in the past year.

"Permanent relocation is seen as unacceptable to the islanders because the island is essential to their way of life. Instead, they want to help themselves to live alongside the volcanic hazard," she explains. "ABOVE is the first time a global collaborative effort like this has been assembled to fill in some of the gaps in our understanding of what makes volcanoes erupt."

The team has also trained local scientists to use the drones to monitor gases as part of a community-led resilience programme. When there is an explosion, the drones help them to see who and what is most at risk.

Meanwhile, Liu continues to collect data from fieldwork. "There's a buzz about being there. When I'm standing at the crater rim, with a line of volcanoes stretching before me... at times like this, I feel a little bit superhuman." ●

MANAM ISLAND

LOCATION
4° 4' 39" S, 145° 2' 21" E

CURRENT POPULATION
Approx. 4,000

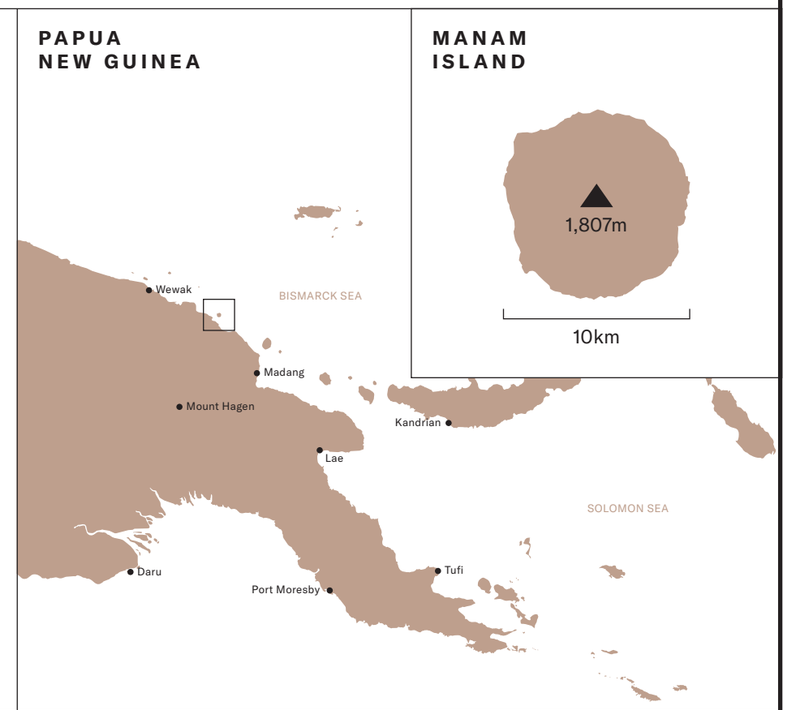
TYPE
Stratovolcano

STATUS
Active

LAST ERUPTION
2010 – ongoing

HAZARDS
Pyroclastic flows, ash fall, lava flows, volcanic gases

LAST FULL EVACUATION
2004, lasting for a decade



Q&Academic Did the Sixties dream die in 1969?

This year marks the half-centenary of 1969. It's a year held up as the end of an era – but have we bought into a dangerous myth? Counterculture expert Dr James Riley delves into the darkness of the Sixties to sort fact from psychedelic fiction.

Dr James Riley
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Illustration Zoë Barker

The Sixties are generally remembered as an era of freedom, innovation and visionary experience. It's the period, after all, that gave us The Beatles, the Summer of Love, the civil rights movement and the Apollo 11 moon landing. As a crucible of the hippie 'dream', its iconic status was one of a loosely defined, youth-led attempt to establish an alternative, harmonious, post-war world.

And then, or so the story goes, the hippie dream 'dies'. It's brought to a crashing halt in the latter half of 1969 thanks to the terrible murders perpetrated by Charles Manson and his followers, 'the Family', the deaths attributed to the 'Zodiac Killer' and the violence at the Altamont Speedway rock concert featuring The Rolling Stones. These events appear to hold up a dark mirror the positive social and cultural advances of the preceding years.

While this narrative may suit the matrix of popular culture and nostalgia that constitutes the Sixties, it bears little resemblance to the historical actuality of the 1960s. Yes the decade ushered in a wave of progressivism and it also had its shadow side but, if anything, the darkness was present from the start, hovering close to the decade's much-vaunted counterculture.

Assassinations, nuclear tensions, globalised conflict, civil unrest, the growth of apocalyptic religious groups: the 1960s were suffused with violence, anxiety and a sense of looming doom. A fraught and difficult decade, the 1960s left a social, cultural and economic legacy that still exerts a powerful influence today.

Yet the 'Sixties' continue to exist in a bubble of comforting misremembrance, regularly offering up another anniversary, exhibition or reunion tour. Altamont and the Manson murders were of course very real events with a terrible human cost, but they have become part of a narrative of disaster that helps to shore up this exceptionalism. What else are we to expect from a supernova era than a spectacular curtain fall, flower power ending in blood-soaked catastrophe?

For those invested in the period's nostalgia industry, framing the Sixties as a kind of cultural Shangri-La – a lost world that we strive to return to – is surely better than acknowledging the pedestrian reality of how the 1960s actually ended? That's the real horror: the slow, inconsequential shift of a dynamic counterculture into adulthood, suburbia and 'proper' jobs (the 1970s, in other words).

The end of the 1960s did not mark the 'death' of the hippie 'dream'. As the 1970s took hold, the countercultural impetus merely recalibrated and flowed in different directions. But this has not stopped contemporary culture from obsessively revisiting and repeating the events of 1969, as if they signal some kind of terminus, yet to be fully understood.

Meanwhile, the world of the early 21st century continues to plough headlong into its own deeply troubling period of postmodern politics, creepingly malevolent soft power and weaponised 'fake news'. When we live in such interesting times, why dwell on the illusions and disillusions of the 1960s?

Fifty years ago, protests took place across reasonably well-defined battle lines against clearly identifiable targets. Now, in today's sphere of edited reality and policies that change as fast as they can be Tweeted, it's difficult to pinpoint where the source of power is, let alone how to protest against it.

To navigate this type of situation, it's important to understand the mechanics at play – how representations are manipulated and how agendas are embedded in seemingly innocuous narratives. This is what the 1960s can teach us.

By interrogating and unpacking the link between the 1960s and the Sixties, we can observe the forces that transform recent history into modern myth. It's also useful to be shocked by how much things have changed. If you are curious, look into the details of the Manson case and think about what it meant in 1969 to 'follow' someone. What you find might make you spend a little less time on Twitter. ●

James Riley is the author of *The Bad Trip: Dark Omens, New Worlds and the End of the Sixties* (Icon Books, 2019)

The big picture

Forests burn, glaciers melt and one million species face extinction. Can we humans save the planet from ourselves? Legendary naturalists Dame Dr Jane Goodall and Sir David Attenborough look at the big picture and see reasons for hope →

Image Endangered rainforest, Indonesia

Credit Robert Nickelsberg/ Getty Images

“Every single day that we live, we make some impact on the planet. We have a choice as to what kind of impact that is.”

“In 1986, I helped organise a conference on how chimpanzee behaviour differed according to the environment. There was a session on conservation and one on conditions in captivity – in both cases, it was utterly shocking. I went to the conference as a scientist, and I left as an activist.

Since then, I’ve been travelling the world raising awareness not only of chimpanzee conservation and welfare, but also of wider environmental issues.

We have just one home, one planet, and we’re destroying it very, very fast. The human population is growing, but on a planet with finite natural resources, and we’re using up these resources faster than nature can replenish them. We’re polluting the air, the water and the land. We’re recklessly pumping out CO_2 into the atmosphere and, at the same time, we’re destroying our forests and oceans – the two great lungs of the world. If we carry on with business as usual, in 20 years’ time, we may have a planet that’s virtually unliveable.

We must not give up hope. Every single day that we live, we make some impact on the planet. We have a choice as to what kind of impact that is.

I see reasons to be optimistic. Nature is resilient. If we work to restore those places that we have destroyed, if we give them time, they will recover. A bleak, destroyed area can become beautiful again as the insects and birds and other animals come back. Animals on the very brink of extinction can be given another chance.

I truly believe we have a window of time during which we can begin to heal some of the damage we’ve inflicted and at least slow down the climate crisis. But we have to act now.

My greatest hope is our young people. There’s a saying, ‘We haven’t inherited this planet from our parents, we’ve borrowed it from our children’. But we haven’t borrowed our children’s future – we’ve stolen it. In my travels, I have met so many young people who seemed depressed, angry or just apathetic, feeling that their future has been compromised and that there’s nothing they can do about it. That was why we started our Roots & Shoots education programme in 1991, to empower young people to make the world a better place.

