

RESEARCH HORIZONS



In this issue

FOOD SECURITY

plus South Asian heart disease,
volcanic eruptions and a
Bronze Age mystery



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Issue 15

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Cover: Farmer transplanting rice; see page 6 for research aimed at re-engineering rice for higher yields. Photographer: Ariel Javellana/part of the image collection of the International Rice Research Institute (www.irri.org/).

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Food security



MARK MINISZKO

Global food security is one of the major challenges that we face in the 21st century. The task is to ensure affordable access to sufficient, safe and nutritious food for an active and healthy life for all. For Cambridge, this is both a challenge and an opportunity to focus and integrate our remarkable research expertise in the natural, clinical and social sciences coupled with the humanities to develop tractable solutions for global food security. These must be sustainable, socially equitable and ecologically successful – the so-called ‘doubly-green revolution’.

The task is made more urgent by the rapid rate of population growth and by the effects of climate change. These are leading to competing demands for energy, food and water, accentuated by demographic changes and urbanisation. Food demand is predicted to increase by 70% between now and 2050, when the global population is estimated to reach nine billion. Even now, with the world population tipping 6.9 billion, one billion people in developing countries do not have enough food to meet their basic needs. Meanwhile, the consequences of unhealthy diets beset populations in the developed world.

Some of the underpinning research on global food security is featured in this issue of *Research Horizons*, including programmes on influenza-resistant strains of poultry, ‘land-sparing’ to optimise crop yields while conserving natural biodiversity, and managing the control of plant disease. Fundamental research is under way to understand the machinery of plant development, hybrid vigour and photosynthesis, to enable plant breeders to adapt crops for higher yields under changing climatic conditions. Other research is drawing together economists and conservationists to formulate new ways to manage soil, and Cambridge engineers, geographers, biologists and mathematicians to develop tools to predict future demands for energy, land and water.

Many of the Cambridge projects are engaging directly with producers and consumers, as well as with policy makers, industry and conservationists at national and international scales. These interactions underline the convening power as well as the research and teaching capacity of the University.

The long-term goals of food security in Cambridge have recently benefited from the opening of the £82 million Sainsbury Laboratory. Earlier this year, we agreed a memorandum of understanding to promote closer interactions with the Biotechnology and Biological Sciences Research Council, the lead partner for the UK initiative in global food security. Plans now focus on drawing further on the breadth of research in Cambridge to establish linkages across the natural and clinical sciences with the social sciences and humanities in addressing global food security.

Chris Gilligan

Professor Chris Gilligan
 Head of the School of Biological Sciences

Red letter day for Darwin Correspondence Project

A £5 million funding package ensures the completion of a project mapping Charles Darwin's life and work through his correspondence.

Widely acknowledged as the greatest editorial project in the history of science, the Darwin Correspondence Project is locating, transcribing, researching and editing thousands of letters written to and from Charles Darwin. A new £5 million funding package will now ensure the completion of the award-winning edition of the *Correspondence of Charles Darwin*.

The letters were exchanged with around 2,000 correspondents and take in every stage of Darwin's life: from school and student days through the voyage of HMS *Beagle*; the publication of *On the Origin of Species* and the controversies that followed; his later publications on the implications of his theories for humans; right up to his death. They offer unparalleled, intimate insight into every aspect both of Darwin's scientific work and of his personal life, and also into the lives and work of many of his contemporaries.

"Darwin's letters are vitally important in showing how science is done, with the constant gathering of new data, and the testing and questioning of theories and ideas," said Professor Jim Secord, Director of the Project, which is jointly managed by Cambridge University Library and the American Council of Learned Societies.

The funding has been given in recognition of the potential that the completed edition of Darwin's letters will have – not only as a foundation and catalyst for further scholarship, but also for education in all aspects of evolution and its history. The lead gift to the University Library of



Letter sent to Darwin on HMS *Beagle* by his sister on 12 February 1834 (his birthday); CUL DAR 204: 102

£2.5 million from the newly established Evolution Education Trust is matched by generous grants from The Andrew W. Mellon Foundation, the Alfred P. Sloan Foundation and the Isaac Newton Trust.

"We are deeply grateful for this visionary support," added Professor Secord. "The greatest threat to long-running projects in the arts and humanities is that it's almost

impossible to secure long-term funds, and so much project time is taken up in applying for and managing short-term grants. Now we can concentrate on finishing the job."

For more information, including freely available summaries of letters, please visit the Darwin Correspondence Project website (www.darwinproject.ac.uk/).

Roadmapping a €1 billion graphene programme

Cambridge is leading the technology roadmap of a pilot project towards a €1 billion European graphene research programme.

An ambitious European initiative aims to achieve a radical shift in information and communication technology by exploiting the unique properties of graphene. Dr Andrea Ferrari at the Department of Engineering is leading the pilot technology roadmap towards the €1 billion programme.

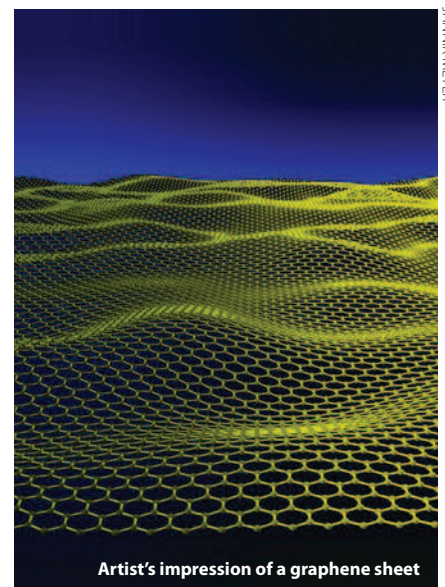
Graphene is a one-atom-thick sheet of carbons in a honeycomb lattice. Its high electrical conductivity and optical transparency mean that it is ideal for applications such as touchscreens, liquid crystal displays, organic light-emitting diodes, and for a spectrum of advanced devices based on emerging technologies, such as spintronics.

"Graphene, a truly European technology, initiated by Nobel Prize winners Geim and Novoselov in the UK, is at the crossroad

between fundamental research and applications," explained Dr Ferrari. "Exploiting the full potential of graphene will have huge impacts on society at large."

"We are thrilled that the European Commission shares our view and believes in our focused and open approach, at a time when the international community, from the United States to Korea, is moving significant resources to strengthen their know-how and facilitate the roadmap to applications."

The pilot phase, which involves nine European institutions, including four Nobel Prize winners, will pave the way for the full, 10-year, €1 billion flagship programme. The plan for this will be submitted to the European Commission in 2012, aiming for GRAPHENE to be one of the two flagship programmes launched in 2013.



Artist's impression of a graphene sheet

For more information, please visit www.graphene-flagship.eu/GF/index.php

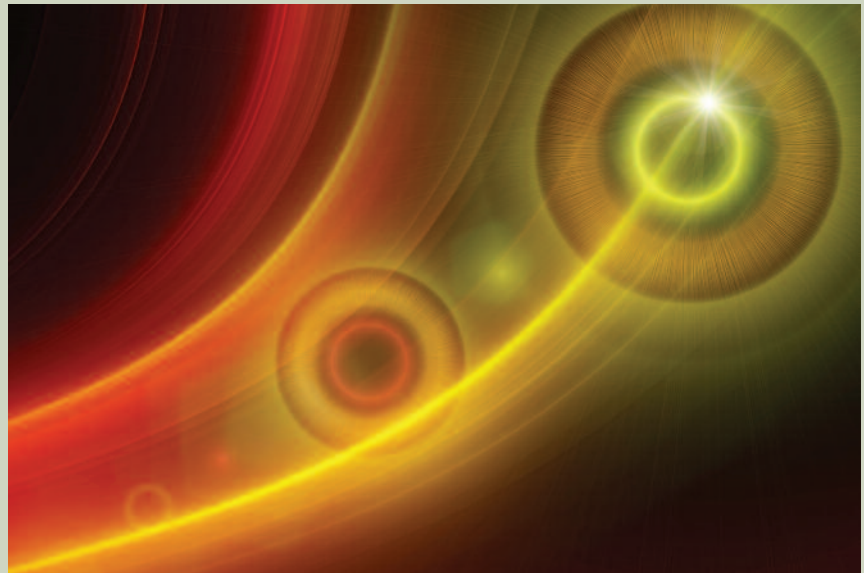
Lumora's bright future

The future looks bright for luminescence-technology-based University of Cambridge spin-out company Lumora Limited.

Lumora Limited, which was spun out from the Department of Chemical Engineering and Biotechnology in 2003, has completed a new funding round worth £1.5 million and licensed its food safety tests to a global leader in the food safety field that is commercialising the technology.

With initial funding from Cambridge Enterprise, Lumora was formed to commercialise its novel BART (Bioluminescent Assay in Real Time) system for use in the food sector. The BART system was designed to detect pathogens such as *Salmonella* cheaply and quickly in food, and is also able to detect 'food fraud', where food is labelled so as to intentionally deceive the consumer for financial gain.

Lumora's technology works by using a modified version of luciferase – the same enzyme that is responsible for bioluminescence in fireflies – to signal the presence of specific DNA sequences, which



©ISTOCKPHOTO.COM/ROMAN OKOPNY

cause the sample to glow when a test result is positive.

Now that its food safety tests are on their way to market, Lumora is expanding into the field of *in vitro* diagnostics for sexually transmitted disease and HIV testing. BART technology can be applied to clinical samples in the same way as for food testing, with simple modifications to the preparation process to handle the different types of samples. The company is currently working with PATH – a major international non-profit organisation supported by the Bill & Melinda

Gates Foundation – to develop the BART system for this purpose.

"This new funding will enable us to accelerate our entry into the *in vitro* diagnostics market, and we are delighted to have Catapult Venture Managers on board," said Dr Laurence Tisi, co-founder of Lumora. "We believe our technology could make an enormous difference to infectious disease testing in the developing world."

For more information, please visit www.lumora.co.uk/

Policy Fellowships Programme extended

The Centre for Science and Policy announces plans to scale up a unique programme that bridges policy and academia.

The Policy Fellowships Programme at the Centre for Science and Policy (CSaP) is being scaled up to 30 new Fellows for the next academic year following the success of a pilot programme which, over the past year, has brought policy professionals in government and industry face to face with researchers in science and engineering.

At the beginning of the two-year Fellowship, an intensive tailored programme of one-on-one meetings with researchers provides each Fellow with a valuable refresh in relevant policy areas.

The programme also adds value to the University by exposing researchers to decision makers in government and by providing direct pathways by which research can have an impact on the development of policy. Increasingly, Fellows will be drawn from industry as well as government, reflecting the influence of corporate agendas on research and policy making.

Professor Jon Crowcroft (see page 28) from the Computer Laboratory welcomed "the opportunity to interact directly with policy makers, and to offer them evidence of the kinds of technologies that they must factor into their decisions."

Current Fellows include Director-level officials from government departments such as the Department for Business, Innovation and Skills, Department of Energy and Climate Change, Home Office, Department for Transport, and Department for Communities and Local Government, as well as senior business people from BP, Pfizer and BAA.

Topic areas for the extended programme will continue to range widely across the disciplines in natural and social sciences and engineering: from sustainability, energy efficiency, behaviour change and biotechnology, to risk and resilience, food security and the 'innovation ecosystem'.

Dr Bob Sorrell (VP for Public Partnerships at BP, and the first industry Policy Fellow) commented: "I spent a fantastic week in Cambridge from which I took away a valuable network of contacts and a whole stream of insights. I came in with a particular expectation, but came away with something completely unexpected – the Fellowship challenged my thinking on a range of issues."

For further details, please contact policyfellows@csap.cam.ac.uk or visit www.csap.cam.ac.uk/

Royal Society Fellows

Seven Cambridge researchers have been elected Fellows of the Royal Society.

The new Fellows, who join the ranks of the UK and Commonwealth's leading scientists including early Royal Society Fellows such as Isaac Newton, Robert Boyle and Charles Darwin, are:

- Professor Andrew Balmford, Professor of Conservation Science at the Department of Zoology (see page 16).
- Professor Jeremy Baumberg, Professor of NanoPhotonics in the Department of Physics and Director of the NanoPhotonics Centre.
- Professor Béla Bollobás, Senior Research Fellow of Trinity College.
- Professor Clare Grey, Geoffrey Moorhouse Gibson Professor of Chemistry at the Department of Chemistry.
- Sir Colin Humphreys, Director of Research at the Department of Materials Science and Metallurgy.
- Professor Robert Kennicutt, Plumian Professor of Astronomy and Experimental Philosophy at the Institute of Astronomy.
- Professor Simon Tavaré from the Department of Applied Mathematics and Theoretical Physics and the Department of Oncology.

Power in the balance

A new research hub will study emerging powers and how nations evolve to become leading political forces on the world stage.

Research at the Centre for Rising Powers will touch on one of the most important questions in international relations: how do different powers rise to the top of international politics, and can we predict their impact?

Some of the Centre's research will concern the big, emerging powers of the present day – in particular the so-called BRIC nations of Brazil, Russia, India and China. Uniquely, however, it will also look at historical cases to understand more about how new powers emerge, how they can be accommodated, and the effect that this has on international stability in different cases.

Dr Amrita Narlikar, Director of the Centre, said: "Power transitions are one of the main sources of deadlock and conflict on the world stage, but they also have the potential to act as sources of renewal and change for the better. As a result, the study of how powers rise and how the process should be handled has a direct impact on international co-operation, peace and stability – and on more general values such as efficiency, fairness and justice in the global order."

"The Centre's research will, in some form or other, be of international policy relevance," added Dr Narlikar. Research findings will be fed back to policy-makers through the Centre's links with various think-tanks, policy institutions and private sector organisations, and through regular seminars, conferences and workshops.

Joseph Nye, University Distinguished Service Professor at Harvard University, gave the inaugural lecture for the Centre, which is in the Department of Politics and International Studies.

For more information, please visit www.polis.cam.ac.uk/crp/

New strain of MRSA discovered

A new strain of MRSA occurs in both human and dairy cow populations.



ROYALTY-FREE IMAGE COLLECTION/FULCRUM

A study led by Dr Mark Holmes from the Department of Veterinary Medicine has identified a new strain of MRSA in milk from dairy cows while researching mastitis, a bacterial infection that occurs in the cows' udders.

Dr Laura García-Álvarez, first author of the paper, who discovered the new strain while a PhD student at the University of Cambridge's Veterinary School, said: "To find the same new strain in both humans and cows is certainly worrying. However, pasteurisation of milk will prevent any risk of infection via the food chain. Workers on dairy farms may be at higher risk of carrying MRSA, but we do not yet know if this translates into a higher risk of infection. In the wider UK community, less than 1% of individuals carry MRSA – typically in their noses – without becoming ill."

When Dr Matt Holden and a research team at the Wellcome Trust Sanger Institute sequenced the entire genome they realised that the new strain possessed unconventional DNA for MRSA. Subsequent research revealed that the new strain was also present in humans. It was found in samples from Scotland, England and Denmark, and has since been identified in Ireland and Germany.

The new strain's genetic make-up differs greatly from previous strains, which means that the 'gold standard' molecular tests that are

currently used to identify MRSA – a polymerase chain reaction technique and slide agglutination testing – do not detect this new strain.

The research, which was published in *The Lancet Infectious Diseases* in June, raises questions about whether cows could be a reservoir for the new strain of MRSA. "Although there is circumstantial evidence that dairy cows are providing a reservoir of infection," said Dr Holmes, "it is still not known for certain if cows are infecting people, or people are infecting cows."

"Although our research suggests that the new MRSA accounts for a small proportion of MRSA – probably less than 100 isolations per year in the UK – it does appear that the numbers are rising."

