RESEARCH HORIZONS

In this issue

BIOENGINEERING and MATERIALS

plus news and views from across the University

UNIVERSITY OF CAMBRIDGE
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Issue 7 | Autumn 2008

Welcome to the autumn issue of Research Horizons, in which we focus on two fast-moving research areas in Cambridge: bioengineering and materials. For bioengineering, the influx of ideas from the physical sciences and engineering into biology is building a flourishing research culture. For materials, innovative research to design higher performance materials with extraordinary properties is being driven by their role in a wide spectrum of applications.

If you would like to hear more about the research activities and collaborations that are defining bioengineering and materials research at Cambridge, join us for the showcase Horizon Seminars on 1 October and 9 December (see page 35 for details).

The two scientists featured on our front cover are engaged in research that spans both bioengineering and materials research. Drs Serena Best and Ruth Cameron lead the Cambridge Centre for Medical Materials in the Department of Materials Science and Metallurgy. They and their colleagues are accomplishing a cross-over between physical and life sciences that is proving vital to the bioengineering of improved materials for medicine.

In a fascinating line-up of other articles, we hear about virtual violins and medical imaging, endangered languages and illicit networks, and what lies beyond the 'terrible twos'. We also take the opportunity to look in detail at two highly successful models of industrial–academic partnership: the Centre for Advanced Photonics and Electronics (CAPE) and the long-established relationship between Rolls-Royce and the University of Cambridge.

I hope that you find much to interest you here, and I welcome your comments and suggestions for future issues.

Louise Walsh

Dr Louise Walsh
Editor
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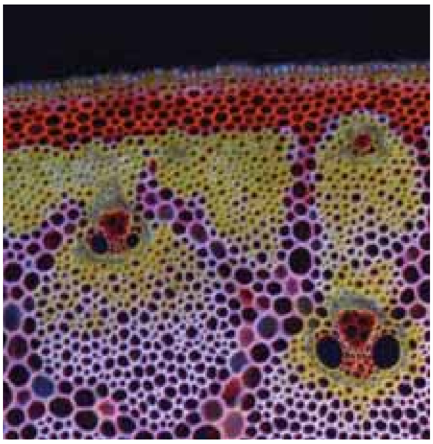
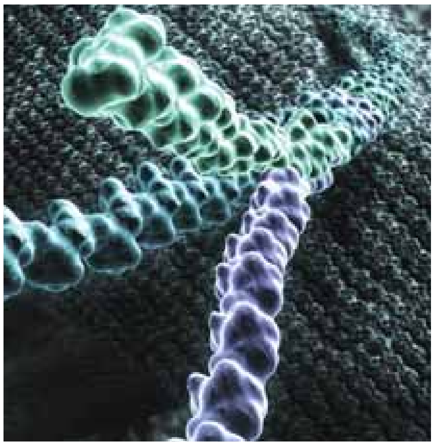


DR JIM HASELOFF

Synthetic biology takes root



DR JON HERAS, EQUINOX GRAPHICS (WWW.E-NOX.NET)

Collagen mechanics: learning from nature

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Cover photograph of Dr Serena Best (left) and Dr Ruth Cameron (Photographer: Mark Mniszko).
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Laboratory of the future

A new £197 million Medical Research Council (MRC) Laboratory of Molecular Biology (LMB) is to be built on the expanding Cambridge Biomedical Campus.

MEDICAL RESEARCH COUNCIL

Design of the new Laboratory of Molecular Biology

Construction of a new building to house the MRC LMB is scheduled to begin later in 2008 and is expected to take three years. Scientists working at the LMB are world-renowned for their revolutionary discoveries in exploring biological processes at a molecular level, and the Laboratory has yielded a total of 13 Nobel prizes since its beginnings in 1947.

'The Laboratory of Molecular Biology has an outstanding track record as an innovator in medical research,' said Sir Leszek Borysiewicz, the MRC Chief Executive. 'The new building will allow the MRC to build on the LMB's position as a globally competitive research centre and continue to attract the best researchers.'

The Government has announced funding of £67 million from the Department for Innovation, Universities and Skills towards the cost of the flagship building. The University will contribute up to £10 million, which includes £7.5 million to lease space for 40 research workers and a substantial commitment from the Wolfson Foundation to cover equipping the University space. Capital generated as a result of the commercialisation of discoveries made at the LMB will contribute to the rest of the cost, funded by the MRC.