Cambridge, like all universities and schools, can play a role in shaping the attitudes of young people. We need to educate and inspire them, to teach them to respect each other and to respect other living organisms. We need environmental concerns to be taught not just in science, but in every discipline.

We are finally beginning to use our intellect to come up with technological solutions that will enable us to live in greater harmony with our planet – electric cars and renewable energy, for instance – and to think about our own ecological footprints. We need the scientific endeavour for which institutions such as Cambridge are famous to be directed towards doing something about the mess that we’ve made of our planet.

The human spirit is indomitable. Throughout my life, I’ve met so many incredible people – men and women who tackle what seems impossible and won’t give up until they succeed. With our intellect and our determined spirit, and with the tools that we have now, we can find a way to a better future.”

Credit ©Vincent Calmel

At the age of 26, Dame Dr Jane Goodall travelled from England to what is now Tanzania, Africa, and ventured into the little-known world of wild chimpanzees. Among her many discoveries, perhaps the greatest was that chimpanzees make and use tools. She completed a PhD at Newnham College in Cambridge in 1966, and subsequently founded the Jane Goodall Institute in 1977 to continue her conservation work and the youth service programme Roots & Shoots in 1991. She now travels the world as a UN Messenger of Peace, speaking about the environmental crises we face, and her reasons for hope.

“The only way to operate is to believe we can do something about it, and I truly believe we can.”

“It might seem like an obvious thing to say but we need to keep saying it: our planet is precious.

It provides the air we breathe, the food we eat, the water we drink. You have only to take a walk through a forest and look up at its canopy to see the outstanding beauty and complexity of ecosystems. Pause in the stillness among the trees and contemplate what is surrounding you: it’s mind-blowing.

But, rather than cherish this planet – our home – we have too often treated it with contempt. Today, as a consequence, we face disaster on a global scale.

Everywhere we look, we see how ecosystems are threatened. The most striking illustration of climate change that I have seen is seared on my memory: the first time I saw a dead coral reef. It had actually bleached. Where once it had been full of hundreds of species, now it was like a cemetery.

A few decades ago, the idea that humans could change the climate of our planet was unthinkable. Now this is incontrovertible and we are talking about the risk of irreparable damage. Rising temperatures mean parts of the planet are becoming uninhabitable. Species less able to adapt to rapid changes will be wiped out. Famine will lead to forced migrations. There will be major upsets in natural boundaries, leading to social unrest.

Fortunately, we are now better informed about the state of the world than ever before. We’ve seen a worldwide protest movement grow, led by young people afraid for their future and the future of their planet. We must listen to them. We must respond. We must act – and act now.

We’ve seen before what can be done. When scientists identified the cause of a catastrophic hole in the ozone layer, the world acted. We saw global leaders listening to scientific evidence and taking action.

The climate crisis is a much larger problem, but if we can all pull together, I believe we can solve it. What each one of us does in the next few years will determine what happens in the next few thousand years. There is hope if we all – every single one of us – take our share of responsibility for life on Earth.

Those in power can influence change. And those with knowledge and the ability to innovate can provide solutions to a great number of problems.

I have had the honour of being part of the Cambridge Conservation Initiative from its inception 12 years ago. I’ve seen what can be achieved when great talent is combined with great ambition: bringing together leaders in research, practice, policy and teaching gives us the greatest chance of developing the solutions required to save our planet.

In the same way, the new initiative Cambridge Zero will be vital. Combining expertise, from science and technology to law and policy to artificial intelligence and engineering, Cambridge Zero will help drive a vision for a carbon neutral future.

It’s a source of comfort to me that people are recognising that their world is at stake, that the ocean is not infinitely full of food, that the ground is not infinitely full of minerals, that life on Earth is not impervious to the damage we cause.

Our planet hangs in the balance. The only way to operate is to believe we can do something about it, and I truly believe we can.”

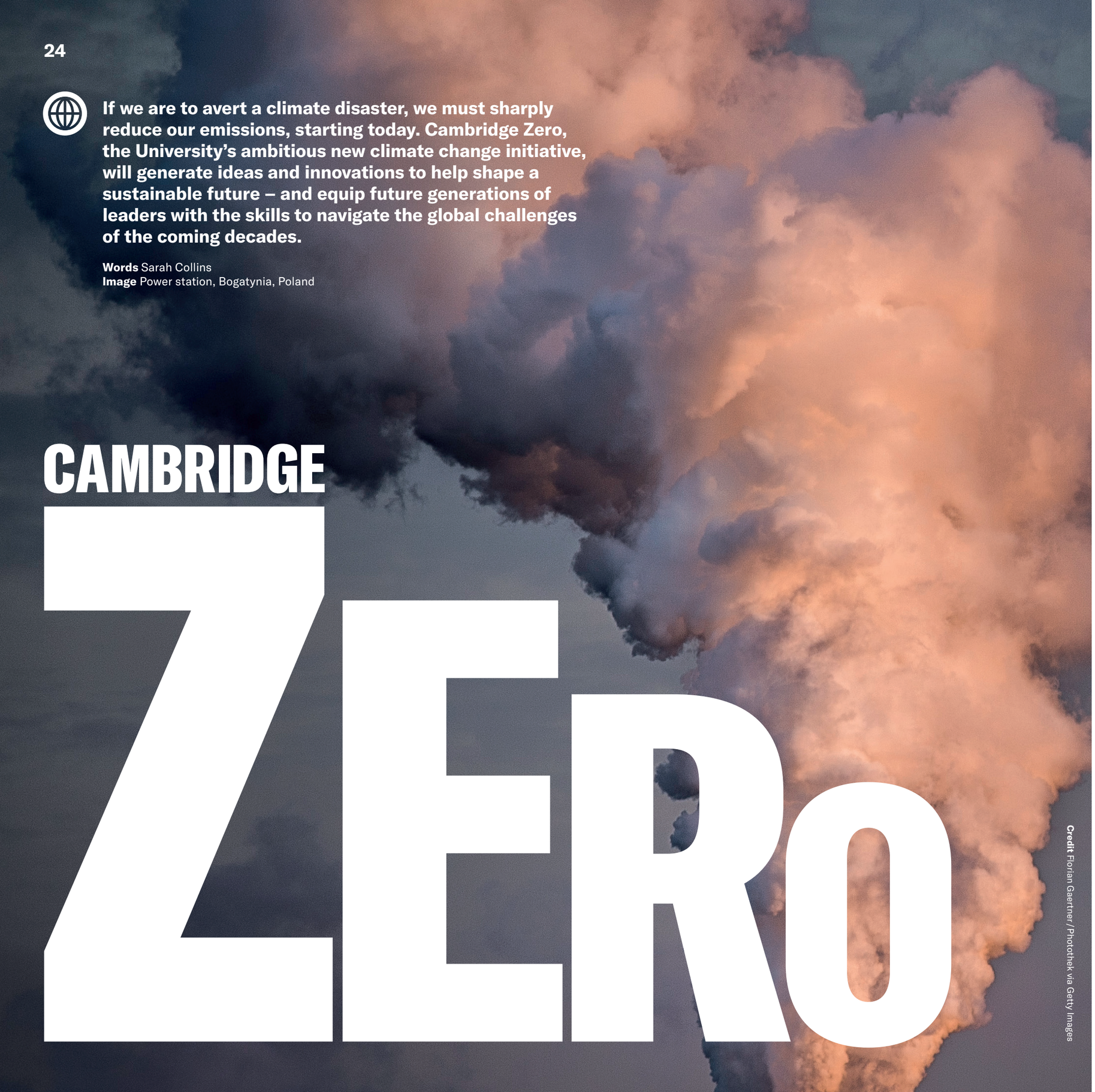
Credit John Phillips / Getty Images

Broadcaster Sir David Attenborough’s documentaries have brought the wonders of the natural world to our screens – from the splendours of terrestrial life, to the otherworldly underwater kingdoms and the frozen ends of the Earth – but they also increasingly show our planet’s fragility in the face of habitat destruction and climate change. He is an alumnus of Clare College and has given his name to the campus of the Cambridge Conservation Initiative – the largest cluster of biodiversity conservation organisations on the planet.

If we are to avert a climate disaster, we must sharply reduce our emissions, starting today. Cambridge Zero, the University's ambitious new climate change initiative, will generate ideas and innovations to help shape a sustainable future – and equip future generations of leaders with the skills to navigate the global challenges of the coming decades.

Words Sarah Collins
Image Power station, Bogatynia, Poland

CAMBRIDGE ZERO



Credit Florian Gaertner / Photothek via Getty Images

Cambridge is the brand-new holder of a dubious record. On 25 July 2019, the temperature at the University's Botanic Garden hit a new all-time record high for the UK: 38.7°C.