With funding from the Medical Research Council, the researchers will next be undertaking prevalence surveys in people and in dairy cattle in the UK to determine how much new MRSA is present in these populations. They will also be performing an epidemiological study on farms to identify any factors that may be associated with infection by the new MRSA, to look for further new MRSA strains, and to explore the potential risks of the new strain to farm workers.

For more information, please contact Dr Mark Holmes (mah1@cam.ac.uk).

Tap into Cambridge research

A new research website and e-bulletin has been launched by the University.

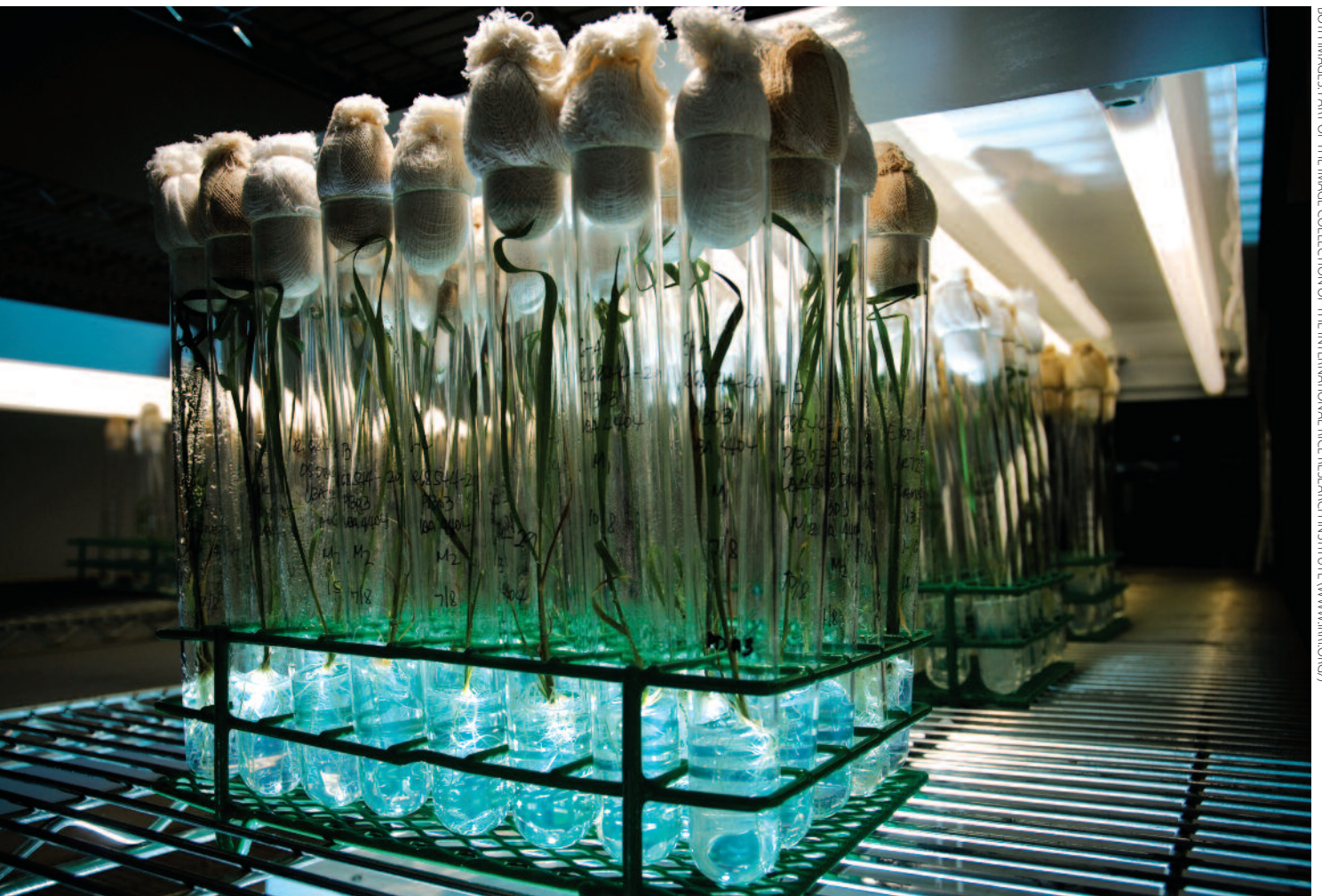
If you're interested in keeping on top of the latest research from the University of Cambridge, take a look at our new research website (www.cam.ac.uk/research/).

As well as news about recent findings and publications, you'll find features, themed areas, videos and audio items about broader areas of research. It's fully searchable, easy to use, and readers can

also have their say on the issues discussed in the comments box under each story.

You can also subscribe to a new e-bulletin, bringing you a round-up of the latest research news and features delivered to your in-box every week. To subscribe, please sign up to receive the bulletin by email at www.cam.ac.uk/research/bulletin





BOTH IMAGES: PART OF THE IMAGE COLLECTION OF THE INTERNATIONAL RICE RESEARCH INSTITUTE (WWW.IRRI.ORG/)

Turbocharging a new Green Revolution

Plant scientists in Cambridge have embarked on ambitious plans to improve crop yields by solving one of the chief limitations of photosynthesis.

Wasteful, inefficient, 'relic of a bygone age' – all indictments that have been levelled at RuBisCO, the most abundant protein in nature and the heart of the reaction that feeds life on Earth. The enzyme is the powerhouse behind photosynthesis, responsible for taking CO₂ from the atmosphere and using the sun's energy to convert it into the sugars that crops need to grow.

But, as its full name, Ribulose 1,5-Bisphosphate Carboxylase/Oxygenase, might suggest, the enzyme has an unfortunate tendency to promiscuity. It evolved at a time when the Earth's atmosphere was very different to the 500-fold excess of O₂ over CO₂ that we have today and, as a result, it sometimes mistakes O₂ for CO₂, to the detriment of potential plant productivity.

Plant scientists such as Dr Julian Hibberd and Professor Howard Griffiths believe that overcoming this inefficiency could be the key both to achieving a leap in the amount of food or energy a plant can produce from the same amount of sunlight and to revitalising the Green Revolution, which has been slowing as the yields of elite cultivars approach their natural limits.

Rice plants propagated using tissue culture at the International Rice Research Institute, Philippines

Nature's remedies

The approaches taken by the two scientists aim to maximise the operating efficiency of RuBisCO by turbocharging it with an increased concentration of CO₂.

"Fortuitously, some plants have developed such a turbocharger," explained Professor Griffiths. "Among them, certain land plants have an advanced type of photosynthesis termed C₄, and aquatic algae have developed mechanisms that actively concentrate bicarbonate to provide a source of CO₂ for the enzyme. Our research aims to emulate what nature has already accomplished, for the benefit of future food security."

The main focus for Dr Hibberd is rice, a cereal grown in global regions where the population is predicted to grow fastest. "About 60% of the world's population lives in Asia, where each hectare of land used for rice production currently provides food for 27 people, but by 2050 will have to support at least 43 people," he said. "One way to alleviate food shortages is to develop higher-yielding rice by reconfiguring its photosynthetic pathway towards that used by land plants that have evolved the upgraded version."

Most of the world's plants produce a sugar with a 3-carbon skeleton in a process termed C_3 photosynthesis. In fact, bacteria developed this means to convert light energy into sugar about 3.4 billion years ago. Fast forward to a comparatively recent 30 million years ago, and the C_4 pathway evolved, in which the initial CO_2 fixation product is a 4-carbon organic acid. Today, C_4 is found in 4% of plants including maize and sugarcane, as well as in 14 of the world's 18 worst weeds.

"Remarkably, C_4 photosynthesis has evolved independently in at least 62 lineages of plants," added Dr Hibberd. "We think it developed in response to selection pressures such as low amounts of CO_2 , high temperatures and more arid conditions."

Crucially, C_4 plants produce higher yields for the same amount of light energy, have double the water-use efficiency of C_3 plants, and their leaves use about 40% less nitrogen to achieve 50% higher yields. A host of biochemical, cellular and anatomical changes in the C_4 plant result in a mechanism that first concentrates CO_2 and then supplies it to RuBisCO in the C_3 pathway.

And therein lies the challenge. To unpick the C_4 apparatus and rebuild it in rice involves literally dozens of genetic changes, as well as alterations to biochemical reactions and even to the way the leaf is built. The project is requiring a major scientific effort, called the C_4 Rice Consortium, funded by \$22 million from the Bill & Melinda Gates Foundation.

Unpicking and rebuilding

The C_4 Rice Consortium involves 12 partner institutions across four continents and is led by the International Rice Research Institute (IRRI) in the Philippines.

In the two years since the project began, the Consortium members have been working on a number of complementary approaches. Dr Hibberd's team has been cloning genes required for the biochemical reactions, and transgenic strains of rice that express them are being grown at IRRI. Other groups are looking for C_4 mutants that have lost their leaf anatomy, and C_3 mutants that have developed it; and a vast gene sequencing screen is searching for new C_4 genes.

Dr Hibberd's recent findings, published in *Science* magazine in April 2011, suggest that genes present in C_3 species can be recruited into cell-specific functions in the C_4 pathway without alterations to their gene sequence. "The discovery dramatically alters the approaches being taken to engineer C_4 photosynthesis," he explained. "These results suggest that it's possible that only some parts of the C_4 pathway might be needed in rice for other parts to fall into place."

IdeasLab

As steps are taken to maximise plant productivity over the next century, there is a pressing need to understand the

determinants of RuBisCO operating efficiency not just in land plants but also in algae. Algae use a carbon-concentrating mechanism that is usually associated with a microcompartment called the chloroplast pyrenoid. Although very little is known about their properties, these structures drive a remarkable 15% of global carbon-based productivity.

To gain insight into one of the most important, yet poorly understood, carbon sequestration mechanisms, Professor Griffiths leads a new project recently funded as part of an IdeasLab competition for the best minds from the USA and the UK to join forces to explore improving photosynthetic yields.

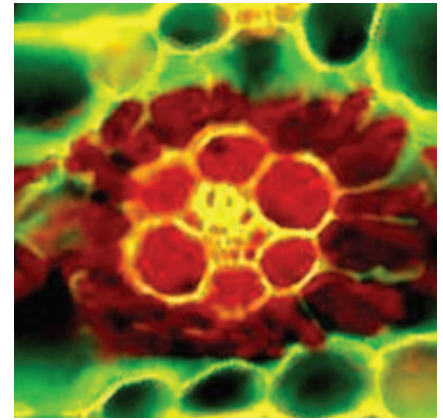
The project is one of two transatlantic IdeasLab collaborations involving Cambridge that were awarded a total of £2.85 million from the Biotechnology and Biological Sciences Research Council and the US National Science Foundation. Dr Hibberd is a member of the other collaboration, which is boosting RuBisCO using tricks to enhance CO_2 transport that are associated with other metabolic processes but that, according to current knowledge, are not used in photosynthesis.

Professor Griffiths explained how algal components could provide the answer to shaking up a wasteful enzyme: "We've known for 30 years that the algal pyrenoid has solved the problem of an inefficient RuBisCO enzyme, which probably evolved to help algae survive in the lower levels of CO_2 availability found in water. Our work has investigated genetic changes in the model alga *Chlamydomonas* that can determine whether the pyrenoid appears or not. The new project will have direct applications for improving algal bioenergy productivity, as well as potential implications for transforming higher plant crop yields by emulating the carbon-concentrating mechanism in every photosynthetically active cell of the plant."

A longer term solution

The scientists are confident that now is a pivotal time for current progress in understanding photosynthesis to be harnessed with genetic techniques and traditional breeding resources to improve crop yields for the future. Nevertheless, none of the projects is a trivial undertaking, as Dr Hibberd explained: "We're looking ahead to at least 15–20 years from now, to transform crop production in the decades when the potential yield of current crops has been exhaustively maximised."

"For the next generation, plant and microbial productivity will become the focus of key global issues," added Professor Griffiths. "It will be the basis for feeding an additional two to three billion mouths, for maintaining biodiversity in the face of climate change and for driving forward an economy currently trading on past sunlight."



The C_4 turbocharger: rings of cells in the plant leaf fix and concentrate CO_2 before supplying it to RuBisCO (in the central cell above)

"Our research aims to emulate what nature has already accomplished, for the benefit of future food security."



Dr Julian Hibberd (left) and Professor Howard Griffiths

For more information, please contact Dr Julian Hibberd (jmh65@cam.ac.uk) and Professor Howard Griffiths (hg230@cam.ac.uk) at the Department of Plant Sciences (www.plantsci.cam.ac.uk/).



DR MARCUS HEISLER

might associate and dissociate at millisecond scales, or even less.”

Professor Meyerowitz likens the approach the scientists will be taking to the computer-aided design process used for the Boeing 777 commercial aeroplane: “We’re not designing a plant – it’s already there – but we’re learning how it’s put together. In fact, plants are so complex that it will be like designing the full interactions of 10 million airplanes of 50 different types. But we know what sort of data we want, and we know how to turn it into knowledge using computational models.”

Computational modelling and mathematical and engineering-based approaches will therefore feature strongly alongside expertise in genetics, cell biology, physiology and evolutionary biology within the Laboratory.

Predictive modelling

Professor Meyerowitz studies the genetics of flowering plants, especially the small laboratory plant *Arabidopsis thaliana*. His team was the first to identify and clone several flower development genes. Two decades ago, they pioneered the re-engineering of flower design, replacing the flowering organs with other organs – a potential 625 possible types of flowers. The scientists can already model many aspects of plant development and then test if the hypotheses about plant behaviour are correct. The future research of the Sainsbury Laboratory will be channelled into such models, with ever-increasing complexity. And, by elucidating the intricacies of plant development, the research will facilitate re-designing crops of the future.

“We’re aimed at 10 or 20, or even 50, years from now so that people can exploit the basic knowledge that we’ve generated, the way the basic knowledge of 30 years ago is being exploited now,” added Professor Meyerowitz. “We’re pretty sure we can figure out how plants develop. It’s not a dream.”

Fundamental research on plant development at the Sainsbury Laboratory will help in the future design of optimal crops.

A search for answers to the mysteries of plant development lies at the heart of research at the Sainsbury Laboratory, a newly opened institute that was made possible by an £82 million grant from the Gatsby Charitable Foundation. In due course, the Laboratory will house 120 research scientists focused on the multifaceted events that unfold from the moment a single plant egg cell is fertilised.

Understanding plant development is both a fascinating and vitally important intellectual challenge, as Professor Elliot Meyerowitz, the Laboratory’s inaugural Director, explained: “The answers will not only enhance our fundamental understanding of life, they will also have important application to a critical problem that faces the world today – how to feed and fuel a growing population with limited resources of land, water and energy.”

More complicated than an aeroplane

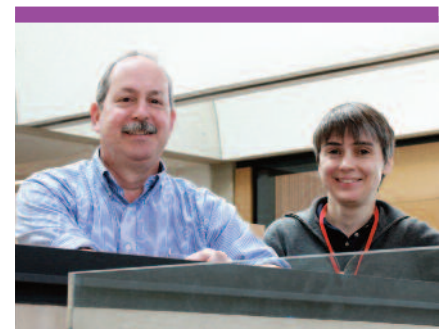
Scientists know some of the structures involved in how a plant develops – the machinery for processing DNA information and the basis of cellular behaviour, for instance. Less is known about the complex

Live imaging of the growing tips of plants as they make flowers; data such as these lead to computational models of plant growth

communication network that exists across the plant as a whole. The movement of small molecules between cells effectively enables plant cells to ‘talk to each other’ during development and to react to their environment.

“Our work aims to understand how plants ‘read-in’ their environment and ‘read-out’ this information as particular patterns of growth and development,” said Professor Meyerowitz.