The new LMB building will provide 'state-of-the-art facilities for making the discoveries of the 21st century,' said Dr Hugh Pelham, Director of the LMB. It will be sited on the Cambridge Biomedical Campus, which supports research-led clinical care by bringing together the Cambridge University Hospitals NHS Foundation Trust, the University of Cambridge School of Clinical Medicine and the MRC, as well as medical research charities including Cancer Research UK and the Wellcome Trust.

For more information, please contact the MRC Press Office (press.office@headoffice.mrc.ac.uk).

New Centre of Islamic Studies

A research centre opening in October 2008 aims to enhance understanding, tolerance and cross-cultural dialogue between Islam and the West.

The Universities of Cambridge and Edinburgh are to share a £16 million endowment funded by HRH Prince Alwaleed bin Abdulaziz Alsaud, Chairman of the charitable and philanthropic organisation The Kingdom Foundation. The agreement was formalised at a ceremony in Buckingham Palace in May attended by Prince Alwaleed and HRH The Duke of Edinburgh, who is Chancellor of both universities.

The new Centre, known as the HRH Prince Alwaleed Bin Talal Centre of Islamic Studies, will be based in the Faculty of Asian and Middle Eastern Studies. Professor Yasir Suleiman, who led the successful bid, said: 'By conducting research of the highest quality, combined with outreach to the public arena, we intend to foster a deeper understanding between Islam and the West.' Professor Suleiman also retains strong research ties with the University of Edinburgh, from where he moved to Cambridge in 2007.

The two main programmes of research at the Centre will initially consider Muslim identities in the UK and Europe, looking at notions of citizenship, ethnicity and religious values, and will explore how Islam and Muslims are represented in the British and European media. 'These are new areas of research for Cambridge and yet they build on a bed-rock of expertise and scholarship in Islamic Studies,' said Professor Suleiman.

'This new Centre at Cambridge will quickly establish itself as a major force for research, teaching and public understanding,' commented the Vice-Chancellor, Professor Alison Richard. 'By providing a clear, central focus for studying Islam in the contemporary world, as well as engagement with the wider community outside the University, it will harness the richness and variety of Cambridge's contributions to research and teaching on Islam to make the whole far greater than the current sum of our parts.'

For more information, please contact Professor Yasir Suleiman (ys310@cam.ac.uk).

Widening participation in higher education

New research could help improve the learning experience of students from backgrounds where there is little tradition of higher education.

©ISTOCKPHOTO.COM/HEATHER NEMEC

A recent study by Professor Diane Reay from the Faculty of Education and Professor Gill Crozier from the University of Sunderland has reached its conclusion after two years exploring working-class students' experiences of higher education. Funded by the Higher Education Funding Council for England (HEFCE) through the Economic and Social Research Council (ESRC), the study forms part of a wider £30 million Teaching and Learning Research Programme.

'Students from working-class backgrounds bring a complex set of social, cultural and learner issues to university and in turn are met with an array of new circumstances and expectations,' said Professor Reay. The aim of this study was to examine these issues in the context of four different higher education institutions: an 'elite' university, a traditional 'red-brick' institution, a post-1992 university (formerly designated a polytechnic), and a further education college.

The research demonstrated the resilience and commitment that working-class students employ in order to 'get in and stay in'. However, it also showed that the experiences of students attending the four institutions were structurally unequal, with the level of their participation depending on competing demands above the general requirements of their course (such as needing to take paid employment to support themselves or their families). How the institutions supported and responded to these issues determined whether the students' disposition to learning was enhanced or undermined.

'Our findings present insights into the need for higher education institutions to be mindful of the diversity of needs amongst the student body,' said Professor Reay. 'Taking these factors into consideration should address inequalities of provision and support that currently impact on their diverse student intakes, and enable all students to be effective learners.'

For more information, please contact Professor Diane Reay (dr311@cam.ac.uk).

Weaving a web of world history

For five researchers embarking on the project 'Civilizations in Contact', finding the links between each of their specialist fields will provide unique insight into pre-modern world history.

Five scholars have received £1.2 million funding to undertake research that collectively spans five millennia of civilisation. For thousands of years, the movement of ideas, people, trade and religion has linked empires and connected civilisations. Evidence of these communication routes, the major sites where commercial and cultural exchanges took place and the historical background against which these contacts occurred offers a view of world history that transcends geographical boundaries.