Few expect this record to hold for long. As temperatures rise globally, extreme weather events – floods, storms, droughts and heatwaves – are becoming the new normal. The Intergovernmental Panel on Climate Change (IPCC) has clearly articulated that, if this continues, we risk venturing into a world of climate-driven food shortages, water stress, refugees, species loss and catastrophic shocks such as the collapse of the vast polar ice sheets.

Scientists have been warning for decades that man-made climate change is happening. But with a few exceptions, we have done little about it. In the past 18 months, however, there has been a noticeable shift.

"The basic science hasn't changed: what is starting to change is public opinion," says Dr Emily Shuckburgh, one of the UK's leading climate scientists. "As the impacts of climate change are starting to be felt around the world, it's finally cutting through that we need to do something and we need to do it now. If we are to avert a climate disaster, we must sharply reduce our emissions, starting today."

Shuckburgh recently joined the University from the British Antarctic Survey to lead an ambitious new programme: Cambridge Zero. →

The programme will harness the full breadth of the University's research capabilities across the sciences, engineering, humanities and social sciences to respond to climate change and support the transition to a resilient, sustainable future.

Cambridge Zero is not just about developing greener fuels, technologies and materials. It's about addressing every aspect of a zero carbon future: the impact it will have on our lives, our work, our society and our economy, and ensuring decisions are based on the best available knowledge.

By developing a bold programme of education, research, demonstration projects and knowledge exchange focused on supporting a zero carbon world, the initiative's ambition is to generate and disseminate the ideas and innovations that will shape our future – and to equip a future generation of leaders with the skills to navigate the global challenges of the coming decades.

Its launch comes a few months after the UK became the first major world economy to legislate for net zero emissions. Eliminating greenhouse gas emissions by 2050 will mean a fundamental change over the coming decades in all aspects of our economy, including how we generate energy, and how we build decarbonisation into policy and investment.

Clean energy "The challenge is how to develop the technologies for the energy transition at the scale, and on the timescales, that we need," says Professor Sir Richard Friend, Director of Energy Transitions@Cambridge, which brings together over 250 Cambridge researchers working on areas such as bioenergy, batteries, photovoltaics, carbon capture, propulsion and power (see p. 40), and cities and transport.

Friend is one of the UK's leaders in the development of next-generation solar cells and super-efficient LEDs, and has founded several spin-out companies based on his research. Since the 1980s, his group at the Cavendish Laboratory has been developing materials for low-cost solar cells that could surpass silicon's efficiency in converting sunlight into energy.

Through initiatives such as the Henry Royce Institute, the UK's national institute for materials science research and innovation, Cambridge researchers are also developing next-generation materials for energy storage and use.

"Cambridge is already one of the UK's leading universities in battery science and a major contributor to the Faraday Institution's battery programme for electric vehicles," says Professor Manish Chhowalla, the Cambridge Royce Champion. "The Royce facilities help us supplement the chemistry and physics research we're already doing with engineering approaches that will help bring our research to market faster."

Friend adds that working in collaboration with industry is the only way to enable the energy transition. Although Cambridge has the research and knowledge base to identify new solutions, it does not have the capabilities to produce those solutions on an industrial scale: "It's important to understand what industry actually wants, rather than what we presume it wants."

Climate change policy Even if a scientist or engineer develops a new technology that solves a problem associated with the energy transition, how do policy changes make the most of innovation?

This question lies at the heart of the work of Laura Diaz Anadon, Professor of Climate Change Policy in Cambridge's Centre for Environment, Energy and Natural Resource Governance, and a lead author on the IPCC's sixth Assessment Report.

"When I first moved into policy and economics work after my PhD in chemical engineering, I was focused on solutions as if they were things that people could and would start using tomorrow. I realised quickly that I wasn't thinking about cost-effectiveness and the role of policy, regulation, business models, political support and their impacts. That was really eye-opening for me," says Diaz Anadon.

"Climate change policy is particularly challenging as it cuts across so many sectors and demands engagement with many different stakeholders," says Dr David Reiner, from the Energy Policy Research Group at Cambridge Judge Business School, and one of the co-editors of the recent book *In Search of Good Energy Policy* with Professor Michael Pollitt. "Good policy isn't just about getting the numbers right, because even the numbers are controversial," says Reiner. "Different groups have different priorities, so how do we determine which numbers to put stock in and which things are actually important?"

Shuckburgh is echoing this broad approach in Cambridge Zero. "This is a once-in-a-generation opportunity for us to make an impact, which is why it's vital we bring in multiple perspectives to ensure that we're translating scientific knowledge into innovations that are rapidly deployed in the real world – and robust, evidence-based policy that works for everyone," she says.

"It's great to see climate change finally breaking through as a priority with the public," says Pollitt. "But the challenge has always been when you start asking about specifics. Lifestyle changes are cheap, but they're intrusive. And if you aren't willing to become a vegetarian, turn the heating down or stop flying, then you're going to need serious decarbonisation policies to reach where we need to get to."

A major energy policy – such as decarbonising the electricity grid or banning petrol cars – generally requires a decade of planning, and another two decades to implement. It also requires public engagement, says Pollitt: "If the public feel they haven't been consulted on a new policy, they're less likely to support it, and they need to see that these policies have benefits that minimise the negative effects. A carbon neutral economy isn't unachievable, but there are massive challenges associated with it, and we have to face those challenges with eyes wide open."

Sustainable finance Beyond policy, the transition to a zero carbon future will also require unprecedented levels of government, private and institutional investment in green and low carbon technologies, services and infrastructure. And financial institutions themselves will need to move to a sustainable finance model, pricing environmental and social risks correctly.

These are areas that interest Dr Nina Seega at the Cambridge Institute for Sustainability Leadership, which bridges the worlds of business, policymaking and finance. "Since the attention called to the issue by the G20 Green Finance Study Group in 2016, we've seen lots of discussion about sustainable finance in the financial world but more action is needed to thread sustainable finance into the day-to-day work of financial firms.

"When we have conversations with financial firms, what we get is a conversation about the costs and risks of transition to a zero carbon future. However, it is refreshing to see the focus turning to opportunities of sustainable finance and the cost of not transitioning. Simply put, it is more expensive to do nothing."

This point is illustrated by the recent Green Finance Strategy, in which the UK government predicts that the population health impacts of not delivering on emissions reductions could be around £1.7 billion per year by 2020 and £5.3 billion per year by 2030.

"Unfortunately, there is still a persistent perception that sustainable investment means sacrificing profitability, but that's not the case," Seega says. "A 2015 review of 2,200 studies found that sustainability has at least a non-negative, and in most cases a positive, relationship to profitability. Prioritising sustainability does not mean sacrificing profitability."

Reasons to be optimistic One of the major successes of global efforts in energy and climate policy has been advances in developing low carbon solutions, which is beginning to pay off. Just since 2010, the average cost of producing electricity globally from solar PV panels has decreased by 77%, and from wind turbines by 34%, and the cost of storing energy in lithium-ion batteries has decreased by 89%, in turn making electric vehicles less expensive.

"Nobody really predicted that costs would come down so fast," says Diaz Anadon, who analysed these figures as part of INNOPATHS, a project funded by the European Union. "Governments around the world have been key drivers of these cost reductions, both through investments in R&D, and policies to incentivise their commercialisation, such as feed-in tariffs, carbon prices and other regulations."

Even so, considering the scale and urgency of the climate change problem, it's easy to become overwhelmed. But Shuckburgh is optimistic that a zero carbon world is achievable.

"Cambridge has the power to bring together industry, finance, policymakers, NGOs and other partners to jointly propose ambitious solutions. But we all need to work together to make this happen," she says.

"The human race has achieved incredible things: lifted billions of people out of poverty, cured diseases, travelled to the moon. The biggest challenge now is how we preserve our only home for future generations, and we need to respond to the challenge with all of our efforts. We cannot fail." ●

Fast Facts

To respond to climate change and support a resilient, sustainable future, Cambridge Zero brings together research on:

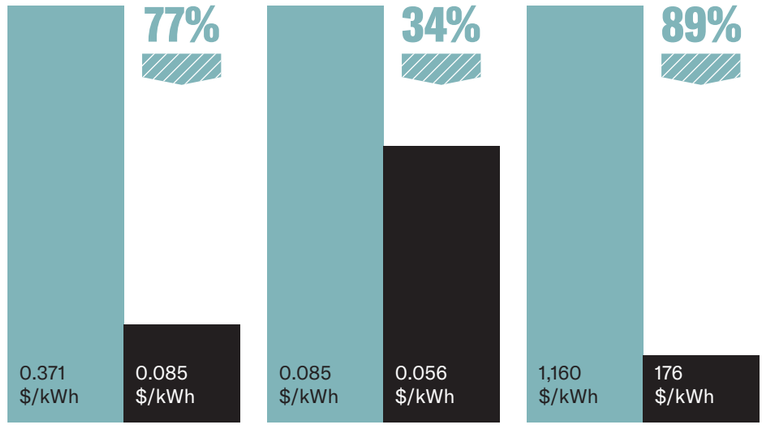
- **Zero carbon energy technologies**
- **Policies and decision-making**
- **Resources and production**
- **Resilient economic futures**
- **Transport, cities and infrastructure**
- **Carbon drawdown and climate repair**

zero.cam.ac.uk

Cutting costs

Cost reductions in common low carbon solutions between 2010 and 2018

Sources IRENA (bit.ly/2WkFueP), BNEF (bit.ly/2HgHyAs)



Snapshot
The investment researcher

Understanding what society must do to decarbonise is the most complex and important puzzle we have ever had to solve, says Dr Ellen Quigley, a researcher at Cambridge Judge Business School and the Centre for the Study of Existential Risk.