Take, for example, branching in plants: how does a plant know where and when to form a branch from its stem, and why does pruning make a plant bushier? Professor Ottoline Leyser, Associate Director of the Sainsbury Laboratory, discovered a hormone network that governs the process. Moving over long distances in the plant, the hormones provide a rich source of information that is then locally interpreted to regulate branching. “It is this complex web of interaction that makes living organisms more than the sum of their parts,” added Professor Meyerowitz. “Even a small plant can have 10 million cells communicating in a whole variety of different modalities, chemical and physical. There may be 50 different types of plant cells, and each cell might have 30,000 different proteins that



Professor Elliot Meyerowitz and Professor Ottoline Leyser

For more information, please contact Professor Elliot Meyerowitz (emm66@cam.ac.uk) at the Sainsbury Laboratory (www.slcu.cam.ac.uk/).



Invigorating plants

Understanding how plants 'silence' invading viruses could hold the key to releasing the hidden potential of plants.

One of the key elements of the Green Revolution – when a series of agricultural initiatives dramatically boosted crop productivity worldwide – was the harnessing of hybrid vigour. This phenomenon occurs when the crossing of two inbred strains results in offspring with superior qualities.

Professor Sir David Baulcombe, Regius Professor of Botany in the Department of Plant Sciences, hopes that a new molecular understanding of hybrid vigour could underpin technology-based plant modifications to stave off future food shortages. This time, he believes, "it will be possible to predict precisely which parents will produce the best hybrid and to fine-tune aspects of that improvement, whether it's yield, drought tolerance or disease resistance."

Plants have memories too

The story begins with a small interfering ribonucleic acid (siRNA). Plants, like animals, have developed mechanisms to ward off disease and 'remember' past infections. One of the most important plant defences against viruses, as discovered by Professor Baulcombe, is called RNA silencing.

Plant cells recognise the foreign genetic material of the virus, copy a section of the viral DNA into siRNA and use it as a 'specificity determinant'. The siRNA binds to the viral genetic material and, rather like hoisting a molecular flag to identify the marauder, causes a protein called Argonaute to bind and stop the virus from working.

"Just as our immune system can be primed by an infection so that we can fight it off

quicker next time, plant cells retain the siRNA as a means of escalating the defence response next time the plant sees the invader," explained Professor Baulcombe.

"Understanding this opens up the possibility of harnessing the process to protect plants against viral diseases – by furnishing the plant with the siRNA so that it is permanently and genetically able to fight off the disease even though it has never seen it."

It turns out that the process is of interest not just as a means of protecting crops from pathogens but also because, in modern plants, RNA silencing has diversified into a mechanism that protects them from the effects of 'selfish' DNA. This process appears to lie at the heart of hybrid vigour.

Releasing latent potential

Over millions of years, plants have acquired pieces of junk DNA – some are the relics of past viral infections, others are moveable elements capable of 'jumping' around the genome; all are termed selfish because, depending on where they end up, the junk DNA can activate or suppress genes. Plants use RNA silencing to shut down the selfish DNA in their genomes.

"We now realise that because different varieties of the same plant have different selfish DNA and different siRNAs to combat it, this could be one mechanism for explaining the mysteries of hybrid vigour," said Professor Baulcombe. "Crossing two varieties results in a mix of siRNA that is different to that of either parent. In some cases, the new mix optimally turns the right combination of genes on and off and results

in an offspring that is better than either parent."

With funding from the Biotechnology and Biological Sciences Research Council, European Union, Royal Society and Gatsby Foundation, and the benefit of newly available DNA sequences of many crops, Professor Baulcombe's team are beginning to exploit this new understanding by predicting which mix of siRNA will produce the improved offspring.

Within their sights is a glimpse of how future plant breeding could change dramatically, by being able to predict on an unprecedented molecular scale how breeders can improve crops by unlocking the latent potential in plant genomes.



Professor Sir David Baulcombe

For more information, please contact Professor Sir David Baulcombe (dcb40@cam.ac.uk) at the Department of Plant Sciences or visit www.plantsci.cam.ac.uk/research/davidbaulcombe.html

Veterinary research in Cambridge is spearheading a new generation of preventive methods to protect livestock from disease.



A genetically modified chicken that prevents spreading of avian influenza to other chickens

Field to fork: safeguarding livestock health

A staggering 17 billion chickens, almost 10 billion pigs, and nearly 2 billion each of cattle and sheep were kept as livestock animals worldwide in 2009. And, by 2050, world meat production is projected to double, principally in developing countries. With the added strain of increasing meat production on resources such as land, water, crops and energy, it's vital to maximise the 'output for input', as Professor Duncan Maskell, Head of Cambridge's Department of Veterinary Medicine, explained: "How you should apportion crops between food for animals and food and fuel for humans is a complex question, so it's crucial to ensure that resource input counts in terms of output of meat, and one of the main moderators of this relationship is animal welfare, especially in terms of infectious disease."

Viral epidemics can sweep through livestock, and endemic diseases such as respiratory infections can affect the rate at which animals grow. A further risk to food security is posed by bacterial infections of

livestock that contaminate meat and cause food poisoning.

Research at the Department of Veterinary Medicine is tackling disease on all of these fronts in what Professor Maskell has described as "a perfect marriage between fundamental biological research and applied clinical outcomes."

'Flu-free' chickens

A breakthrough was announced earlier this year that could prevent future bird flu outbreaks from spreading within poultry flocks. Dr Laurence Tiley, in collaboration with researchers in the Roslin Institute at the University of Edinburgh, produced the world's first genetically modified chickens that prevent the spread of avian influenza.

Since 2003, over 300 million poultry have been culled as a result of influenza outbreaks, and in some countries the virus is now endemic in wild bird populations. Preventing virus transmission in chickens would reduce both the economic impact of the disease and

the risk for people who are exposed to the infected birds.

The scientists introduced a new gene that manufactures a 'decoy' molecule into the chicken genome. In a clever move to confuse the flu virus into ignoring its own replication needs, the decoy mimics an important control element of the virus and diverts the viral replication machinery away from its own genetic material.

"Because the control element is absolutely conserved across strains, we expect that the decoy will work against all strains of avian influenza and be difficult for the virus to evolve around," said Dr Tiley, whose research was funded by the Biotechnology and Biological Sciences Research Council (BBSRC). Although the birds become sick themselves, they don't transmit the infection to other chickens, even those without the decoy molecule.

"At this stage, the chickens are not intended for consumption," Dr Tiley added. "This genetic modification is a significant first

step. Our objective now is to develop chickens that are completely resistant to avian flu."

Threats from the wild

Viral epidemics are not just a concern in livestock, but also in relation to wildlife, as Professor James Wood explained: "Often, emerging infectious diseases originating from wildlife are a particular challenge because little might be known about the virus, how it's transmitted to livestock and humans, or the potential for epidemics to spread."

Nipah virus, for example, was first recognised in 1999 when an outbreak causing severe inflammation of the brain occurred in pigs and pig farmers in Malaysia. When the source of the virus was traced, it was found to be on fruit contaminated by infected fruit bats, the natural host of the virus.

"Bats epitomise the growing challenges associated with the spread of wildlife diseases," added Professor Wood: "They are associated with a wide range of viruses, live in close proximity to animals and humans, and many important puzzles remain about the social, environmental and biological dynamics that shape pathogen transmission."

The first steps to remedy this lack of information were taken last year when a unique network was created comprising experts from institutions worldwide including collaborators in Bangladesh, Ghana and Kenya. The consortium was funded by a Catalyst grant from the Medical Research Council and three other research councils. "The network has a long-term aim of creating vitally needed interdisciplinary knowledge," said Professor Wood, one of the leaders of the network, "as well as pioneering interventions geared to enabling bats, animals and people to co-exist with reduced disease risk."

Super-vaccination at one sniff

Respiratory infections in pigs are a major animal welfare issue and cost the pig industry millions of pounds each year. An innovative project has begun the process of developing a 'super-vaccine' to guard against infection by the bacteria that are responsible for the most serious infections.

Funded with £5.6 million from the BBSRC, the consortium links experts from the University of Cambridge, Imperial College London (the project co-ordinator), the London School of Hygiene and Tropical Medicine, and the Royal Veterinary College.

Dr Dan Tucker, who together with Professor Maskell leads the Cambridge component of the five-year project, explained why these infections matter so much to food security: "When a pig gets sick it diverts its energy away from growth to fighting off the infection. This requires treatment with antibiotics and decreases the efficiency with which vegetable protein is converted into kilograms of meat."

The goal is to create a single super-vaccine that can be administered by nasal

spray and protect against *Actinobacillus pleuropneumoniae*, *Haemophilus parasuis*, *Mycoplasma hyopneumoniae/hyorhinis* and *Streptococcus suis*. "Our gold standard would be to create a live vaccine based on a mutated version of one of these bacteria that no longer causes the disease, and then engineer it to display portions of the other three bacteria so that a strong immune response is made to all," said Dr Tucker.

High-throughput sequencing in collaboration with the Wellcome Trust Sanger Institute is enabling the scientists to assemble the largest ever sequenced collection of these bacteria. The team has begun to identify which genes need to be 'knocked out' to provide a live vaccine – information that will also help in understanding why some strains cause more virulent disease than others.

Alongside vaccine development, a diagnostic kit will be developed to detect all four pathogens in less than six hours. The goal is to have a diagnostic test and potential vaccine ready for field trials at Huazhong Agricultural University in China within three years.

Safety first

Diseases can also be spread by meat. Although the global incidence of food-borne illness is difficult to estimate, up to 30% of the population in industrialised countries may be affected each year according to the World Health Organization.

"One key aim is to provide the fundamental knowledge and clinical tools to keep livestock healthy and our food safe."

Salmonella and *Campylobacter* – two of the most common sources of food-borne disease – are the basis of multiple research programmes at the Department of Veterinary Medicine, such as the research led by Professor Maskell. His team has particularly focused on understanding the dynamics of the interactions of bacteria with their animal hosts.

"Thanks to the completion of genome sequences for many of the chief culprits and the advent of high-throughput sequencing," said Professor Maskell, "the door has been opened on many of the secrets of how pathogens such as salmonellae cause disease."

"We are committed to maintaining strong basic research, but do this in the context of finding improved intervention strategies," he added. "Health standards and life expectancy have gone up globally, and a large part of this is better nutrition. At many levels this means more meat and high-protein food. One key aim of our research is to provide the fundamental knowledge and clinical tools to keep livestock healthy and our food safe."



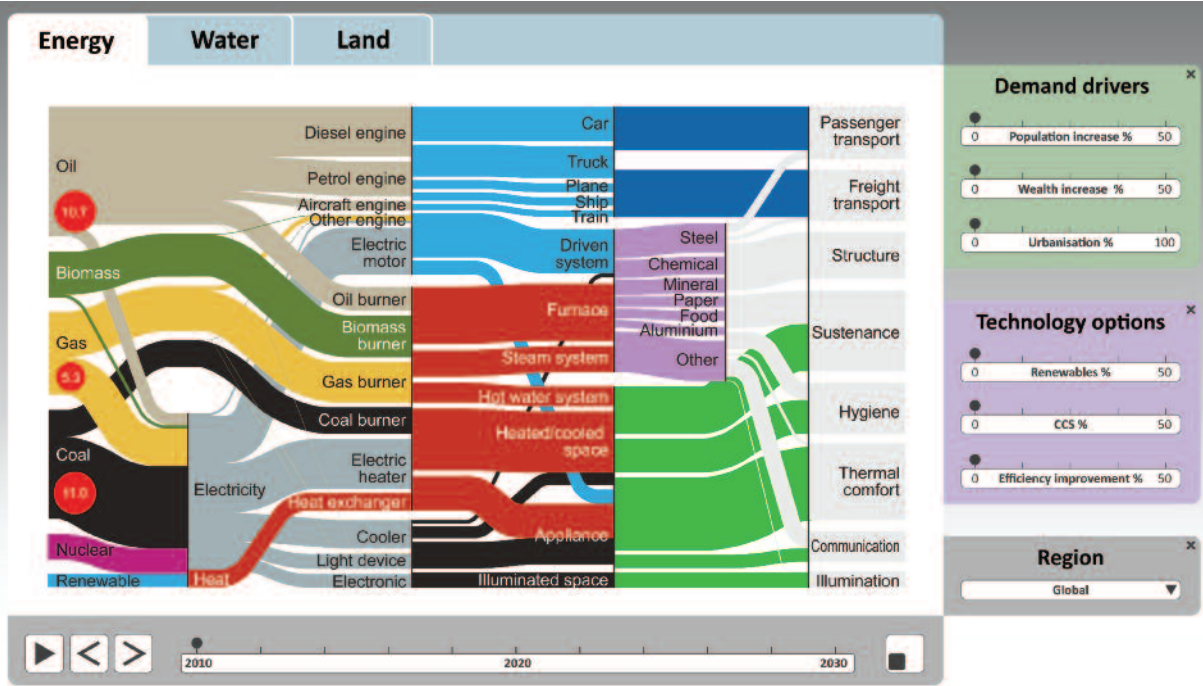
DAVID HAWMAN

Infectious diseases carried by animals in the wild, such as this bat in Ghana, can be transmitted to livestock



From left: Dr Dan Tucker, Professor James Wood, Professor Duncan Maskell and Dr Laurence Tiley

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Foreseer of future resources

The Foreseer tool is based on Sankey diagrams, where the width of each line is proportional to the quantity of resource

An online tool will help users predict trade-offs between the global commodities of energy, water and land.

Understanding how energy can be used efficiently is key to reducing carbon emissions and mitigating future fuel and food shortages. But energy use is only part of the story. The link between resources and final services – such as food, warmth, shelter and transport – is only really complete if water and land use is also factored in.

Almost a year ago, nine experts from seven different departments across the University set out to do precisely this. They reasoned that to understand the uncertainties ahead it is vitally important not only to integrate models of energy, water and land use but also to create a visualisation tool that could be widely used, by industry, policy-makers, researchers and others, to understand the consequences of how decisions today might play out in decades to come.

Foreseer

The Foreseer Project is funded through BP’s Energy Sustainability Challenge, which is supporting projects in 12 leading research universities worldwide to explore some of the key issues that could shape future energy supply and demand.

At the heart of the Cambridge project is the use of the Sankey diagram – a remarkably intuitive visual interpretation of the quantity of resources and how they are consumed.

Although Sankey diagrams have been in use for over a century for mapping energy flow, they have had limitations, as Dr Julian Allwood, who leads the Foreseer Project, explained: “Past diagrams were based on

economic data and stopped short of tracing the length of each energy chain from fuels all the way to consumers, halting instead at sectors. They gave you an idea of who to blame for energy use but they didn’t provide a basis for what you could change.”

By demonstrating two years ago that it was indeed possible to create a global snapshot of energy flow from fuel to final service, Dr Allwood and colleague Dr Jonathan Cullen realised that it might also be feasible to turn this into a tool with forecasting potential.

“We could then ask ‘what if’ questions such as what if car engines were to become twice as efficient?” Dr Allwood explained. “But to be truly predictive, mapping energy flow alone is not enough. An increase in biofuel, for instance, has implications for land and water use, as well as fertiliser use, which itself is an energy-demanding product. Energy, land and water are interlinked.”

Good decisions

The key innovation of the Foreseer Project is integration. Access to the data, physical models and expertise were already in existence in departments across the University; Foreseer has brought them together for the first time. “It has been a fascinating experience for each of the Project members to expand from thinking about the variables that each of us are familiar with to thinking about how they couple with other resources on a massive scale. The Project has really got under everybody’s skin.”

The team has had to start from first principles to understand how to build a map for land and water use. The first stage, recently completed, focused on California, USA, and Beijing, China, and the goal now is to expand this to other regions and then worldwide.

“Ultimately we want to be able to ask global questions such as: what are the resource implications of rapid economic development and urbanisation in developing countries, and the expansion of mega-cities? How will changes in climate, population and technology affect services such as food provision? Making good decisions now, including energy investment decisions, requires physically based predictions of future needs and pressures.”