"We need electrification of our energy systems, decarbonisation of supply chains, new technologies that will help us cut emissions by at least half by 2030 – or sooner – and all of this needs a financial ecosystem that is up to the task. Plus, we are the last generation who can do something about catastrophic climate change."

Appointed earlier this year as the Advisor to the Chief Financial Officer of the University, Quigley is establishing a research programme to understand how shifting the focus of investment – at institutional, national and global levels – can achieve system-wide changes that "will help us move rapidly and justly" towards decarbonisation.

"I'm one of many who are worrying about whether the financial system is fit for purpose in an era of climate crisis. My research is looking at everything an institution like the University can do in terms of responsible investment – from encouraging financing of decarbonisation spin-outs, to adopting soil management techniques to sequester carbon, to supporting government policies like carbon pricing.

"Everything we do here in Cambridge could be a useful template for other institutions. We are picking the things that are most effective and moving as quickly as possible in this very brief period we have to make the difference we need to make."

Dr Ellen Quigley

We are laying waste to the biosphere. If we're serious about saving millions of species, then it's our own that must change how it thinks about, lives off and values the planet it inhabits.

Words Fred Lewsey
Image Deforestation in the Amazon basin, Brazil

ECOSYSTEMS OVERLOAD

Credit Joao Laet / AFP / Getty Images

Overwhelming. That's how a 15-year-old work experience student described the task facing her generation to Professor Bhaskar Vira – the task of preserving diverse life.

We bequeath our children a mass extinction unlike anything the world has seen in 60 million years. A United Nations report in 2019 claimed a staggering one million species now face annihilation. "It's easy to feel disempowered by the scale of the problem," says Vira.

He points out that relatively young people these days have experienced tangible biodiversity loss in their lifetime; butterflies they chased as a child, for instance.

If the headlines induce existential dread, then the exuberant bustle that greets visitors to the David Attenborough Building – known as 'the DAB' – offers something of a salve. Welcome to the fight back.

Named for the Cambridge alumnus whose films inspired its occupants, the building is home to the largest cluster of conservation organisations in the world. Part of the UK operations of nine charities and NGOs share the space with researchers from several University departments, all linked by the Cambridge Conservation Initiative (CCI) founded 12 years ago by Dr Mike Rands.

Vira heads up the University side of things, as Founding Director of the University's Conservation Research Institute. He's a political economist, and studies the 'ecosystem services' through which nature sustains humans.

"Conservation messaging can get stuck on cuddly animals," he says. "But biodiversity provides us with basic sustenance through fisheries or the bees that pollinate crops. It is richness of life that regenerates the soil and regulates water, not to mention the cultural and spiritual value. These losses leave the planet a far more difficult place to inhabit."

Vira works in the Himalayas to understand how its communities value ecosystem services. "We are just beginning to comprehend the fragile link between snow-capped mountains and hydroelectricity, agriculture and the lives of one billion people nearby. It's a simple question: where does your water come from, and what is that worth to you?"

Natural capital Earlier this year, DAB resident Dr Chris Sandbrook published data from the largest survey of conservationists yet undertaken. →

Ascribing monetary value to nature emerged as one of the field's most contentious issues, with some 61% believing economic arguments are risky.

However, many see it as a necessary tactic for persuading humanity to overhaul the systems driving destruction, and 'natural capital' is starting to permeate policy lingo. The UK government now believes the country's pollinators are worth £680 million per year in improved crop productivity.

The Treasury has commissioned the eminent Cambridge economist Professor Sir Partha Dasgupta to lead a major review of the link between biodiversity and economic growth, which is due to be released in autumn 2020.

"My overarching aim is the reconstruction of economics to include nature as an ingredient," says Dasgupta. "Vast intellectual energy is given to estimating Gross Domestic Product (GDP), but there is little quantitative data on human demand for natural goods and services – and the biosphere's capacity to sustainably meet it."

A basic example of the gaping hole in our accounting might see woodland destroyed to build a shopping centre. GDP records an increase in produced capital but not a depreciation of natural capital. National economies are judged to be thriving as their finite biological assets fall off a cliff.

Dasgupta takes his cue from Charles Dickens when he argues that we live in the best and worst of times. Since 1950, life expectancy for the average person on Earth has increased by 25 years, and the average per capita wage has more than quadrupled.

"If God gave me the option of being dropped into any point in history, I would still choose a time in the last 70 years," says Dasgupta, who advised Pope Francis ahead of the Pope's Encyclical on the Environment. "We have done so well in so many ways, but it has been at the expense of the future."

He points out that if you take GDP to be a rough indicator of the extraction and pollution that accompanies production and consumption, there has been a more than 12-fold increase in our impact on the biosphere since 1950 – a year often designated as the start of the Anthropocene.

During this time, the planet's population has leapt from 2.5 billion to 7.7 billion. In 2017, Dasgupta published a paper with demographer Dr Aisha Dasgupta (his daughter) in which they attempted to calculate the number of people the biosphere can sustainably support with a degree of comfort. The conclusion was 3.5 billion, the population size of the late 1960s.

"This is far from a definitive answer, and more a way to concentrate attention on the question," says Dasgupta. "The numbers we used are crude, but there's so little available. Ecosystem services are simply absent from most national statistics."

Yields and meals that spare Ballooning populations bring ever-greater demand for food. Expanding the footprint of farming – which already covers half of all agriculturally useable land on the planet – is now the most significant threat to endangered species, as ancient wilderness is converted to monoculture crops and cattle feedlots.

The question of how to feed the world without costing the Earth goes to the heart of conservation. Many say farmers must share their fields with wildlife – reinstating hedgerows and ponds, reducing chemicals – even if output is curbed. The biologist Professor Andrew Balmford argues differently.

"Measures that lower farm yields mean ever more land has to be farmed to meet food demands," he says. "Our evidence shows the least bad approach for biodiversity is to wring as much food as sustainably possible from the land we already farm, and in doing so spare more habitats from the cow and plough."

One study he led suggests that if land spared in the UK through intensive farming was used for woods and wetland, the resulting sequestration of carbon could potentially offset almost all national emissions from farming by 2050 – and massively boost biodiversity.

Another study looked at agricultural sectors across four continents – from Asian rice to Latin American beef – and concluded that, per portion of food, high-yielding production was often better than alternatives (including organic farming) for environmental outcomes such as soil retention.

Fast Facts

Cambridge's interdisciplinary Conservation Research Institute works alongside the largest cluster of conservation organisations worldwide

UK Treasury commissions Cambridge economist to lead a major review of the link between biodiversity and economic growth

Researchers work on how to grow food and change diets to best preserve the biosphere

Celebrated MPhil programme is about to mark 10 years of training the future leaders of conservation

"As conservationists, we can't afford to be overly ideological," says Balmford. "We have to be agnostic and compare options based on what counts." More recently he has been researching the European problem: a continent with such deep agricultural history that some species now rely on low-yield farmland.

"Some areas require a three-compartment approach, where concentrated farming buys space for both natural habitats and some very low-yielding farmland. But humanity cannot afford the space that nature needs unless conservation is allied to high-yield production."

His group is building profiles of policies that can tie increased yields to habitat protection – mechanisms such as land-use zoning, reformed farm subsidies and access to credit made conditional on environmental stewardship.

The central dilemma of food security stretches beyond number of mouths. What each of us chooses to eat is part of the drumbeat that dictates natural devastation rates, and vast tracts of wilderness are lost to meat-heavy diets.

PhD researcher Emma Garnett would "love to be in the jungle counting butterflies. But I think we need to be studying people instead to protect nature. We're causing the problems."

> **"These losses leave the planet a far more difficult place to inhabit."**
>
> **Professor Bhaskar Vira**
> Founding Director, University of Cambridge Conservation Research Institute

Instead, she experiments on students. Working with several Cambridge Colleges, she gathered data and tested dining hall arrangements to see if she could 'nudge' undergraduates away from meat towards vegetarian. "We've got to make the right choice easy."

She found that upping vegetarian options cut meat consumption without denting sales – particularly among the most carnivorous – and identified the optimal positioning of dishes to bolster plant-based eating.

Future leaders Inspiring the next generation of conservationists is one of the most important things Cambridge can do, according to Vice-Chancellor Professor Stephen Toope. Perhaps the essence of this future-building philosophy is the flagship Masters in Conservation Leadership. This one-year course is open to those with at least three years' experience in the field.

"Conservation has long been run mostly by biologists who find themselves in leadership roles, taking decisions on things like strategy, communication and lobbying without effective training in such areas," says course leader Sandbrook. "The Masters was created to fill that gap."

Every partner organisation within the DAB helps to teach and train each cohort of carefully selected students. Since starting in 2010, the course has 144 alumni from over 70 nations. Most hail from the Global South, returning home to promote conservation after their year-long dip in the DAB.

Alumni include Odacy Davis, who became Deputy Commissioner for Guyana's protected areas after leaving Cambridge in 2016. Two-thirds of current Masters students receive full or significant partial scholarships, and applicants from countries rich in biodiversity but poor financially are given priority.

For Sandbrook, this diverse group often feels like the soul of the DAB, "lifting up the rest of us", and the course's strength lies in lessons learnt not only from conservation heavyweights, but also from each other. "The first thing we do with a new cohort is take them to the Norfolk Broads for three days," he says. "We introduce them to a UK protected area, but also start a bonding process that lasts long after they leave us. We are creating a global community of conservation leaders who support each other, sharing stories of failure and success."

A focus on carbon emissions as the principal ecological emergency has encouraged thinking around technological fixes. But, while technology may help us find smarter ways to live, the species extinction crisis will not bow to a *Deus ex machina*.

To preserve the diversity of species we need to change the way our own thinks. It means recognising models for coexistence, not exploitation. It means rethinking how we value nature. And it means championing the future protectors of the planet. ●

Snapshot
The human geographer

Dr Rachel Carmenta's research takes her to an Amazonian 'RESEX' area, where people who have been there for generations are allowed to farm. "They have smallholdings to grow bitter manioc, they hunt and fish, and every interaction revolves around the landscape."

Carmenta's research project analyses the forest cover associated with different conservation and development interventions in the Amazon. Her focus is expanding performance measurements to capture the wellbeing of those living on the land.

"Identities, attachments and relational values are derived from interactions with place," says Carmenta, from the UCCRI/Geography Department. "If you fish every day with cousins, and teach your children, it's not just food but your social fabric."

A RESEX is 'zoned' land where small-scale traditional agriculture is permitted. The team is also working with people in buffers of "fortress-style" protected areas, as well as those who find themselves "surrounded by a sea of soy" when big agribusiness encroaches.

"We want to understand the impact of strict protection, intensive farming and integrated approaches on deforestation – but also how these interventions impact people's relationship with the land."

Carmenta also studies the social impacts of uncontrolled tropical wildfires. "The fires are a burden to people and nature, incurring lost crops, devastated landscapes, and impaired livelihoods and wellbeing. Recognising this humanitarian dimension is not only an ethical imperative, but could be part of a more emotive and powerful language for change towards fire-free futures."

Dr Rachel Carmenta

Plastic has become a malevolent symbol of our wasteful society. It's also fundamental to almost every aspect of our lives. How do we shift our 'take, make, throw-away' plastic world towards 'recycle, recover, re-use'?

Words Louise Walsh

THE 'P' WORD

IN Tokyo, a householder consults her 60-page 'Garbage Separation and Disposal' system to check whether it's a recycle day for plastic bottles or for all other plastic packaging. In a coastal village in Kenya, an order has been received for 2,000 bricks made from waste plastic and earth. On a chemistry bench in Cambridge, bubbles of hydrogen form and rise around a thumbnail-sized square of plastic cut from a water bottle.

All around the world there are instances where we are getting things right with plastic – recycling, recovering, re-using – and instances where we are getting things very wrong.

Our awareness of just how wrong is riding the crest of a plastic-polluted wave: every year, more than 8 million tonnes of plastic waste ends up in the world's oceans. Environmental agencies have predicted that if these trends continue, our oceans will contain more plastic than fish by 2050.

But plastic is also one of the most successful materials ever invented: it's cheap, durable, flexible, waterproof, versatile and lightweight. It's also a resource that we are wasting, says Professor Erwin Reisner.

"As a chemist I look at plastic and I see an extremely useful material that is rich in chemicals and energy – a material that shouldn't end up in landfills and pollute the environment. Plastic is an example of how we must find ways to use resources without irreversibly changing the planet for future generations."

Reisner leads the new Cambridge Creative Circular Plastics Centre (CirPlas). Funded by UK Research and Innovation, it aims to eliminate plastic waste by combining blue-sky thinking with practical measures, connecting expertise across the disciplines, and collaborating with industry and local government.

In doing so, their research reaches from the Tokyo householder to the Kenyan brickmaker to the Cambridge chemist, and further, to help shift the balance from drastic plastic to fantastic plastic.

Words to live by "There's a word in Japanese that conveys a feeling of regret when something useful is wasted. It's *mottainai*," says anthropologist Dr Brigitte Steger, from the Faculty of Asian and Middle Eastern Studies. →

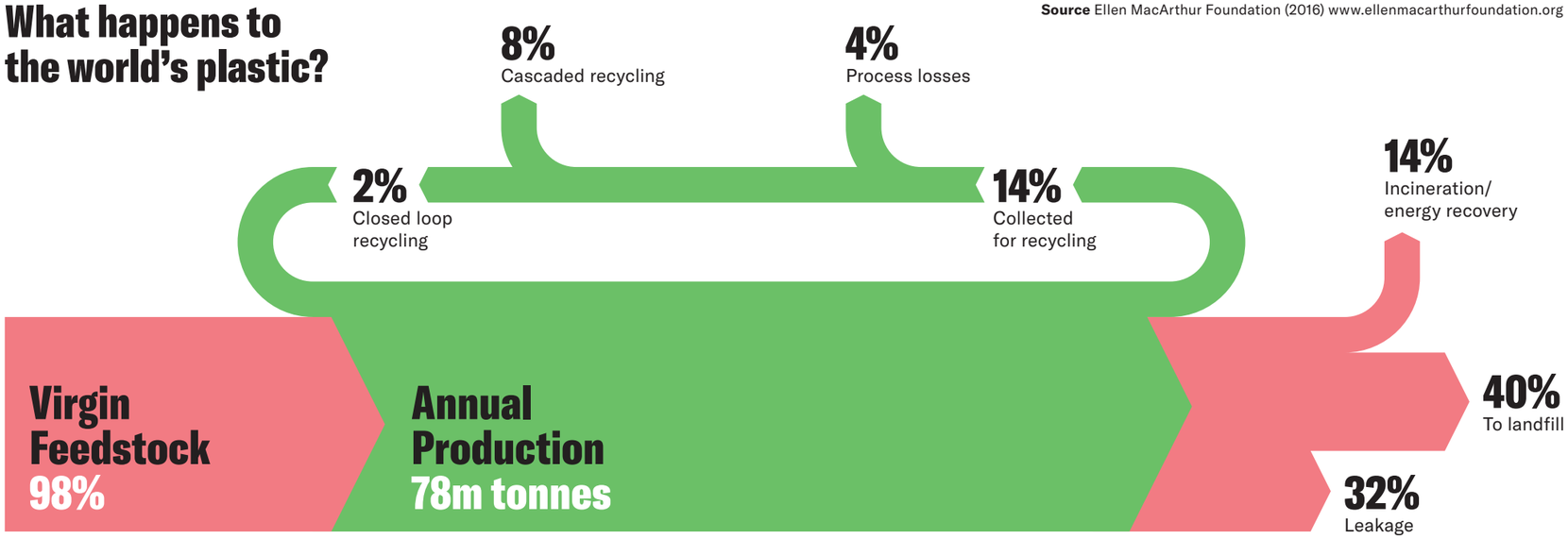
Fast Facts

New Cambridge Creative Circular Plastics Centre focuses on innovations in plastic use, re-use and avoiding use

Roadmap sets out how to achieve zero plastic packaging waste by 2030

Researchers examine business case for packaging manufacturers adopting a localised circular economy

What happens to the world's plastic?