Dr Julian Allwood

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Far from being merely 'dirt', soil plays a fundamental role in food production, water availability and biodiversity. A new research programme aims to safeguard its future sustainable management.

In soil we trust

Put simply, we cannot survive without soil. Its rich combination of minerals, carbon-rich organic matter and water supports plant life. It also harbours its own diverse ecosystem of millions of microbes and fauna that aerate the soil, cycle nutrients, decompose dead matter and mineralise rock fragments around them.

And although forests might most readily spring to mind when considering the role of the natural environment in carbon exchange, what may not be so obvious is the vast carbon sink under our very feet. In fact, more carbon is stored in soil worldwide than is found in the atmosphere and the planet's biomass put together.

Yet this fundamental resource is under threat from intensive agricultural practices and erosion. The catastrophe of the Dust Bowl of the 1930s, when a combination of severe drought and intensive farming caused dust storms across the American prairies, shows the extent to which major damage can be inflicted.

Now, a major programme with €7 million funding from the European

Commission will help to define a policy for sustainable management of soils, with a view to adopting a legally binding Soil Framework Directive, such as exists for air and water.

The Ecological Function and Biodiversity Indicators in European Soils (EcoFINDERS) programme, which launched in January 2011, brings together 22 institutional European research partners, including the University of Cambridge, to formulate how best to manage the health of soil.

Soil value

Given the demands made on soil, it can't look after itself. The goal of EcoFINDERS is to design and implement soil strategies aimed at ensuring the sustainable use of soils, as Dr Unai Pascual, who leads the Cambridge component of the programme, explained: "The general hypothesis is that changes in the diversity of microbes and fauna in soil indicate how healthy it is. EcoFINDERS is therefore characterising soil biodiversity and determining how this links with soil functions and ecosystem services."

"Our contribution to the programme is focused on working out the value of the soil ecosystem services: essentially, how much does soil matter when you take into account all of the functions it performs?" added Dr Pascual. "Our task is to design cost-effective and socially fair policy instruments for the conservation of soil biodiversity."

In effect, soil provides such a vast array of essential ecosystem services that maintaining its health has implications for food production, water availability, climate-induced environmental change, resistance to diseases and pests, and the regulation of its own and above-ground biodiversity.

Dr Pascual believes that understanding the value of soil biodiversity conservation in relation to its function to deliver key ecosystem services that support human wellbeing will open up a whole new way of looking at soil and land management in Europe and elsewhere, especially in the context of current global challenges such as food security and climate change.

Food security, biodiversity and soil carbon

How can incentives for soil carbon contribute to food security and biodiversity conservation?

This key question was explored recently at a Cambridge Conservation Initiative (CCI) collaborative workshop led by the UNEP World Conservation Monitoring Centre (WCMC) and the University's Departments of Plant Sciences and Land Economy.

"While incentive measures that encourage maintenance of forest carbon are well developed, those for soil carbon management are less so," explained Alison Rosser of the UNEP-WCMC

Biodiversity, Biomass and Food Security Programme. "The workshop proceedings will aid development of a policy brief for decision makers as to how we might address this as a global priority. The importance of maintaining soil carbon cannot be overstressed, both for the widespread benefits it brings to producing food and conserving biodiversity, and for its role as a carbon sink," added Dr Ed Tanner of Plant Sciences.

The workshop was funded by the CCI Strategic Initiative Fund and highlighted the unique capabilities of partners in CCI and other experts to review the opportunities and challenges for biodiversity and food supply.



Dr Unai Pascual

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Mathematical modelling is an important weapon in the armoury against crop disease, as plant epidemiologists demonstrated when they turned their sights on root madness in sugar beet.

Modelling the root of crop disease



Sugar beet provides around 30% of the world's sugar but yields are reduced by infestations of rhizomania

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For sugar beet farmers, the appearance of yellowing patches in a field of sugar beet is an alarming sight. It could signal the presence of 'root madness', or rhizomania, and a potential reduction in their root sugar yield by 50–60%.

Diseases like rhizomania – which was first identified in Italy almost 60 years ago and now occurs in all the major sugar beet growing areas of the world – are a frequent and recurring problem in crop production, causing a reduction in potential food yields year upon year.

Breeding disease resistance and deploying pesticides have made remarkable progress in crop protection. But such strategies are not always feasible, particularly for emerging epidemics where appropriate methods may not yet exist. Another route, known as containment, is to destroy the crop and prohibit its further growth on the infected farm.

Monitoring the effectiveness of any kind of crop protection is vitally important, and mathematical models that track and predict disease, such as those created by Professor Chris Gilligan and his team in the Department of Plant Sciences, are helping to provide policy makers and regulators with the basis on which to make crucial strategic decisions.

Sugar beet rhizomania is among the many plant diseases that the Cambridge scientists have modelled. Their work, in close collaboration with government policy makers at the Department for Environment, Food and Rural Affairs (Defra), has helped both to gauge the effectiveness of containment strategies for this potentially devastating disease and to curb the potential for a future epidemic.

Keeping ahead of the virus

"The difficulty with rhizomania," explained Professor Gilligan, who is a Biotechnology

and Biological Sciences Research Council Professorial Fellow, "is the infection can be asymptomatic and the pathogen, beet necrotic yellow vein virus, can be readily spread by a soil-borne fungus through the movement of infested soil. In fact, by the time a farmer has identified symptoms in their own fields they have unwittingly been exporting the pathogen on shared contractor's agricultural machinery to their neighbour's fields."

Strenuous efforts to contain the disease adopted by the Ministry of Agriculture, Fisheries and Food (MAFF, now Defra) involved annual surveys, destroying symptomatic plants on a field basis and prohibiting sugar beet cropping on affected fields. An additional, farm-scale measure was also introduced by the sugar beet industry: any growers worried about the disease status of their neighbour's farm could transfer their sugar beet quota to farmers in regions of reduced risk.

Both schemes were discontinued when a partially resistant variety of sugar beet became available. However, the virus continues to evolve, and an aggressive strain has emerged that overcomes previously resistant varieties of sugar beet, highlighting the importance of the continuing development of resistant strains and of evaluating the effectiveness of control strategies.

The mathematical model developed by the Gilligan group looked at the relative success of field-scale versus farm-scale containment, using data from the initial infestation of rhizomania in East Anglia in 2000.

Their simulations were able to predict the relationship between the effectiveness of containment and the behaviour of growers, both in terms of how aware they are of the disease state of their neighbours' fields and how risk averse they are in terms

of passing on their quota as soon as their neighbours detect rhizomania.

"The simulations show that the field-scale approach fails to prevent invasion because, by the time the symptoms appear, the virus has already spread," explained Professor Gilligan. "The farm-scale approach however works well, so long as most farmers sell their quota as soon as their neighbours detect the disease. Interestingly, the model shows that this strategy is robust to non-compliance – most but not all farmers have to comply for it to work."

The research on matching control with inherent epidemic scales was originally funded by MAFF and British Sugar PLC. It now continues in the development of a mathematical toolkit to predict the outcome of control strategies to protect crops worldwide and safeguard food security.



Professor Chris Gilligan

For more information, please contact Professor Chris Gilligan (cag1@cam.ac.uk) at the Department of Plant Sciences (www.plantsci.cam.ac.uk/).

Nature's value to business

A programme convening business leaders and policy makers is helping to identify the value to business of nature – and the step changes needed to build food security – as its co-Directors explain.

For many years businesses have been aware of the impact of their activities on the environment. But far less is understood about the value to business of the goods and services that nature provides. Yet, increasingly, this dependency is becoming a prominent issue, particularly for those in the food and agricultural sectors who rely directly on natural resources for their commodities and products.

Over the past year, a unique project – the Cambridge Natural Capital Programme at the Cambridge Programme for Sustainability Leadership (CPSL) – has developed innovative and practical recommendations for the corporate sector, helping to identify risks, opportunities and step changes in the face of growing pressures on the ecosystems and natural capital that underpin the global economy. The programme is one of a number developed by CPSL over 20 years that draw on the leading research and networks of the University to help business leaders address the critical global challenges they face today.

Risks and opportunities

Launched in April 2010, the cross-sector programme convenes 20 companies with global reach, including ASDA Wal-Mart, Cargill, Kraft Foods, Nestlé, Olam International and Unilever, who recognise the benefits of working collaboratively and learning from the experience of others. An initial food security roundtable with businesses leaders clarified where CPSL could add value, and four 'collaboratories' have been created with the intention of developing practical actions and informing public policy.

One area that requires a practical solution is how to 're-tune' retail and manufacturing supply chains to share one planet's worth of resources, and how to include local communities in the equation.

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Responsible farming and production practices throughout the value chain is helping Nestlé, one of the companies involved in the CPSL programme, to optimise its supply chain

Many natural resources, including water and soil, are already under great stress, and security of supply and access to materials are becoming a major risk for companies.

Another area under investigation is the evolving landscape of risk and opportunity for business generated by the intensifying pressures on ecosystem services and natural capital. Many of the companies brought together by the programme realise that such risks and opportunities are poorly understood at a business level. The tools they have developed in the collaboratories have helped them devise better strategies and anticipate likely policy responses by government to these risks.

On the other hand, investors are assessing risks and opportunities operating within an economic model that does not take account of the natural limits to growth. The programme is examining how to accelerate the mainstreaming of natural capital into investment decisions as well as into the creation of new investment opportunities so that we live off the 'natural interest' rather than the natural capital of our resource base.

Outcomes of these business collaboratories will feed into international policy processes, including Rio +20, the United Nations Conference on Sustainable Development next year in Brazil.

Frameworks for food security

At the heart of ecosystem and natural capital decline are constraints to food security – the ability of the current global food system to deliver sufficient food within the carrying capacity of the planet. Looking ahead, the programme will focus on helping business and policy makers to understand the system shifts needed to overcome these constraints.

Solutions lie in devising new business models that can provide nutritious, safe and affordable food to over nine billion people by 2050, using less land, fewer inputs, with less waste and a lower environmental impact, and in ways that are socially and economically sustainable. Essential to success will be supportive national and global policy frameworks.

The power of such a University-based programme is its ability to convene influential business leaders and policy makers and to offer unique collaborative research opportunities to tackle these complex problems and devise practical solutions.



For more information about CPSL's Cambridge Natural Capital Programme, please contact its co-Directors, Martin Roberts (martin.roberts@cpsl.cam.ac.uk) and Margaret Adey (margaret.adey@cpsl.cam.ac.uk) at CPSL (www.cpsl.cam.ac.uk/).

Farming and the fate of wild nature

Some wildlife, such as the Chocolate-backed Kingfisher above, will only survive if intact natural habitats are protected

As the drive to increase food production gathers pace, conservation scientists suggest that reconciling food security with protecting biodiversity might require unexpected solutions.

Cambridge Conservation Initiative

Launched in 2007, CCI is a collaboration between six departments of the University of Cambridge and nine leading conservation organisations based in the Cambridge area. It represents a critical mass of expertise at the interface of research and education, policy and practice, for the conservation of biodiversity and ecosystems.

For more information, please visit www.conservation.cam.ac.uk/

Farming is the greatest extinction threat to birds, mammals, plants and insects, and widespread land clearing, irrigation and chemical treatments have profoundly affected wild species and habitats the world over. But why should we care about biodiversity when the necessity of meeting an expected doubling of global food demand is only decades away?

The stark reality, as conservation scientist Professor Andrew Balmford explained, is that biodiversity is not a luxury, it's a necessity for human life: "As well as being a vital source for many people of food and fuel, wild nature is crucial for every one of us in mitigating climate change, regulating water flows, and buffering people from the impact of storms and floods."

"World agriculture developed and flourished during a period of climate stability," he added. "We don't yet know how our current agricultural systems will be affected by climate change but my guess is that they will be more sensitive than we realise. For me, this uncertainty underscores the importance for the future of farming of agriculture having least possible impact on what remains of nature."

Professor Balmford, who helps lead the Conservation Science Group in the Department of Zoology, advocates thinking smart from the start. "It's vitally important to integrate biodiversity concerns into the inevitable expansion in agriculture, especially in developing countries and regions where crop farming is likely to increase the most," he said, "and to do this at an early stage, not when it's too late to save remaining wild habitats and the species that depend on them."

A dual challenge

From the moment that humans first began transforming land from wild nature, we have been a direct competitor with biodiversity, as a great many studies measuring the rate of species extinction in relation to land development have shown.

However, as Professor Rhys Green, also from the Department of Zoology, explained: "It's now not enough to count how many species are disappearing or to understand why ecosystems are collapsing. We need to work out what kinds of farming provide the food we need yet give the best prospect for minimising biodiversity losses."

The real question therefore is what can be done to tackle both problems in tandem? Professor Green, together with Professor Balmford and others, came up with a model (published in *Science* in 2005) that, when the right data are collected, can be used to answer this question. They looked at the impact on biodiversity of two potential solutions – land sparing and land sharing – and asked, theoretically, which would be best for wild nature.

"With land sparing, the idea is to farm the productive region as intensively as possible, without damaging areas away from farmland, and then to set aside other land for wild nature," explained Professor Green. "With land sharing, agricultural practices encourage wildlife through retention of hedgerows, patches of native vegetation and fewer pesticides. This usually means lower yields and therefore more land is needed to grow a given amount of produce."

"The argument for land sparing is rarely made by conservationists – it's more commonly advocated in the agriculture

literature,” he added. “Yet our mathematical model suggested that land sparing might allow more species to persist.”

In search of data

To find out if land sparing was indeed a better option for productivity and wildlife required a combination of data that had never been collected before.

Measurements were needed of the abundance of individual species in matched landscapes that vary only in the degree of agricultural development – from wild nature, through wildlife-friendly farming, to high-yield intensive farming – as well as, crucially, of the agricultural yield of these same landscapes.

“We know quite a lot about the impact of different landscapes on wildlife, but this can be misleading without information on yields as well,” said Dr Ben Phalan, who for his graduate studies spent 15 months in Ghana surveying wildlife and measuring agricultural yields and profits, while fellow graduate student Malvika Onial did the same in northern India.

“Our studies suggest that if we want to reconcile biodiversity and food production then we might well be better separating them than trying to integrate them on the same land.”

Although agricultural change is an important driver almost everywhere, the research focused on developing countries because these regions are home to some of the largest concentrations of biodiversity and also to the most rapid changes in human populations and agricultural practices.

“By quantifying how species are affected by increasing yield, we can work out whether it’s better to spread farming out over a larger area to dilute its impact or to concentrate production in existing croplands, allowing the protection of natural habitats such as rainforest,” said Dr Phalan.

More recently, the team has also begun to look at other regions of the world such as more-developed countries.

Smarter thinking

“Inevitably, there will be unease about advocating high-intensity food production,” added Professor Balmford. “It will be important to look carefully at practices that have impact beyond the farm – use of fossil fuels, fertilisers, water abstraction, pollution, social concerns and so on. But our studies suggest that if we want to reconcile biodiversity and food production then we might well be better separating them than trying to integrate them on the same land.”

The first steps in using the information to inform future agricultural practices have already begun. Dr Phalan has embarked on a broad-sweep analysis of the tropics to

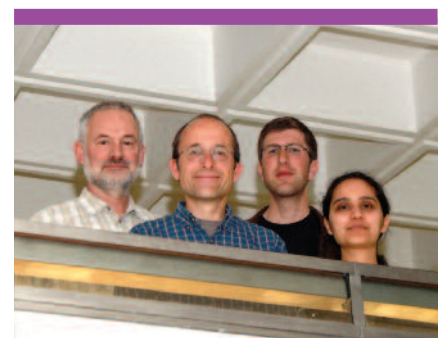
identify where croplands are expanding most and where there is likely to be greatest conflict with conservation priorities.