Source Ellen MacArthur Foundation (2016) www.ellenmacarthurfoundation.org

"One woman being rehoused after the Fukushima Daiichi nuclear disaster told me she would only move to an area where she was familiar with the complexities of the recycling system. The Japanese are very good citizens in terms of sorting and recycling but they also use a huge amount of plastic – and don't regard single-use plastic with *mottainai*."

Steger and her team look at cultural attitudes to plastic and waste globally: "We need to understand what practical and moral needs plastic fulfils to know what can be done to shift behaviour towards living more sustainably. Moreover, policymakers define solutions in response to how problems are defined. We need to clarify these."

"It is argued by some that we are using resources 50% faster than can be replenished," says economist Dr Khaled Soufani, who leads the Circular Economy Centre in Cambridge Judge Business School. "It has also been said that by 2030 we will require the natural resources of two Earths, and by 2050, three."

He and Steger are contributing to CirPlas by asking how individuals, communities, companies and public bodies approach their use and recycling of plastic. He adds: "Today's cradle-to-grave economy sees around 80% of plastic landfilled, incinerated or lost into the natural environment. What we need is a circular economy with re-use of products and recycling of embedded materials into new products for as long as possible."

Keeping track of plastic Ask anyone what they know about plastic and they might tell you about the need to ban single-use materials, or that it's essential for healthcare, or that it's lighter and more fuel efficient than packaging alternatives.

"What no-one will tell you is how any of this relates to how much and what type of plastic we use, how long those products are in service, and what happens to them afterwards. The fact is – no-one knows," says Dr André Serrenho.

It seems a simple enough set of questions but the data is complex and held by many different bodies. And so, as part of CirPlas, he and Dr Jonathan Cullen in the Faculty of Engineering are creating a map of the flow of plastic in the UK economy by amassing all of this data in one place.

Meanwhile, engineer Dr Ronan Daly is exploring digitally enabled solutions to label and track plastic, and zoologist Dr David Aldridge is using sensing technologies to measure how much microplastic is entering the food chain.

"All of these studies will take us closer to answering something we've never been able to answer before," adds Serrenho. "Plastic helps us live safer, more convenient lives but how much is enough plastic and how much is too much?"

Plastic rematerialised Our need for plastic is here to stay, and so Cambridge researchers are exploring how we re-use it – as well as developing alternatives to take its place.

For instance, Taylor Uekert, working with Reisner in the Department of Chemistry, has developed a technology called photoreforming that turns plastic waste into hydrogen fuel, using only water, a photocatalyst and sunlight. The technology is still very new but already they've produced enough hydrogen from polyester fibres to power a phone for 40 seconds.

Dr Aazara Oumayyah Pankan is also exploring electricity generation from waste plastic – this time using biology. She's testing microorganisms from environments like toxic waste dumps for their ability to decompose plastic. Working with Dr Adrian Fisher in the Department of Chemical Engineering and Biotechnology, her aim is for these 'plastic composters' to provide off-grid power for rural communities.

In Kenya, a coastal community has started converting waste plastic into bricks, using a method developed by a student-led team from Cambridge's Department of Engineering and prototyped by the Kenyan community. They have just received an order for 2,000 bricks for a local school.

Physicist Professor Jeremy Baumberg is using plastic waste as the raw materials for low-cost 3D printers. His team's approach is to design printable scientific instruments like microscopes for resource-poor countries to turn low-value waste into high-value locally manufactured components.

Meanwhile, biochemist Professor Paul Dupree and materials scientist Professor James Elliott have set out to design a completely new class of materials based on modified plant fibres that have some of the good properties of plastic and yet are easy to recycle or decompose naturally.

Zero waste from industry One area where plastic has transformed modern-day living is in food safety. Of the 5 million tonnes of plastic used each year by the UK, 37% is used for packaging, of which almost three-quarters is for soft drinks. The challenges presented by waste from this packaging cannot be ignored, least of all by the industries that depend on it.

"What's needed now is collective and informed action from individuals, government and business to shift us back in the right direction," says Beverley Cornaby.

Last year, she and colleagues at the Cambridge Institute for Sustainability Leadership worked with 10 of the UK's largest bottled drinks companies to understand what this collective action might look like. The result was an ambitious roadmap for zero plastic packaging waste from the industry being sent to landfill or escaping into the natural landscape by 2030.

"One of the areas we identified was around design. Businesses can sometimes move faster than government policy and so making changes to their own products can provide quicker fixes. We've worked with companies to understand how to reconsider their approach to using plastic packaging. We're now looking at alternative packaging choices and what the relative impact might be on carbon emissions, and water and land use."

Circularity by design Cambridgeshire-based packaging company, Charpak, is, they believe, the first in the UK to adopt a 'localised circular economy' in which local plastic waste is collected, re-processed and re-manufactured into new packaging. The company has been chosen by Soufani's team as a case study to look at the viability of a circular business model.

"Before any company will look at embedding circularity, they are going to ask a very simple question: how will it impact on me financially? Communities, companies and governing bodies need to see practical business cases and models in action," adds Soufani.

"Minimising plastic leaking into our environment is a responsibility we take very seriously, so we must ensure plastic becomes a resource and not waste," says Charpak Managing Director Paul Smith. "Why transport essential plastics resources nationwide, or overseas, and risk ocean plastics when the plastic resource is required for manufacture and re-manufacture within the UK? We want to be part of the solution."

Soufani agrees, adding: "We need to shift from a culture of mass consumption and waste towards renewability, dematerialisation and reduced resource loss. Our need to reduce, remake and recycle is a continuous journey towards circularity that will define our relationship with the planet forever." ●

Snapshot
The solution catalyser

Bringing the right people together to solve a major global environmental problem like waste is essential. With this in mind, Dr Curie Park from the Institute for Manufacturing took her emergent circular economy process for creating the right mix of people to Thailand.

"Thailand uses a staggering amount of single-use plastics every day, but its waste management system lags far behind its economic advances. We saw first-hand the marine waste at a coastal village, where plastic debris floats from the rivers and is washed up as current changes seasonally.

Everyone recognised the problem, which seemed too big for any one individual to tackle. But there had been regular beach cleaning activities and some of this collected plastic could be turned into viable products locally.

We brought together a construction company, an environmental NGO, university students, a local windsurfing world champion turned beach cleaning heroine, municipal officers, local primary schools and start-ups, and applied our innovation process.

Giving everyone a chance to share their views, providing stimuli and sharing what's happening in other communities ignited a creative momentum to come up with novel solutions. We ended up with 56 ideas for using the waste as a raw material – paddleboards, compost bins, roof tiles – seven of which are in the commercialisation pipeline by the construction company and the local start-ups."

Funded by a Global Challenges Research Fund Impact Acceleration Award

Dr Curie Park

From removing ruminant meat from its menus to building ‘green’ buildings, the University is weaving sustainability into its very fabric. Only bold steps will help it achieve an ambitious Science Based Target of becoming zero carbon by 2048 – or earlier.

Words Craig Brierley
Photography Nathan Chandler / Nick Saffell

FOLLOW THE LEADERS ↴

↑ **Nick White, University Catering Service**
“It’s become clear over the past few years that sustainable catering is important to our students.”

↑ **Joanna Chamberlain, Environment and Energy team**
“I’ve had other universities who I consider leaders in this field saying: ‘Can I find out more?’”

↑ **Verner Viisainen, PhD student**
“We can all be instigators of change, just by having conversations with the people around us.”

IT’S Wednesday lunchtime at the University Centre main dining hall. On the menu today are aubergine rogan josh, butternut squash lasagne, roast chicken and breaded pork escalope.

Notably absent are beef and lamb: it is no longer possible to buy these ruminant meats at any outlet managed by the University Catering Service (UCS). The reason is simple: the substantial carbon footprint of these livestock.

“It’s become clear over the past few years that sustainable catering is important to our students,” says Nick White, Head of UCS, which is responsible for 14 outlets across the University and over 1,500 hospitality events each year.

UCS had already introduced various sustainability measures, including a KeepCup scheme, compostable ‘vegware’ crockery and cutlery, and fairly traded coffee and tea. But White felt that this was not enough. He sought advice from one of Cambridge’s leading conservationists, Professor Andrew Balmford from the Zoology Department, on what they could do to have the biggest impact while remaining financially viable.

“‘That’s really simple,’ he told me. ‘You have to stop selling ruminant meat and promote plant-based foods. You need to not sell any unsustainable fish. And you need to reduce food waste.’” These four actions formed the basis of a new Sustainable Food Policy, implemented by the University in 2016. →

Fast Facts

The University's Sustainable Food Policy has reduced carbon emissions from its catering service by 33%

Cambridge is the first university in the world to announce an independent Science Based Target for carbon reduction

All new capital building projects must consider full carbon and financial lifecycle costs

"Science Based Targets are set externally, independently, and are based on what the science says you need to do. They are not arbitrary."

Professor Ian Leslie Special Advisor to the Vice-Chancellor on Environmental Sustainability

Bringing the customers along turned out to be surprisingly easy, possibly because they didn't announce what they were doing: they just removed ruminant meat and increased the number of vegetarian and vegan options. They also used subtle 'nudge' techniques, including placing vegetarian options before meat options and being canny with labelling, removing 'vegetarian' or 'vegan' labels in favour of just listing the ingredients.

To minimise the amount of food waste, the team is now using improved forecasting to predict how much food they will require and more accurate portion control. Where possible, surplus ingredients are used the following day in salads and composite dishes.

UCS has also removed single-use plastic from their facilities in favour of compostables. Everything from the serving platters used at hospitality events to cups and even crisp packaging can be taken along with food waste to a local energy plant for anaerobic digestion.

The result has been a dramatic reduction in UCS's carbon footprint and landfill waste – and it has also been a financial success. "Our sales and our gross profits improved. That's an important message to take to the commercial sector – you can do this profitably."

Science Based Targets The Sustainable Food Policy is one of several initiatives of which Joanna Chamberlain, Head of Environment and Energy, is particularly proud. "I've had other universities who I consider leaders in this field saying 'What you're doing on sustainable food is great. Can I find out more?'"

Chamberlain's team is responsible for implementing the University's Environmental Sustainability Vision, Policy and Strategy, which sets ambitious targets in areas such as energy and carbon management, water and waste management, biodiversity, and sustainable travel.

The University is moving in the right direction in terms of resources and efforts, but she says it faces a challenge in terms of reducing carbon emissions because its estate has grown significantly and it carries out energy-intensive research.

Cambridge is the first university in the world to adopt a 1.5°C Science Based Target for carbon reduction, committing itself to reducing its energy-related carbon emissions to absolute zero by 2048, but aspiring to reach this target 10 years ahead, by 2038.

As Professor Ian Leslie, Special Advisor to the Vice-Chancellor on Environmental Sustainability, explains, "Science Based Targets are set externally, independently, and are based on what the science says you need to do. They are not arbitrary."

By committing to achieving this target a decade early, he says, we aim to provide opportunities for others to learn from our approach – including where we are successful and where we struggle.

Achieving this target will involve putting in place measures such as increasing the University's capacity to generate its own electricity, for example by building its own solar farm; entering into agreements with suppliers to provide certified green energy; moving to electric vehicles for its fleet and bus service; and weaving sustainability into its fabric, such as in the design of the new Civil Engineering building.

One of the major challenges will be removing gas for central heating and cooking from its estate. The University has just launched a feasibility study looking at whether and how it might do so. "The elimination of gas could be a huge thing if we achieve it," says Leslie.

Cambridge's target focuses on direct emissions from its own sources and indirect emissions from the generation of the energy it purchases. But the big elephant in the room is air travel. Research is about fieldwork, collaborations, sharing findings at conferences – all often necessitating long-haul air travel.

"We need to think about why we all travel to conferences, whether we can do it less frequently and if it can be replaced by more online interaction," says Leslie.

It's not easy being green Making systematic changes at the University is not straightforward, says Chamberlain – in part because of Cambridge's devolved governance structure.

"We know that the carbon footprint from what we buy is huge, for example, but it's difficult for the University to influence that when procurement decisions are very much devolved."

When it comes to energy usage, the University pays for utility bills centrally, meaning that when a department constructs a new building or buys new kit it only needs to consider the upfront cost, rather than energy efficiency.

"Project managers get frowned upon if they spend too much money," says Leslie. "No-one gets punished for having a high electricity bill."

Things could be about to change. Chamberlain's team is looking at financial incentives for purchasing energy-efficient machines and charging departments for their energy usage. The Council, the University's governing body, has said no new building will be given the green light unless its full lifecycle carbon footprint is taken into consideration.

Green people Arguably the University's greatest assets are its people, and students in particular often actively push for change across every facet of the University.

The University provides opportunities through its 'Living Lab' scheme for students to improve environmental sustainability on its estate through projects, internships and research, some voluntary, others contributing to their undergraduate or graduate studies.

In numbers...

Impact of the Sustainable Food Policy

33% ↓

reduction in carbon footprint of food

142 ↪

tonnes of waste redirected away from landfill to anaerobic digestion since August 2017

500 ↻

tonnes of CO_2 saved since adoption of policy (equivalent of driving 1.2 million miles in average car)

Sometimes these projects can have significant impacts. In one of the scheme's earlier projects, for example, Si Min Lee, a Masters student in Engineering, analysed the performance gap in electricity and gas consumption at the Sainsbury Laboratory between the as-designed and the as-built laboratory. Her recommendations led to changes in the Building Energy Management System that reduced the amount of energy used by 30%, equivalent to £6,000 savings annually.

"It's wonderful when you get students in a room, and they're talking to people who work on the operational side about their work, bouncing ideas around – *We found this. We think this might be why. Have you thought about doing this?*" says Amy Munro-Faure, who manages the Living Lab scheme.

Peter Lumb, who manages the Green Impact Awards at Cambridge, says there is no shortage of enthusiasm and willingness among staff and students to get involved.

Cambridge has been taking part in the Awards since 2012. To receive an award, a department, College or team has to complete a set number of actions from a checklist. This year, the University gave out 50 awards, covering 2,245 actions completed by 39 teams, among them Corpus Christi College.

Jenny Reavell, who sits on Corpus's Green Committee, is very modest about their achievements, yet as she begins to list off some of their initiatives, it becomes clear they are extensive.

"We've got PV [solar] panels on some of our refurbished buildings. We've changed the way that we get the supplies from our laundry companies so that things don't come wrapped in so much plastic. We've got some amazing biodiversity schemes out at our postgraduate accommodation. We've just done a major refurbishment of our kitchens, where we've moved to induction from gas..."

Even if the Green Impact Awards didn't exist, she says the College would still be doing all of this work because it is the right thing to do. "We still want the College and the University to be here in another 500 years' time. It's part of our ongoing commitment to future generations."

This perhaps goes to the heart of why sustainability measures are so vital, not only for the operation of the University and its Colleges, but also for society as a whole, as Leslie explains: "We no longer have a choice. We have a moral obligation to future generations to make the changes now that will help to preserve their future." ●

Snapshot
The changemaker

By day, Verner Viisainen is a PhD student in the Department of Engineering. But when he steps away from his test rigs and software, he's a 'changemaker' intent on contributing to a more sustainable planet.

In 2018, he was in the first cohort of Engage for Change – a student-led scheme supported by the University's Environment and Energy team to help people create a lasting impact around an environment sustainability issue. A year later, he was commended for his environmental work by Cambridge's Vice-Chancellor at the inaugural Social Impact awards.

"For me, Engage for Change was the start of a journey," he says. "It laid the groundwork and gave me the necessary tools, inspiration and confidence to go out there and instigate an environmental project.

I'd noticed old equipment lying around in labs that could be valuable to other researchers if only they knew these were available. After discussions with technicians, academics and staff, I started a system for the re-use and sharing of kit.

I wanted to do more when the programme finished. I co-started Cambridge2Environment to spread awareness of environmental volunteering initiatives within Cambridge City for anything from community gardens to FoodCycle.

Part of the beauty of Engage for Change is it's not really about what you have achieved in empirical terms that matters but rather about being part of a group who feel passionate about sustainability, about making a difference. We can all be instigators of change, just by having conversations with the people around us."

Verner Viisainen

GREEN SKY THINKING

A super-fast way to turn ideas into new technologies in the aviation and power industries has been developed at Cambridge's Whittle Laboratory. We hear from Professor Rob Miller, Director of the Whittle, about how researchers plan to scale the process to cover around 80% of the UK's future aerodynamic technology needs.

Professor Rob Miller
Whittle Laboratory,
Department of Engineering
rjm76@cam.ac.uk

Credit Whittle Lab

We're seeing a transformational change in the propulsion and power sectors. Aviation and power generation have brought huge benefits – connecting people across the world and providing safe, reliable electricity to billions – but reducing their carbon emissions is now urgently needed.

Electrification is one way to decarbonise, certainly for small and medium-sized aircraft. In fact, more than 70 companies are planning a first flight of electric air vehicles by 2024. For large aircraft, no alternative to the jet engine currently exists, but radical new aircraft architectures, such as those developed by the Cambridge-MIT Silent Aircraft Initiative and the NASA N+3 project, show the possibility of reducing CO_2 emissions by around 70%.

A common thread in these technologies and those needed for renewable power is their reliance on efficient, reliable turbomachinery – a technology that has been central to our work for the past 50 years. Currently we're working on applications that include the development of electric and hybrid-electric aircraft, the generation of power from the tides and low-grade heat, like solar energy, and hydrogen-based engines.