This project is a collaboration between the Department of Zoology, BirdLife International, the Royal Society for the Protection of Birds (RSPB) and the UNEP World Conservation Monitoring Centre – all of which are members of the Cambridge Conservation Initiative (see panel) – with vital seed funding provided by the Isaac Newton Trust.

“The new project is a chance to understand how to resolve trade-offs between conservation and agriculture, and to make wise choices about where and how we farm,” explained Professor Balmford. “Only then can we hope to meet increased food demands at the least cost to the other species with which we share our planet.”



Dr Ben Phalan conducting a point count for birds in a mature oil palm plantation, Ghana



From left: Professor Rhys Green, Professor Andrew Balmford, Dr Ben Phalan and Malvika Onial

For more information, please contact Professor Andrew Balmford (a.balmford@zoo.cam.ac.uk) or Professor Rhys Green (r.green@zoo.cam.ac.uk) at the Department of Zoology (www.zoo.cam.ac.uk/). Professor Green is also a Principal Research Biologist at the RSPB.

Academia makes a considerable and valued contribution to society that goes far beyond commercialisation of applied research, as Professor Alan Hughes, co-author of the first in-depth study of all UK university–business interactions, explains.

When people think about how academia links with external organisations they often think in terms of commercialisation of research. But the results of a large-scale survey of academics across all disciplines in every UK university, and a parallel survey of all sectors of UK business, tell a very different story.

The surveys were carried out by the Centre for Business Research (CBR) at Cambridge Judge Business School as part of a research initiative funded by the Economic and Social Research Council and the respective higher education funding councils of England, Scotland, Wales and Northern Ireland.

The results were finalised last year and have now been interrogated in greater detail, and supported by a set of detailed case studies, for the arts and humanities – a group of disciplines conventionally given little emphasis in relation to discussions of the socio-economic impact of university activity.

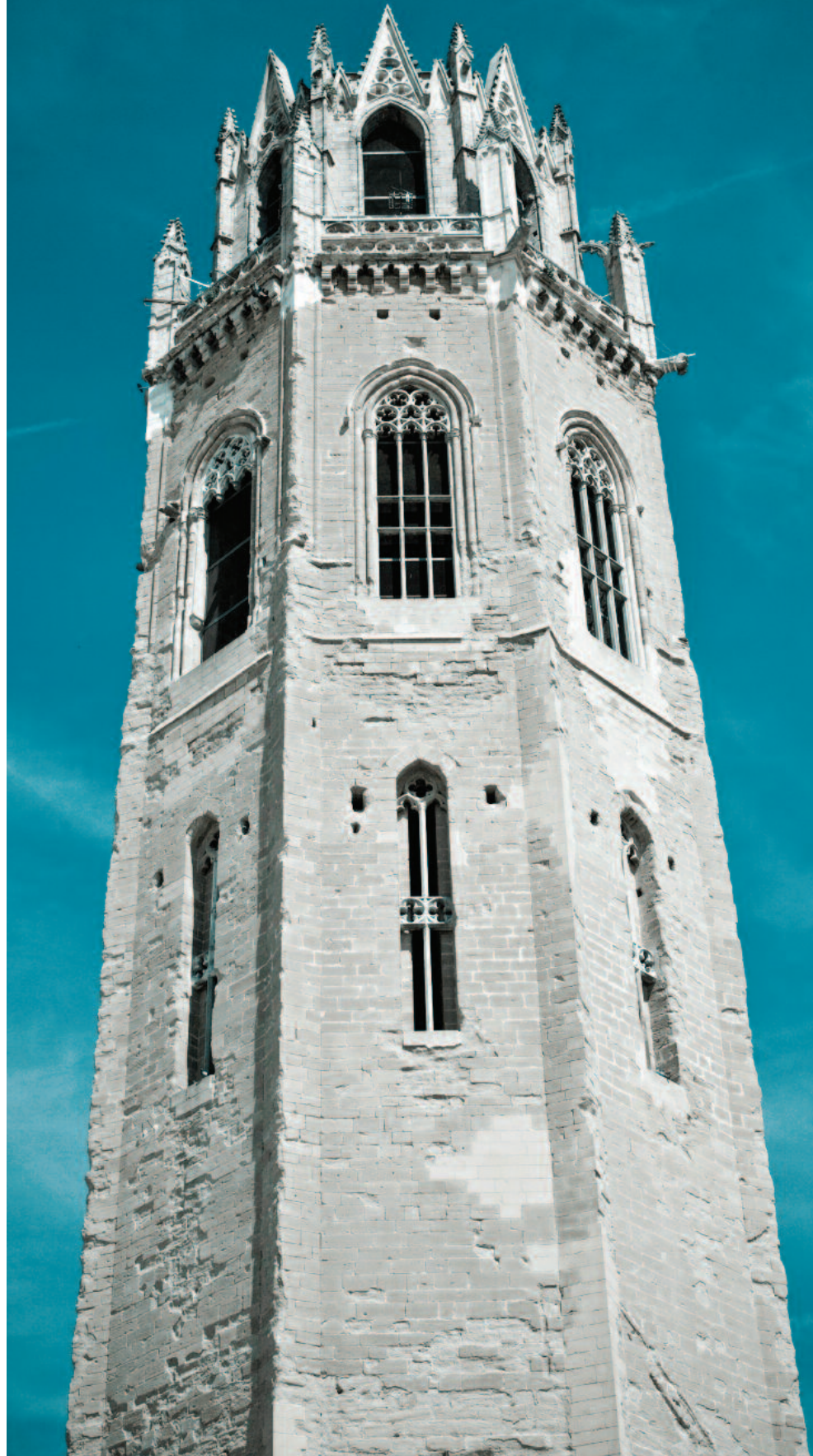
A recently published report of this latest research, which was funded by the Arts and Humanities Research Council (AHRC), explodes some of the myths surrounding the alleged ivory tower isolation of university academics, to reveal the wide, but often hidden, impact of universities outside of academia. They also show the way in which universities can act as a ‘public space’ within which a variety of initially informal interactions can develop into a broad spectrum of fruitful interactions with the public, private and third sectors.

UK-wide survey of all academics

Over 22,000 academics responded to the survey – the largest survey in the world to date to cover academic involvement with external organisations – as well as over 2,500 businesses of all sectors and sizes. The results permit a detailed mapping of the patterns of interactions of academics with external organisations in the public, private and community sectors, together with an in-depth examination of private sector business views of their relationships with academics.

For the UK academic community as a whole, the survey results make it very plain that commercialisation activities in the sense of licensing, patenting or spin-out companies are a very small part of the overall knowledge exchange spectrum.

Exploding the ivory tower myth



Compared with 5% and 7% of UK academics, respectively, who report having licensed research or are carrying out patenting activity, over 30% report being involved in standard-setting forums with external organisations or are directly employed in employee training and student placement with external organisations. Nearly 90% attend events such as conferences involving external organisations. These people-related activities dwarf knowledge exchange through direct commercialisation.

In addition, problem-solving activities, such as involvement in research consortia, prototyping, testing and, in particular, the provision of informal advice, are between five and 10 times more important than direct commercialisation. Finally, around a third of academics are involved in lectures for the community, school projects and the provision of a wide variety of public exhibitions and arts activities for the community.

The academic survey also revealed that the external organisations involved in these academic interactions extended beyond the private sector to include a rich set of interactions with the public sector, and with a wide range of charitable community and local and regional organisations.

In terms of the constraints on knowledge exchange between the private sector and academia, the conventional wisdom that constraints are caused by cultural differences, conflict over intellectual property and differences in time periods over which research should be carried out is not supported by evidence. Instead, the principal constraint reported by businesses was their own internal capacity to manage academic relationships effectively. From the academics' point of view, it is the pressure of time and the need to manage pressures to combine external relationships (which were frequently seen to be positively related to research and teaching activities) with the demands of career prospects (which are dominated by academic publication).

Arts and humanities

The overall survey includes 3,650 responses from academics in fields within the scope of the AHRC, including English, linguistics and modern languages, classics, history, philosophy, architecture, cultural studies, and the creative arts and media.

An analysis of patenting and licensing reveals that this is, with the exception of the creative arts and media, a relatively low level of activity for these academics. However, once we move beyond this narrow perspective to include knowledge exchange that spans people-based, problem-solving and community-orientated activities, the arts and humanities display as rich and diverse a set of connections as other disciplines, and a particularly wide range of third sector and community interactions.

Academics from the arts and humanities therefore emerge as highly connected with the UK economy and society. Moreover, these interactions are regarded by the academics involved as strongly supportive of scholarship and represent a two-way complementary interaction with external organisations.

The notion therefore that knowledge exchange is an activity driven solely by commercial and pecuniary interests is mis-founded – for most academics in the arts and humanities, the main impact of connecting with others is complementary to their research and their teaching.

Even within a narrow commercialisation perspective, a disaggregation of the arts and humanities to distinguish the creative arts and media from other humanities reveals that the former displays connection characteristics as deep as other disciplines and with considerable private sector and commercial interactions.

The business survey responses also reveal a pattern of interactions with academics that spans all disciplines and stretches beyond patenting and licensing. Businesses frequently use multiple disciplinary sources including the arts and humanities to address a wide range of activities spanning marketing and organisational change and which go beyond a focus on technology development.

University as a public space

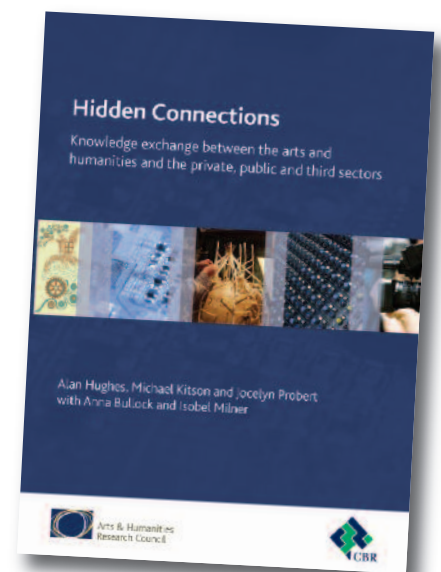
Many academics from the arts and humanities (and those from other disciplines) do not connect with external organisations because it is not considered necessary for their research or teaching. Two striking findings of the research in this respect are, first, that the connections which are made are most frequently initiated by the external organisations that academics partner and, second, that they are not initially instigated via technology transfer offices.

For knowledge exchange to be effective and provide benefits to all partners, the development of mutual understanding and management of expectations are crucial. Where there are areas in which improved connectivity would support both academic pursuits and wider social and economic objectives, knowledge exchange can therefore be best improved by mechanisms that can support informal interaction, the discovery of mutual interests and the subsequent development and management of relationships.

Maintaining a strong pattern of knowledge exchange activities is closely connected to what may be termed the 'public space' role of universities: a forum in which a wide variety of individuals and organisations can interact and develop relationships. Some of these relationships may lead to a commercial and contractual stage, but their development depends on the ability to connect in a way that is, at least

initially, not driven by strictly instrumental and commercial needs. Universities provide an environment to nurture interactions and potential links from which a wide variety of other connections, including strictly commercial ones, may develop.

“The notion that knowledge exchange is an activity driven solely by commercial and pecuniary interests is mis-founded.”



Hidden Connections: Knowledge exchange between the arts and humanities and the private, public and third sectors by Alan Hughes, Michael Kitson, Jocelyn Probert, Anna Bullock and Isobel Milner was published by the AHRC and CBR in May 2011.



Professor Alan Hughes

For more information, please contact Professor Alan Hughes (a.hughes@cbr.cam.ac.uk), Director of the Centre for Business Research at the Cambridge Judge Business School and member of the Prime Minister's Council for Science and Technology. A report on the full academic survey can be found at www.cbr.cam.ac.uk/pdf/AcademicSurveyReport.pdf



Eruptions that shook the world

In a new book, Dr Clive Oppenheimer sifts the evidence to see how far claims that volcanic catastrophes change the world hold up and whether lessons from past eruptions can help governments prepare for future events.

If you thought the Icelandic volcano was bad – think again. According to a new study, the recent ash clouds that grounded aircraft and marooned holiday-makers were “just a taste” of the widespread air pollution, public health problems and agricultural crises that future, bigger eruptions could bring.

These are just a few of the conclusions of what, rather ironically, claims to be a “non-catastrophist” new book by the University of Cambridge volcanologist Dr Clive Oppenheimer, entitled *Eruptions that Shook the World*.

It explores both the nature and history of volcanoes, showing how eruptions that we may think of as disastrous for their local communities actually had dramatic consequences for the Earth’s climate, and therefore sometimes for societies on the other side of the world.

Volcanic activity, Oppenheimer argues, was at least part of the reason for numerous major events in world history – among them the collapse of Minoan civilisation, medieval bubonic plague, the 19th-century prairie trail migrations to the American West; and even the rise of anti-Semitism in Europe.

That may not sound particularly non-catastrophist, but his concern is with sifting through real evidence – from the

volcanic rocks themselves, as well as from archaeology, historical documents, mythology and ancient climate records. “What we need is a reality check – a forensic test to see how far claims about catastrophes changing the world really hold up,” Oppenheimer said.

Oppenheimer believes that volcanoes remain widely misunderstood. “There is a lot to learn about volcanoes,” he said. “They affect our lives in so many ways, even if we don’t live near one.” With, according to one estimate, 10% of the world’s population and at least 12 major cities now located within range of a volcano, a more accurate perspective is needed on what they can do, so that rational plans can be drawn up in preparation for future events.

“The Japanese earthquake, tsunami and knock-on effects at the Fukushima nuclear plant show that cascading failures can have massive impacts on societies,” he added. “The problem for governments is that the potential scale of the damage really big eruptions can cause is difficult to consider against the improbability of them occurring. We need effective tools for making informed decisions about how to prepare. This means deducing as much as we can from past eruptions.”

Kilauea Volcano, Hawaii, one of the world's most active volcanoes; in March 2011, a new vent opened when the floor of the Pu'u O'o crater (shown here) collapsed

Death and disaster

Beyond the geological information proffered by volcano sites, much of the evidence comes from natural records like sulphate found in the polar ice cores and tree rings. Worryingly, this points to a number of as-yet-undiscovered eruptions – one as recently as 1809. The largest sulphur fallout of the past 7,000 years was in 1259. Nobody knows which volcano was responsible.

This evidence also shows why the repercussions of volcanoes are felt far beyond the impact zone. The large eruptions of the past few millennia produced huge clouds of sulphurous dust, which caused dramatic climatic swings.

One case, in 1783, shows what a bigger eruption in Iceland could do. That year, an eruption took place at Laki that was 200 times the size of the 2010 example. It emitted 122 megatonnes of sulphur dioxide, wiped out a fifth of the country's population and coincided strikingly with tens of thousands of deaths in England and France.

The reason for the scale of the catastrophe may be linked to the sulphuric cloud that spread over Europe. Documented at the time as a mysterious 'haze', this cloud initially interacted with an area of high pressure over the continent, causing a heat wave that killed thousands. A very severe winter then followed – the result of a temperature drop as the sulphuric particles in the atmosphere reflected solar radiation that should have been reaching the Earth back into space. First, the Thames and other rivers froze. Then, as the snow melted, there was widespread flooding.

These changes in the climate resulted in dramatic crop and livestock failures and the spread of disease. The death rate in England spiked in both the summer of 1783 and the following winter; an estimated 25,000 people lost their lives overall.

Laki is just one example of volcanoes that have disastrous consequences far away. An eruption 3,600 years ago entombed the island of Santorini in the Mediterranean and, as debris hit the ocean, caused a tsunami that contaminated farmland elsewhere. Within a few generations, the Minoan civilisation that had dominated the region collapsed.

In 536, a still-unknown volcano again caused a climate swing and an agrarian crisis. It is probably no coincidence that the first pandemic of bubonic plague happened at the same time – rats would have abandoned the dying fields and headed for man-made grain stores where they spread the bacterium.