We're also working on existing technologies as a way of reducing the carbon emissions, like wind turbines, and developing the next generation of jet engines such as Rolls-Royce's UltraFan engine, which will enable CO_2 emission reductions of 25% by 2025. A great example is Dr Chez Hall's research on a potential replacement for the 737. This futuristic aircraft architecture involves an electrical propulsion system being embedded in the aircraft fuselage, allowing up to 15% reduction in fuel burn.

A key element of meeting the decarbonisation challenge is to accelerate technology development. And so, over the past five years, our primary focus has been the process itself – asking 'can we develop technology faster and cheaper?' The answer is yes – at least 10 times faster and 10 times cheaper. Our solution is to merge the digital and physical systems involved. In 2017, we undertook a pioneering trial of a new method of technology development. A team of academic researchers and industrial designers were embedded in the Whittle and given four technologies to develop.

The results were astonishing. In 2005, a similar trial took the Whittle two years. In 2017, the agile testing methods took less than a week, demonstrating a hundred times faster technology development.

We describe it as 'tightening the circle' between design, manufacture and testing. Design times for new technologies have been reduced from around a month to one or two days using augmented and machine-learning-based design systems. These make use of in-house flow simulation software that is accelerated by graphics cards developed for the computer gaming industry.

Manufacturing times for new technologies have been cut from two or three months to two or three days by directly linking the design systems to rows of in-house 3D printing and rapid machining tools, rather than relying on external suppliers. Designers can now try out new concepts in physical form very soon after an idea is conceived.

Testing times have been reduced from around two months to a few days by undertaking a 'value stream analysis' of the experimental process. Each sequential operation was analysed, enabling us to remove over 95% of the tasks, producing a much leaner process of assembly and disassembly. Test results are automatically fed back to the augmented design system, allowing it to learn from both the digital and the physical data.

There's a natural human timescale of about a week whereby if you go from idea to result then you have a virtuous circle between understanding and inspiration. We've found that when the technology development timescale approaches the human timescale – as it does in our leaner process – then innovation explodes.

The New Whittle Laboratory will house the National Centre for Propulsion and Power, due to open in 2022 with funding from the Aerospace Technology Institute. A national asset, the Centre is designed to combine a scaled-up version of the agile test capability with state-of-the-art manufacturing capability to cover around 80% of the UK's future aerodynamic technology needs.

Key to the success of the Whittle Laboratory has been its strong industrial partnerships – with Rolls-Royce, Mitsubishi Heavy Industries and Siemens for over 50 years, and with Dyson for around five years. So another component of the new development will be a 'Propulsion and Power Challenge Space'. Here, teams from across the University will co-locate with industry to develop the technologies necessary to decarbonise the propulsion and power sectors.

The length and depth of these partnerships have so many benefits. They've enabled technology strategy to be shared at the highest level, and new projects to be kicked off quickly, without the need for contract lawyers. Joint industry–academic technology transfer teams move seamlessly between industry and academia, ensuring that technologies are successfully transferred into product.

Most importantly, the partnerships provide a source of 'real' high-impact research projects. It's these long-term industrial partnerships that have made the Whittle the world's most academically successful propulsion and power research laboratory.

We are at a pivotal moment, in terms of both Cambridge's history of leading technology development in propulsion and power, and humanity's need to decarbonise these sectors. Just 50 years ago, at the opening of the original Whittle Laboratory, research and industry faced the challenge of making mass air travel a reality. Now the New Whittle Laboratory will enable us to lead the way in making it green. ●

"When the technology development timescale approaches the human timescale, of around a week, then innovation explodes."

Professor Rob Miller Director, Whittle Laboratory

Partnership AstraZeneca

Words Sarah Fell

Researchers at AstraZeneca, a global biopharmaceutical company, have been working with Cambridge University researchers for more than two decades.

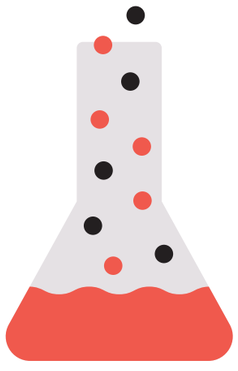
Much of the collaboration has been deliberately organic – based on mutual learning and a shared commitment to developing new treatments that will make a real difference to patients' lives. It's also based on the shared belief that this only happens by letting scientists follow their noses.

Today, the academic partnership with Cambridge is AstraZeneca's largest – resulting in 100 active research grants and 70 funded PhD students. In 2016, the company moved its global headquarters to Cambridge to build on its collaborations with the University and other local research institutions, hospitals and businesses that comprise the most successful life sciences cluster in Europe.

The partnership has evolved to be more than R&D, important though that is. It's also about a joint commitment to sustaining the ecosystem that nourishes extraordinary science and innovation. We hear from just a few of the people who are contributing to this multifaceted story...

Longer article available online
→ bit.ly/2P9JyOZ

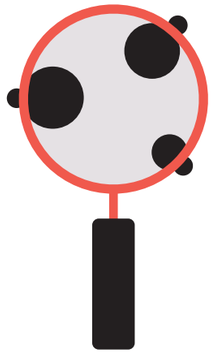
Blue skies research



"It's a totally symbiotic relationship. Cambridge has fantastic expertise, and we bring the drug-hunting, translational element. Geography is really important: when you are doing basic science you need constant interactions. Being in Cambridge gives us that."

Dr Lynne Murray (AZ), who with Dr Emma Rawlins (Gurdon Institute) and Dr Joo-Hyeon Lee (Wellcome-MRC Cambridge Stem Cell Institute), is working towards creating new lung cells that one day could treat patients with chronic lung disease.

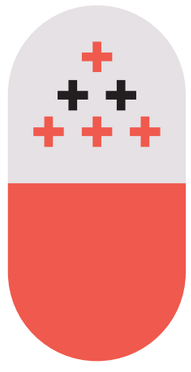
Diagnosing disease



"Cancer Research UK and AZ scientists work side by side on the same projects here – Cambridge researchers bring forward ideas for novel targets, and AZ works to deliver diagnostics and therapeutics. This outstanding collaboration really makes things happen."

Professor Richard Gilbertson, Director of CRUK Cambridge Institute, where a range of joint activities with AZ include the development of a diagnostic for children with a hard-to-treat brain cancer.

Improving drugs



"The collaboration encouraged all scientists to be much more imaginative in their approaches. Astonishing things came out of those five years' work that impacted the bioprocessing of biopharmaceuticals."

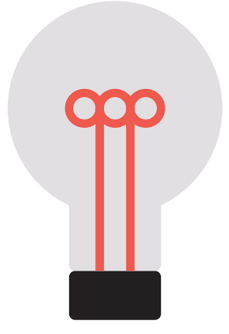
Professor Nigel Slater, Department of Chemical Engineering and Biotechnology, whose collaboration with AZ involved over 30 scientists working to make drugs more stable.

Clinical trials

"The best way to develop new drugs is by having partnerships between academics who bring expertise in whether the drug is working and industry like AZ and GSK which is expert in making molecules. That's why this training is so important – we're creating a talent pool to capitalise on translating basic science discoveries to improve outcomes for patients."

Professor Ian Wilkinson, who leads the Experimental Medicine Initiative, which is training a new generation of doctors to run clinical trials on patients at an early stage.

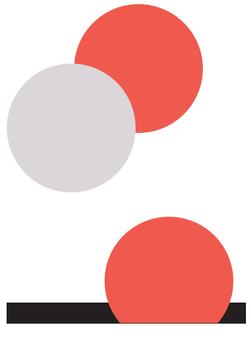
New talent



"I definitely think the impact of my PhD would have been less without AZ's input – they really pushed me both in terms of the underlying biology and in thinking about its long-term human application."

Helena Rannikmae, Department of Biochemistry and one of the cohort of joint PhD students, is finding out about the very early stages of bowel cancer.

Start-ups



"AZ helped us crystallise our thinking about how we would get our rapid DNA diagnostics to market. We secured the investment we needed and we are launching the product early next year."

Dr Ben Shaw (SwiftDx) is CEO of one of the start-up ventures that has benefited from mentoring by almost 70 AZ scientists through the Cambridge Judge Business School Accelerate programme.

Local opportunity

"We're working together on issues relating to improving transport and infrastructure, helping schools to develop skills and opportunities across the region, and working with the government to invest more in R&D. Together we want to make Cambridge a stronger place and a springboard for enriching the region, the country and, ultimately, the rest of the world."

Dr Andy Williams, AZ's Vice President Cambridge Strategy, has been working with the University to foster a strong regional research environment.

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