And in 1815, global cooling caused by 30 megatonnes of sulphur emitted from an eruption on Sumbawa, Indonesia, led to the infamous 'year without a summer' of 1816 in both Europe and the eastern USA. In the latter, the failure of crops in places like Connecticut sparked a wave of migrations westwards. In Europe, where the Napoleonic Wars had just ended, an economic crisis occurred. Amid the riots and looting were a number of pogroms – violent reprisals against Jews. They were the first in an ongoing chain of such events that reached their final, terrible conclusion with the rise of the Nazis.

Emergency planning

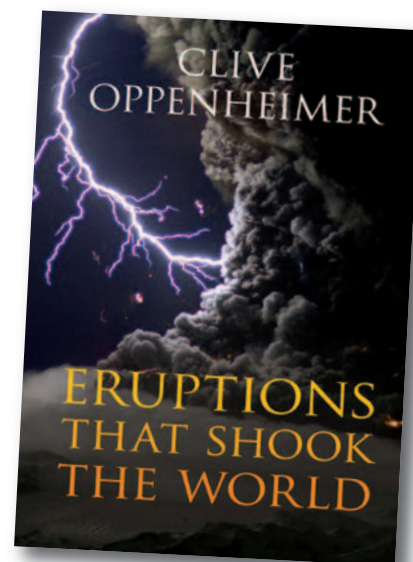
Such catastrophic scenarios may seem unlikely today, but, Oppenheimer argues, volcanoes could still wreak havoc if we don't prepare for larger eruptions. A Laki-type event in Iceland now would do far more than upset a few indignant tourists; its sulphur cloud could add to the air pollution in modern European cities and produce a serious public health crisis. Then there is the possibility of a super-eruption, which would cause a major humanitarian disaster. The last one we know about happened 26,000 years ago. Oppenheimer estimates that there is roughly a 1/500 chance of one recurring in the next century – odds long enough for governments to ignore, but short enough to cause serious concern.

His study recommends that international organisations already exist that could introduce measures like spot traffic bans or the distribution of dust masks in a repeat of the Laki eruption. For those who find themselves in the immediate vicinity of a volcano, however, Oppenheimer says evacuation is the only real solution – adding that governments should consider creating and maintaining plans for this in potential disaster zones.

In spite of that, however, his conclusion is oddly optimistic: "Humankind has yet to run into the buffers as the result of a volcanic eruption and may have learned to adapt and benefit from them in the long term. As the global population heads towards 10 billion, the human track record shows that we can manage the consequences of eruptions with resolve, flexibility and creativity – if we prepare properly."

Reporting by Tom Kirk

"We need effective tools for making informed decisions about how to prepare. This means deducing as much as we can from past eruptions."

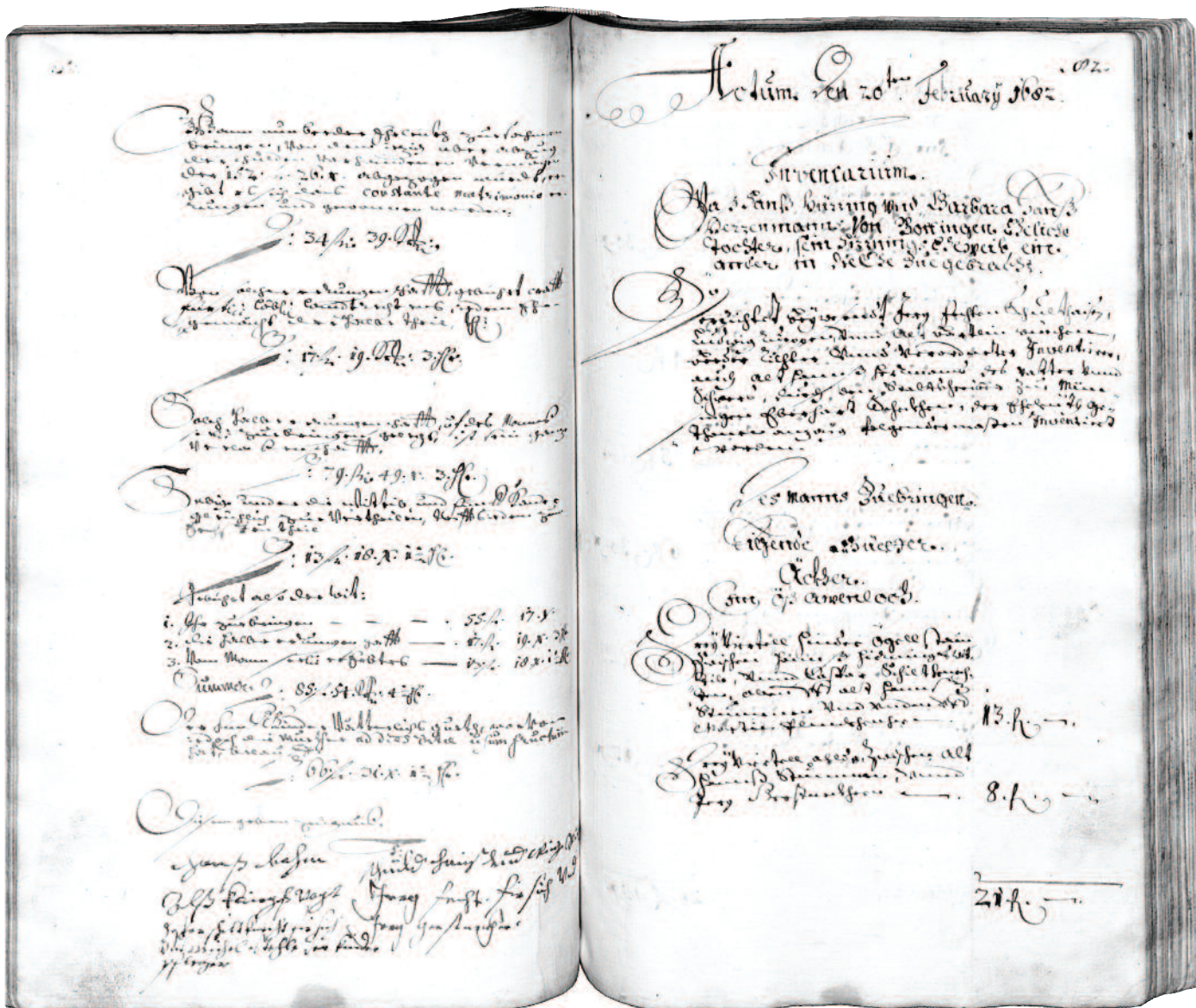


***Eruptions That Shook The World* by Dr Clive Oppenheimer is published by Cambridge University Press**



Dr Clive Oppenheimer

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Marriage inventory of Hanss Hürning and Barbara Herrenmann from the Württemberg village of Auingen, 20 February 1682

300 years of list-making

A collection of personal inventories spanning three centuries is helping researchers to unlock information about how poor European societies in the past improved their living standards, and could hold lessons for developing economies today.

‘One cabbage-spoon, a new dungbarrow, two badger-skins and a half share of an old pregnant mare...’ – so read the belongings of Hanss Hürning on the occasion of his marriage in 1682 to Barbara, owner of ‘nine white bonnets, a new scarlet over-bodice, a small spinning-wheel and a three-year-old red-brown cow.’

Many of us today would find it incredibly difficult to list absolutely everything we own, but in the southwest German territory of Württemberg until 1900 such lists were drawn up over hundreds of years for most newly-married brides and bridegrooms and bereaved widows and widowers.

From clothing to kitchen goods, land to luxuries, the entire contents of homes and businesses were inventoried for inheritance purposes, down to the last oaken water-vat or sack of dried apple slices. And, remarkably, many thousands of these Württemberg inventories survive today.

Now a team of researchers, led by Professor Sheilagh Ogilvie, an economic historian at the University of Cambridge, and funded by the Economic and Social Research Council, is systematically studying these unrivalled documents for the first time to

chart the history of how poor economies improve living standards. They hope that understanding the rise in human wellbeing in European economies over past centuries could hold lessons for developing economies today.

Reconstructing history

Professor Ogilvie first stumbled across the Württemberg inventories as a graduate student 30 years ago: ‘Ledger upon ledger contained lists that in isolation were fascinating but, together, offered an incredible community-wide compendium of who owned what, and how this changed from marriage to death and with successive generations.’

Although inventories survive elsewhere, those in Württemberg are exceptionally detailed, covering marriage and death, women and men, poor and rich, mansions and mousetraps.

For the past three years, the Cambridge researchers have been painstakingly examining each handwritten document, compiling its contents in a vast database, and carrying out multivariate statistical analyses. In so doing, the team is reconstructing 300 years of economic history, from 1600 to 1900,



Masters of the tanners guild; guilds such as this benefited their own members but blocked entrepreneurial activities by outsiders

The wrong trousers

How would you like the government or your neighbours to tell you how to dress?

Traditional societies often have informal customs about what people (especially women) are allowed to wear. But some go further and actually pass laws about it. This is what happened in many parts of pre-industrial Europe. German states, for example, passed at least 1,350 laws regulating clothing between 1244 and 1816.

You might think such laws were unenforceable. But in early modern Germany they *were* enforced. In 1662, for instance, a Württemberg community court reprimanded an unmarried weaver's son "on account of his very wide trousers, a fashion that it is unfitting for him to wear", fined him about two weeks' wages, and warned him that "if he should again put on trousers of this fashion, they shall, by virtue of the Princely Command, be confiscated."

In 1708, another Württemberg village court forbade Magdalena Schöttlin, a local weaver's wife, to wear "her excessively large neckerchief, which she is accustomed to wearing above her station." When Magdalena went on wearing it, she was summoned before the court and fined the equivalent of 11 days' wages for a local maidservant.

Dress laws couldn't totally stop people from doing new things, of course. But they increased the costs and risks of participating in an Industrious Revolution – especially for women, young people and the poor. It may not be a coincidence that in England and The Netherlands, the 'miracle economies' of pre-industrial Europe, dress laws were abolished around 1600, just before their Industrious Revolutions really began to take off.

for two Württemberg communities – the village of Auingen on the Schwäbische Alb and the small town of Wildberg in the Black Forest. In 2013, the completed database will be deposited in the UK Data Archive, which is open to public access.

What really brings the inventories alive is information generated by a previous project, led by Professor Ogilvie and funded by the Leverhulme Trust, which created a full demographic reconstruction of the same two communities. Family trees, fertility and mortality are linked to occupational background, wealth, farm size, household structure, literacy and social networks, and now, through the new project, to individuals' belongings.

To date, 28,000 handwritten folios have been analysed, representing 460,000 separate items of property and their monetary values. For over 3,000 individuals, the researchers now know who they were and what they owned, their gender, age and marital status, place of origin, occupation, credit relationships and office-holding, whether or not they could sign their name, and who were their family members and heirs.

An 'Industrious' Revolution in the making?

This wealth of information is opening a window on how market consumption affects the economy. In fact, it's the most comprehensive attempt yet to investigate the theory of the 'Industrious' Revolution – the idea that the Industrial Revolution was preceded by a time when a growing desire for consumer goods spurred changes in households' time allocation and productivity.

"Aspirations for the latest fashions, furnishings and stimulants motivated people to shift time from leisure and do-it-yourself to income-earning work, creating a virtuous circle," explained Professor Ogilvie. "More work meant more earnings, more earnings meant people could buy more consumer goods, and this spurred producers to innovate and expand."

Up to now, the Industrious Revolution theory has relied almost exclusively on English and Dutch records before c. 1750. But many European economies – such as Germany – were much poorer and slower-growing than the north Atlantic seaboard.

What held Germany back? Professor Ogilvie's past research has pointed towards the dominance of guilds and merchant associations in resisting changes that threatened their monopolies. Guilds erected barriers against even the simplest commercial innovations such as peddling or rural craftwork that brought goods cheaply to poor consumers. Governments and elites tried to control what ordinary people could consume.

"It might be argued that such prohibitions were merely futile gestures, were it not for the fact that people at the time took them quite seriously," said Professor

Ogilvie. "Social norms about the appropriate quantity, quality and style of consumption for particular social groups were enforced with sumptuary penalties and public shaming, even for inviting 'too many' guests to your wedding or wearing excessively wide trousers." [see panel]

This reduced people's ability to buy new goods and their incentive to work more hours to afford them. The German Industrious Revolution was held back until guilds, merchant associations and sumptuary laws broke down, after about 1800.

For the Cambridge project, this means that small changes in what people owned – even the first coffee cup to appear in someone's inventory – are significant because they could indicate the beginnings of an Industrious Revolution.

"We encountered our first coffee cup in an inventory of 1718," said Professor Ogilvie. "After that we expected that a fashion for coffee and its associated equipment would take off, but instead there was no further mention until 1733. We have just found our third coffee cup in 1739. We know that they become common by the 1750s so we are on tenterhooks for the next couple of months while we work our way through the 1740s."

With their gigantic database at their fingertips, the team can ask fine-grained questions such as who started using coffee cups, calico dresses, or any other trend. Were they rich or poor, educated or illiterate, male or female, locals or migrants? The team can trace how rapidly any trend spread and whether – as the Industrious Revolution predicts – it coincided with other household changes.

Tracing such changes in history is important for understanding present-day developing economies, as Professor Ogilvie explained: "We think that household-level changes in consumer behaviour and literacy are good predictors of economic development, lower child mortality, a better position for women, and higher human wellbeing. Now we have a powerful tool to describe these changes accurately – and to explain them."



Professor Sheilagh Ogilvie

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Why is heart disease increasing at a greater rate in South Asia than in any other region globally? Large-scale population studies in Pakistan and Bangladesh aim to discover the basis of a little-studied public health problem of epidemic proportions.



High-risk hearts: a South Asian epidemic

Cardiovascular disease (CVD) is the most common cause of death and disability worldwide. For South Asians, though, this global killer poses an even more sinister threat. Over the past three decades, the incidence of heart attacks and strokes among South Asians has risen steeply. Today, South Asians, even those living in other countries, are considerably more likely to die prematurely from the disease than are other ethnic groups. Moreover, the increase appears to be unrelenting.

The identification of 'classic' risk factors such as blood fats, blood pressure, diabetes and smoking has contributed to a decline in CVD-related deaths in high-income countries. Although the same risk factors apply to South Asians, it seems likely that they may be affected by additional, as-yet-unrecognised, factors.

"The study of vascular disease among people living in South Asia has been comparatively neglected," said Professor John Danesh, Head of the Department of Public Health and Primary Care. "South Asians number 1.5 billion people worldwide, yet until recently there have been few powerful studies tailored to evaluate the distinctive genetic, biochemical and lifestyle risk factors affecting this group."

Now, two population studies jointly led by Professor Danesh and other researchers at the Department of Public Health and Primary Care hope to find some answers. With 35,000 participants, the Pakistan Risk of Myocardial Infarction Study (PROMIS) is the most powerful study so far to search for biological and other risk factors for CVD among Pakistanis. And, despite commencing only in January 2011, the Bangladesh Risk of Acute Vascular Events (BRAVE) study already exceeds any previous study in scale.

PROMIS

"Pakistan is a country of 187 million people, yet fewer than 1,000 patients have been assessed in previous epidemiological studies of heart disease," said Dr Danish Saleheen, who leads PROMIS. "When I was a medical student in Pakistan, infrastructure was lacking to conduct large-scale genetic investigations in that region. Moreover, there were not any instruments or studies that could specifically investigate lifestyle and dietary exposures which are very specific to South Asia in relation to conditions like heart attacks and stroke."

He began a project with colleagues in Pakistan to investigate what it might be about South Asians that makes them more

vulnerable to the development of heart diseases. Were local dietary practices, such as the use of ghee as cooking fat, to blame? Or the many non-cigarette-based ways of consuming tobacco, including chewing, sniffing and ingesting? Or cultural habits such as marriage between first cousins? Or environmental influences such as contaminants in food and water?

After Dr Saleheen moved to Cambridge in 2006 as a Cambridge Commonwealth Trust scholar, the study design was optimised, long-term funding was secured, and full-scale recruitment commenced under the joint leadership of Professor Danesh. It now recruits patients with heart disease, stroke or diabetes at a rate of 10,000 per year from 13 institutes across Pakistan through the Centre for Non-Communicable Diseases in Karachi, whose current Director is Dr Saleheen.

The study is poised to yield a harvest of novel findings. For example, it has recently contributed to the discovery of five genes for coronary artery disease and five separate genes for type 2 diabetes, with the findings published in *Nature Genetics*. Other detailed analyses are in progress with the support of more than £10 million in research funding from the US National Institutes of Health, Wellcome Trust and British Heart Foundation.

Perhaps where PROMIS will have its greatest potential impact will be the evaluation of local risk factors that can be modified. "We are beginning to identify distinctive factors which increase the risk of, or protect against, heart diseases," said Dr Saleheen. "For instance, consumption of ghee and indigenous types of tobacco, including 'naswar', increases the risk of heart attack. Through PROMIS, we are now able to pinpoint the contribution of these factors in a more precise manner than ever before."

BRAVE

Of all South Asian countries, Bangladesh probably has the highest rates of CVD and yet is the least studied. Dr Rajiv Chowdhury, who is himself from Bangladesh, explained the severity of the situation: "In the late 1990s it was estimated that there would be a 100% increase in CVD across South Asia by 2020. But, when you look at Bangladesh, there has already been a 3,500% increase. In the global combat against CVD, Bangladesh is a country 'missing in action'."

Gates Scholar Dr Chowdhury leads the BRAVE study, which began seven months ago in pilot form in readiness for a subsequent large-scale study. Because of the astonishing rate at which patients are arriving at the National Institute of Cardiovascular Diseases in Dhaka, medical officers are recruiting three times as many patients as was anticipated, and the study will reach 1,000 by the end of this year.

"One important objective is to build an epidemiological resource – the first in Bangladesh – to be shared between the

Measures to strengthen Indian public health

A simple piece of software built by PhD student Raghupathy Anchala could, if successful, "prevent the death of millions of people around the world".

In countries with significant public health challenges and few resources, advice received at the first point of contact with a healthcare professional can be literally life-saving. And when it relates to a public health problem as serious as the rise in CVD currently facing South Asia, then the advice could have a major impact on public health.

Raghupathy Anchala, a PhD student in the Department of Public Health and Primary Care, is currently in India trialling his Decision Support System, which aims to help physicians provide optimal care to hypertensive patients, and is based on Indian guidelines. The program guides the physician through which physical measurements and lifestyle factors to record, alerts as to whether the patient is at risk for CVD, and suggests lifestyle and drug management advice to improve the patient's health.

"If this intervention works and is cost-effective, it will provide a very adequate means to prevent the death of millions of people around the world, especially in lower and middle income countries," said Dr Oscar Franco, who is supervising the research.

The project is part of a wider Anglo-Indian initiative to bolster public health training and research in India. Despite substantial economic progress, India faces a chronic inadequacy of public healthcare systems and trained professionals; in 2009, a £5 million initiative funded by the Wellcome Trust was launched to remedy the situation. Professor Danesh is the initiative's lead investigator from the University of Cambridge.

Over a five-year period, the partnership between the Public Health Foundation of India (PHFI) and 14 UK institutions, including Cambridge, aims to train over 70 public health researchers like Raghupathy. On their return to India, the researchers will provide the faculty for up to eight new public health institutes across India.

For more information, please contact the UK-PHFI on-site co-ordinator, Dr Adam Butterworth (asb38@medschl.cam.ac.uk) or Dr Oscar Franco (ohf22@medschl.cam.ac.uk).

"Because of the astonishing rate at which patients are arriving... medical officers are recruiting three times as many patients as was anticipated."

Bangladeshi and UK collaborators with equal intellectual partnership," said Dr Chowdhury, who jointly leads the study with Dr Emanuele Di Angelantonio and Professor Danesh. "The biorepository will be used to test current and future hypotheses relating to potential risk factors to help shape local and global cardiopreventive policies."

Dr Chowdhury is certain that, as in Pakistan, crucial risk factors will be discovered. "Bangladesh has the highest rate of urbanisation and population density in South Asia, and is facing the worst threats of climate change globally. Factors associated with such extraordinary circumstances may have influenced the population's massive shift in epidemiology towards increased CVD. Equally, it could be linked to suboptimal nutrition, widespread environmental contaminants such as arsenic in ground water and plants, or specific vulnerabilities in the genetic or metabolic make-up that have yet to be discovered."



From left: Dr Emanuele Di Angelantonio, Dr Danish Saleheen, Dr Rajiv Chowdhury and Professor John Danesh

For more information, please contact Professor John Danesh (hs428@medschl.cam.ac.uk) at the Department of Public Health and Primary Care (www.phpc.cam.ac.uk/).

Island of broken figurines

Why were Bronze Age figurines smashed, transported and buried in shallow pits on the Aegean island of Keros? New research sheds light on a 4,500-year-old mystery.

On a June morning in 1963, Colin Renfrew stepped from a caique boat onto the scrub-covered Aegean island of Keros on the basis of a tip-off. In search of material for his graduate studies, the young Cambridge graduate had been intrigued by rumours of a recent looting of the almost uninhabited island relayed to him by a Greek archaeologist.

Sure enough, evidence of looting abounded. As he reported back to the Greek Archaeological Service, on whose permit he had been surveying the Greek Cycladic islands, smashed marble statues and bowls and broken pottery lay scattered over the hillside.

Despite the destruction, it was clear that the fragments were Early Cycladic, an interesting find in itself. In fact, as he was to discover, he had also stumbled upon the first evidence of an astonishing Bronze Age ritual.

Broken bodies

A year later, the Greek Archaeological Service carried out a major recovery, finding fragments of a type of sculpture found previously mainly in Cycladic Bronze Age graves. The simplicity of these eerily beautiful figurines, with their folded arms, sloping feet and featureless faces, are said to have inspired Pablo Picasso and Henry Moore.

On Keros, however, apart from a single intact figurine, all others were broken. There were 'body parts' in their hundreds – an elongated foot, a single breast, a folded arm,



a pair of thighs, a face – all jumbled together with broken bowls and pots.

When the 'Keros Hoard', a collection widely believed to be part of the looted material, appeared on the antiquities market in the 1970s and all the fragments were also broken, the mystery deepened. Was the site on Keros an ancient burial ground that, perhaps in haste, had been destroyed by looters, or was the site something else entirely?

A special deposit

A new opportunity to investigate came in 1987, when Renfrew, by then a Professor in the Department of Archaeology, and two Greek archaeologists were permitted to excavate and survey the looted area, which they called Special Deposit North. "We recovered great quantities of broken material and yet as we excavated more we found no indications of tombs," said Professor Renfrew.

Not only were the fragments not grave goods but the first of several astonishing features came to light, as Professor Renfrew explained: "As I studied the marble materials for publication, I realised that nearly all of the breakages seemed to be ancient and not the result of the looting. They had been deliberately broken before burial."

"Although this excavation didn't resolve the puzzle, it did emphasise how rich the site was and how puzzling." The archaeologists felt sure that more light would be shed by the investigation both of an area a few

hundred metres further south that also seemed to be a Special Deposit and of the tiny steep-sided islet of Dhaskalio that lay 80 metres offshore from Keros.

Return to Keros

It was another two decades before Professor Renfrew was able to return, this time for three seasons of excavation, ending in 2008, and with an international team of almost 30 experts. The post-excavation analyses of the finds are now nearing conclusion.

In the first year, the Cambridge-Keros Project team excavated at the southern site and confirmed the presence of another Special Deposit, but this time undisturbed by looters. Many of the materials were bundled together in small pits up to two metres in diameter. The breakages were old and deliberate. Moreover, the absence of marble chips, expected in the case of breakages on the spot, showed the fragments had been broken elsewhere. As later radiocarbon dating confirmed, they had been deposited over a 500-year period from 2800 BC to 2300 BC.

"But the strangest finding of all was that hardly any of the fragments of the 500-odd figurines and 2,500 marble vessels joined together," said Professor Renfrew. "This was a very interesting discovery. The only conclusion we could come to was that these special materials were broken on other islands and single pieces of each figurine, bowl or pot were brought by generations of Cycladic islanders to Keros."



Fragments of figurines found on Keros; almost 800 have been discovered to date

"The breakages were old and deliberate."

Excavation on Dhaskalio, 80 metres off Keros (in the foreground), has revealed a major Bronze Age stronghold

Bronze Age guesthouse?

Meanwhile, across the short stretch of water to Dhaskalio, a very different picture was emerging. From the outset, the islet showed evidence of having been a major Bronze Age stronghold with structures built on carefully prepared terraces circling a summit, on which a large hall was erected. The settlement dates from around the time of the Special Deposits, and then continued to operate before being abandoned around 2200 BC.

Examination of its geology showed that the beautifully regular walling of the settlement was imported marble rather than the flaky local limestone found on Keros. Remarkably, in the same era that the pyramids were being built and Stonehenge was being erected, Cycladic islanders were shipping large quantities of building materials, probably by raft, over considerable distances to build Dhaskalio.

Here, too, there were puzzling finds: a stash of about 500 egg-shaped pebbles at the summit and stone discs found everywhere across the settlement. And, although there was evidence that the olive and vine were well known to the inhabitants of Dhaskalio, the terrain there and on Keros could never have supported the large population the scale of the site implies, suggesting that food also was imported.

One answer is to hypothesise a largely transient population. Several strands make this plausible, as Dr Michael Boyd, who is collating the results of the post-excavation analyses, explained: "Archaeobotanical evidence implies that the site was not intensively occupied year-round, and the imported pottery and materials suggest the possibility of groups coming seasonally from elsewhere."

"A possible attractor to the site," he added, "would of course be the Special Deposit on the immediately opposite shore." In fact, team geologists believe that Dhaskalio and Keros were probably one land mass during the Early Bronze Age and that tectonic movement and rising sea levels created the divide.

Sanctuary

As the team members conclude their analyses of the finds, all indications point towards Keros having been a major ritual centre of the Cycladic civilisation. "We believe that the breaking of the statues and other goods was a ritual and that Keros was chosen as a sanctuary to preserve the effects," said Professor Renfrew.

He speculates that the objects were used repeatedly in rituals in the home islands, perhaps carried in ritual processions in much the same way that icons are paraded today in Greek villages: "They had a use-life, probably being painted and repainted from year to year. Perhaps the convention was that when a figure had reached the end of its use-life, it could not simply be thrown away or used conventionally, it needed to be desanctified in an elaborate process."

"Strangely," he added, "there seems to have been some obligation to bring a piece of the broken figure and deposit it on what must have been the sacred island of Keros, possibly staying a few days on Dhaskalio while the ceremony was completed." The missing pieces of the statues, bowls and pottery have never been located on other islands, and Professor Renfrew wonders if they were thrown into the sea during transit and have long since disintegrated.

This wouldn't be the first time a sanctuary has been identified in the Greek islands – Delphi, Olympia and Delos, for instance – but it would be the earliest by about 2,000 years and certainly the most mysterious.

The Cambridge-Keros project was authorised by the Greek Archaeological Service and supported by the British School at Athens, with funding from the Institute for Aegean Prehistory, McDonald Institute for Archaeological Research, Society of Antiquaries of London, Stavros Niarchos Foundation, British Academy, Leventis Foundation and Leverhulme Trust.



Professor Colin Renfrew

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FluPhone: disease tracking by app

A mobile phone app developed by Cambridge researchers that tracks how people behave during an epidemic could be used to limit disease spread.

Influenza is sweeping the UK, schools are closing, workplaces are short staffed, and the race for a vaccine has begun – all the elements of a scenario that is not so very hard to imagine.

Localised epidemics and global pandemics periodically pose a significant national and global threat. When this

happens, it becomes vital for public health and government authorities to track how far and how fast the disease is spreading. But, to minimise the health, social and economic impact as far as possible, it's also important to know how people are likely to change their behaviour during the course of an epidemic.

"How people behave could limit or exacerbate their risk of infection," explained Professor Jon Crowcroft. "Patterns of social interaction that worsen the spread of disease pose a significant risk. On the other hand, if people stay at home rather than work, the cost to the economy may be

greater than the cost incurred through actual illness."

Understanding how people change their activities during an epidemic might not only help authorities to devise strategies to reduce the scale or length of the crisis but also help them to tailor healthcare messages effectively.

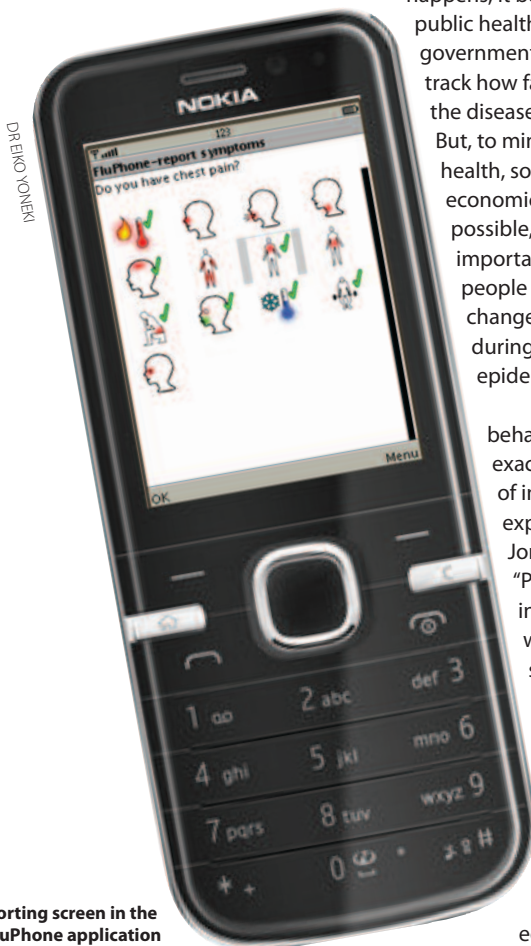
Meet, connect, communicate

The FluPhone study at the Computer Laboratory, led by co-principal investigators Professor Crowcroft and Dr Eiko Yoneki, has developed a new tool to study behaviour and its consequences using mobile phones. Dr Yoneki explained: "The application in the mobile phone monitors influenza-like symptoms by prompting questions for the mobile phone owner. It also captures physical proximity information between individuals by recording other devices nearby via Bluetooth communication."

In a pilot study, volunteers (mainly University of Cambridge employees and students) downloaded a Java-based application to their mobile phones using an intuitive interface. Ethical issues were handled carefully during participant registration to the FluPhone study, and the study did not record the location information using GPS because of ethical considerations.

"A post-facto analysis of these data will yield valuable insight into how human communities are formed, how much time people spend together, and how frequently they meet. Such data show complex network-like structures, which is very useful for understanding the spread of diseases," said Dr Yoneki.

Data collected over a few months – ironically coinciding with an outbreak of



Symptom reporting screen in the FluPhone application

mHealth

The use of mobile communication devices to gather data on how pandemics spread is one of the many innovative applications examined in a wide-ranging study of mobile communications for healthcare (so called mHealth) recently completed by the University.

The report – which is available for download at <http://bit.ly/enEwq3> – describes the mHealth applications that have the potential to transform healthcare worldwide, from remote diagnostics and management of long-term conditions to clinical information systems, targeted public health messaging and supply chain management.

The report uses primary research in China to illustrate the applications being developed by the world's largest mobile telecoms operator, China Mobile (who sponsored the project), together with an extensive literature review of applications in the rest of the world. It also examines the benefits, costs and business cases for deploying mHealth services in developing and developed economies, and outlines the business strategies for telecoms operators.

"In the next phase of deployment, generic service platforms are going to play a crucial role," commented Professor Ian Leslie, lead author of the report. "Until recently, advanced applications required dedicated servers, but the emergence of cloud computing is obviating this need, and the upfront investment required to deploy new applications is coming down. The actors best placed to drive a move toward publicly available platforms are the large network operators."

For more information, please contact project manager Dr Nick Gray (ng338@cam.ac.uk).

Data collected over a few months – ironically coinciding with an outbreak of swine flu – demonstrated the enormous potential of mobile phones as scientific instruments with which to measure the social activity of a population in real time.

they are also considering ways that could be used to counteract unhealthy or risky behaviours, or those that threaten economic stability.

The researchers see potential use for the approach in targeting and measuring the effectiveness of public health messages – something that is traditionally very difficult to do because of the time it takes to gather data using traditional methods that involve surveys through primary care providers. Tellingly, their findings indicate that people are more likely to intend to heed health advice if it is underpinned with an understanding of why people may not be able to conduct a recommended behaviour, such as carrying on working during a pandemic.



Professor Jon Crowcroft and Dr Eiko Yoneki

For more information, please contact Professor Jon Crowcroft (jon.crowcroft@cl.cam.ac.uk) and Dr Eiko Yoneki (eiko.yoneki@cl.cam.ac.uk) at the Computer Laboratory or visit www.cl.cam.ac.uk/research/srg/netos/fluphone/

swine flu – demonstrated the enormous potential of mobile phones as scientific instruments with which to measure the social activity of a population in real time. "There are more cell phones than people," said Professor Crowcroft, "and, in most urban areas, network coverage is close to 100%, hence we can get very accurate measurement and sampling of the population."

In fact, the study highlighted how mobile phones can provide data that would be otherwise unavailable, as Professor Crowcroft explained: "In this particular outbreak, it's now known that some people carried the disease yet were asymptomatic. Our system is capable of identifying these asymptomatic 'superspreaders' because they show up by virtue of the contacts who develop the disease."

To develop the model further, a virtual-disease epidemic application has been prototyped. Dr Yoneki explained: "A specific disease infection model can be programmed, and the fake 'pathogens' can be transmitted via Bluetooth radio communication when two individuals are in proximity range."

"This has proved to be a fantastic tool – you can run a 'what if' experiment on the live population based on their contacts, simply by randomly choosing some of the mobile phones to be infectious," said Professor Crowcroft. "We can then model the effect of behaviour on disease spread."

Given that technology such as this raises ethical issues concerned with privacy, and approval from the relevant ethics committees was required before the project commenced, the team are now developing a series of guidelines. They hope that these guidelines will smooth future deployment of a

communication protocol via a mobile phone app, particularly in the event of a major disease outbreak.

Spreading information

FluPhone is part of a wider project involving seven academic institutions and government agencies led by the University of Liverpool and funded by the Economic and Social Sciences Research Council. The Cambridge team is planning a larger project using the FluPhone technology together with one of the project partners, the London School of Hygiene and Tropical Medicine, to work in several African countries at village population level in Malawi, Kenya, Tanzania, Uganda, Gambia, Ethiopia and Ghana.

Dr Yoneki also leads a new five-year project funded by the Engineering and Physical Sciences Research Council to extend and develop the analysis and modelling approaches used in FluPhone. "Specific individuals can be identified who act as coalescing hubs at different points in space and time and who influence data flow. I want to investigate these spatial and social clusters to determine what impact they have on the spread of viruses."

Together, the multi-institution network of epidemiologists, psychologists, economists and computer scientists is developing new ideas about the different ways individuals and organisations might respond to an outbreak of infectious disease.

These include how people might behave when they or their dependants become ill, why they might avoid populated areas or workplaces for fear of infection, how they might respond if their workplace or school was closed, and what might be driving their attitude to risk and infection. Crucially,

The 'voices' of the artistic elite of Stalin's Soviet Union, among them Dmitri Shostakovich, are being heard afresh in the first comprehensive study of a unique collection of transcripts.

Musical notes from Stalin's prize-givers

The year is 1940 and a team of stenographers are recording every word spoken by an illustrious gathering of the Soviet Union's most influential musicians, composers, artists, actors and writers. The event is the annual gathering of Joseph Stalin's Prize Committee for the arts. As the stenographers preserve verbatim the conversations around them, they unknowingly create what will become a gem of musical history.

Stalin's Soviet Union was a time not only of political persecution and repression but also of artistic censorship. The favoured style was 'socialist realism', which championed the heroes and ideals of the socialist regime, and renounced the more experimental modern styles such as surrealism, futurism and cubism.

This black-and-white portrayal is how many have come to regard the Stalinist regime, but how far did the artists, musicians, writers and composers of the time accept Stalin's dictates? The transcripts of the Stalin Prize Committee – which have astonishingly lain unexamined on the shelves of Moscow archives for over half a century – offer the first chance to look at the situation as it really was.

"It feels like time travel," said Dr Marina Frolova-Walker from the Faculty of Music, who has begun a two-year study of the archive funded by the Leverhulme Trust. "When I began to read the transcripts, their voices lifted off the page. It was as if I was sitting in their meetings listening to the debates as they happened."

Eyes on the Stalin Prize

The dozens of volumes of transcripts cover the annual meetings held between 1940 and 1954, when up to 50 of the main players in the cultural world of Stalin's Soviet Union would meet to discuss the nominations over

a two-week period. Meanwhile, a separate committee would do the same for advances in science, technology and medicine.

Their remit was to decide whose achievements should be honoured through the Stalin Prize – an honour so great in terms of recognition and remuneration that when Geidar Guseinov was awarded the prize only to have it retracted he tragically committed suicide.

"What the transcripts offer is access to how the elite circle made their crucial decisions and how they balanced merit with the ideological constraints of socialist realism," explained Dr Frolova-Walker. "The Committee would make their recommendations but the list would be at the mercy of Stalin's prerogative to overrule. It will be fascinating to compare the final recommendations with what happened after the list reached Stalin."

"Because the meetings lay in a grey area between private and public discourse," she added, "the members felt safe despite the regime, possibly because they were protected by their professions and their institutions. As a result, they are remarkably candid and at times outspoken."

New perspectives

As she works her way through the archive, she is coming across instances that breathe new life into contemporary understanding of the Soviet musical world. "At one point a debate rages as to whether composer Dmitri Shostakovich should receive a Prize, given that his music challenged even the Committee members in how far it broke the mould. One member describes the atmosphere as being as intense as a nuclear laboratory." Shostakovich was himself a Committee member and, in the transcripts, ceaselessly champions the work of his students, talented people who tended not to conform.



Russian State Archive of Literature and Art in Moscow, where the Stalin Prize Committee transcripts are held

MATIAS GO



LUCY

Dr Frolova-Walker hopes to discover lost pieces of Soviet music that did not win the recognition they might have deserved, as a consequence of Stalin's tendency to overrule. "This is a dream opportunity for me, allowing me to combine my experience as a musicologist with the skills I have amassed in my work with historical documents from the Soviet period."

Her detective work in putting together a coherent picture from the documentary raw material will provide the first true insider's perspective on the workings of the Soviet musical world.



Dr Marina Frolova-Walker

For more information, please contact Dr Marina Frolova-Walker (mf263@cam.ac.uk) at the Faculty of Music (www.mus.cam.ac.uk/).



BOTH IMAGES: AXEL STEUWER

out of the window in the back of the ambulance to want to get out there to work.

Have you ever had a Eureka moment?

Realising, as a graduate student, that there is no definitive text of any single saga was a very exciting moment. The sagas were copied continuously in Iceland from the medieval period right up until the 19th century, and even into the early 20th century. They are anonymously authored and each time someone copied a saga from one manuscript they were free to alter the text however they liked, to improve the style or content, for example. The manuscripts bear witness to centuries of human engagement with, and enjoyment of, the sagas. Suddenly, the sagas became more to me than compelling stories printed between the covers of editions lined up on library shelves. The idea that the concept of an 'original text' is irrelevant as far as the sagas are concerned, and also that no single manuscript-text of a saga need be considered the 'best' text, was an extremely liberating one that opened up all kinds of new possibilities for me as far as my research into the sagas, and their transmission and reception, was concerned.

What's the best piece of advice you've ever been given?

My grandfather used to say 'Let the saw do the work' when teaching me and my brother and sister wood-working as children; I can hear him intoning the phrase as though I'm listening to a recording. My carpentry skills never really evolved beyond making various crude constructions that parents seemed to value as presents, but I have come to think that it's not a bad precept to try to live and work by – to utilise the energy, ideas and resources one has already in order to try to move forward and make progress.

If you could wake up tomorrow with a new skill, what would it be?

Waking up with a professional understanding of exactly what's going on under the bonnet of my Land Rover (as well as the Icelandic words for every part of the engine) would be very useful... I am learning on the job, so to speak, and have various manuals to hand (this makes people I've met here who know about cars laugh!). But it's another world in there and I wouldn't say I'm a natural mechanic...

What is your favourite research tool?

This year: my two feet, walking boots and a 31-part set of 1:100,000 maps of Iceland.

Watch out for the next Cambridge Ideas film, featuring Emily's 21st-century pilgrimage to the sites of the *Íslendingasögur*.

Dr Emily Lethbridge

Now mid-way through a year-long 21st-century pilgrimage to the settings of Iceland's famous medieval *Íslendingasögur* ('sagas of Icelanders'), Dr Emily Lethbridge has crisscrossed the country in her ex-MOD Land Rover ambulance on the trail of outlaws, shapeshifters, mound-dwelling viking-zombies, and ordinary men and women who lived in Iceland a thousand years ago.

Written in the 13th and 14th centuries, the *Íslendingasögur* are an extraordinary literary genre that transmit stories about the individuals who lived, loved, fought and died in the 9th, 10th and 11th centuries after the island had been settled by them. To this day, the sagas are a cornerstone of Icelandic culture.

Researcher Dr Emily Lethbridge's quest to travel around Iceland reading each of the 30 sagas in the very landscapes, the 'saga-steads', in which they were set began in January 2011. The decommissioned 'Ambulance' is her mobile home for the duration of the research project.

One objective of her partly sponsored and partly self-funded trip, which can be followed at <http://sagasteads.blogspot.com/>, is to gather material on Icelandic culture for her research in the Department of Anglo-Saxon, Norse and Celtic.

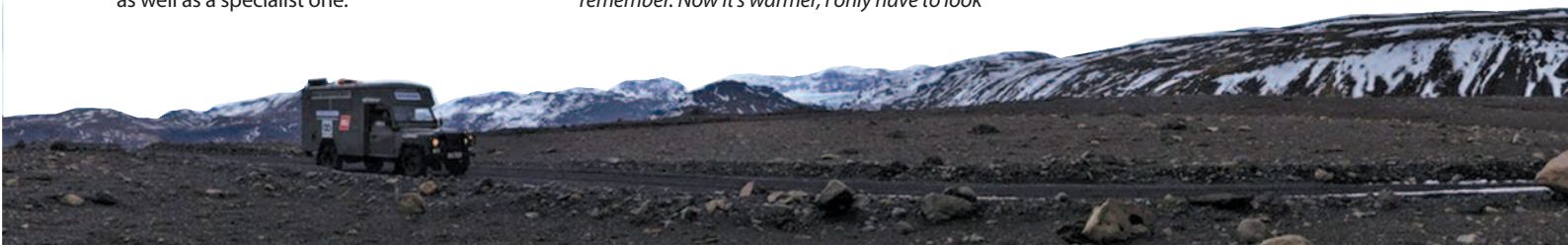
"This kind of 'literary fieldwork' approach is not only strengthening and making my understanding of the sagas more nuanced, both as narratives in themselves and as a medieval and modern cultural phenomenon, but also I hope that the book I'm writing about the sagas and the ways in which they are inscribed in the spectacular Icelandic landscape will appeal to a general audience as well as a specialist one."

What would others be surprised to learn about you?

I can milk a herd of 50 cows on my own and at times I am happiest with shovel in hand and a good half-an-hour's worth of early morning cow-pat clearing-up to get stuck into... I learnt how to speak modern Icelandic by spending the summer of 2008 on a farm in the north of Iceland, during the first year of my Research Fellowship at Emmanuel College. The family on the farm taught me modern phrases and pronunciation (my Old Icelandic vocabulary prompted equal amounts of laughter and bewilderment); the cows taught me to be more patient.

Who or what inspires you?

The magnificence and power of the Icelandic landscape, in all different weathers and at all times of year. I consider myself exceptionally lucky to have this opportunity to explore the endlessly varying terrain across the country in such depth. Travelling and living in the ambulance in the winter months did present certain physical challenges at times, but the northern lights, the perfection of deep unblemished snow on the mountains and in the valleys, and the feeling of exhilaration when storms were raging outside but I was safe and warm in the ambulance will be what I remember. Now it's warmer, I only have to look



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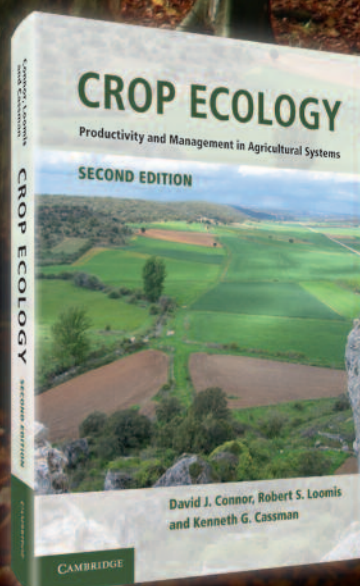
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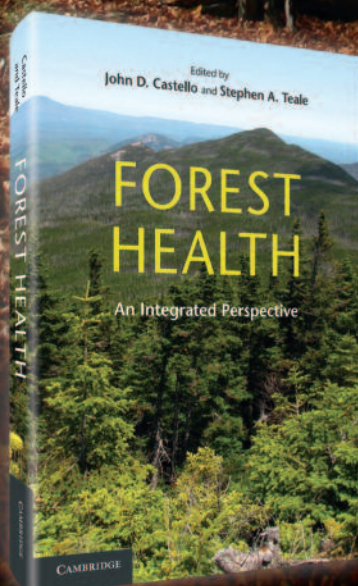
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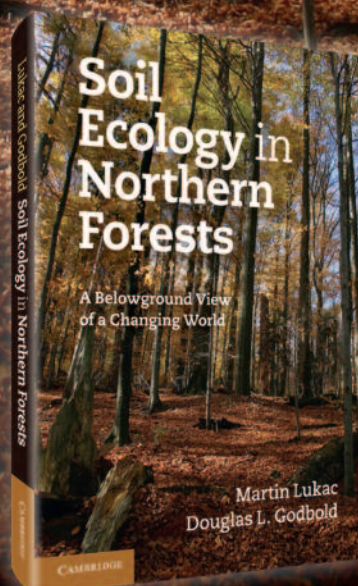
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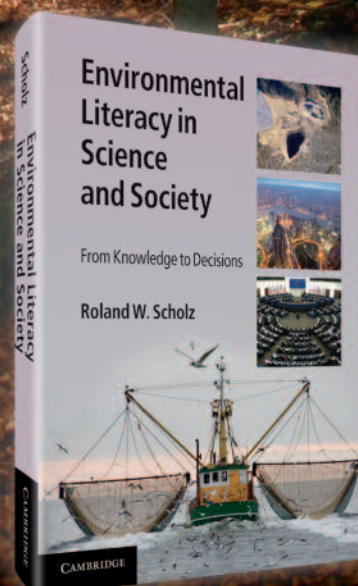
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