'Under the aegis of the Civilizations in Contact project, not only will five scholars each be authoring excellent stand-alone research but also, by tracing the points of contact between them, they will have the opportunity to create something even greater,' explained Professor Geoffrey Khan, the project's Principal Investigator, from the Faculty of Asian and Middle Eastern Studies.

The researchers, Sally Church, Robert Harding, Paul Lunde, Jane McIntosh and Caroline Stone, will each study a period of Afro-Eurasian history. Their research will include trade across the Iranian plateau and through the Gulf; the movement of pilgrims and merchants across the Indian Ocean; the routes taken by diplomatic missions to and from pre-modern China; and the development and administration of emporia in Southeast Asia and Japan. 'Just one example of civilisations in contact is the pilgrimage of hundreds of Chinese monks across the Silk Road into India in the first millennium AD and the important effect this had on the development of Buddhism when they returned to China,' explained Dr Harding.

The project, with offices at Wolfson College, has been funded by the Golden Web Foundation, a charitable foundation with international funding based in Cambridge. Paul Keeler, Director of the Foundation, commented: 'We are delighted to support this project, the fruits of which will be available through our innovative Golden Web system when it launches in 2011.'

'Our aim is to research exchanges across cultural and political boundaries, and to study the evolution of societies and economies in the light of these exchanges,' said Dr Church. 'The history of civilisations in contact reminds us time and again that globalisation is not a new phenomenon, but has a long and significant history, which when investigated can provide fresh perspectives on the world today.'

For more information, please contact Dr Sally Church (skc1000@cam.ac.uk).

ANITA MENON-HARDING

Front row, from left: Caroline Stone, Sally Church, Jane McIntosh; back row, from left: Robert Harding, Paul Lunde

'Academic Incubator' to develop new medicines of value

GlaxoSmithKline (GSK) has signed its first agreement with the University to optimise the early clinical development of new GSK medicines for obesity and addictive disorders.

The ground-breaking concept of the 'Academic Incubator' will tap into the highest quality thinking in academia to optimise the early clinical development of new GSK medicines in a model of shared risk and reward. The new agreement provides a framework for a team of academic experts led by Professors Ed Bullmore, Barry Everitt, Trevor Robbins, Paul Fletcher and Stephen O'Rahilly, from the Departments of Psychiatry and Experimental Psychology and the Institute of Metabolic Science, to develop a novel centrally acting agent with therapeutic potential for obesity and addictive disorders.

'Sometimes drug development needs to cut across traditional boundaries, and the development of drugs that act on the brain to deliver health benefits in terms of reduced body weight is a good example,' said Professor Bullmore. 'The University has established expertise in both neuroscience and metabolic science and, importantly, there is already a strong track record of interdisciplinary research between these groups. This was particularly attractive to GSK as a scientific environment to support the innovative development of centrally acting anti-obesity drugs.'

Although Cambridge is the first academic institution to pioneer the incubator model of working with GSK, it is not expected to be the only one if the model proves successful here. Clinicians and scientists at carefully selected academic institutions worldwide will be expected to challenge industry norms and set a unique path for preclinical and early clinical development activities that will deliver on the promise of an asset at the earliest stage. Importantly, the agreement also allows the academic scientists freedom to publish results arising from their work on incubator projects.

'This puts academia–industry relationships on a new footing and allows academics who are leaders in their fields the opportunity to become directly involved in developing medicines for patients and to have the freedom to take the programme in exciting new directions,' said Patrick Vallance, Senior Vice President, Drug Discovery at GSK. In support of all its incubator projects, GSK will provide operational support, access to in-house clinical research and imaging facilities, and background preclinical data on the drug. For incubator projects based in Cambridge, an important component of GSK's support for the academic teams will be provided by the facilities and staff of GSK's Clinical Unit Cambridge. The Unit is embedded in the Cambridge Biomedical Campus in close physical proximity to departments of the School of Clinical Medicine and the Wellcome Trust Clinical Research Facility.

Patrick Sissons, Regius Professor of Physic and Head of the School of Clinical Medicine in Cambridge, said: 'We place great value on our relationship with GSK and are delighted to be working with them in this innovative new partnership between leading clinical scientists in the University and industry.'

For more information, please contact Professor Ed Bullmore (etb23@cam.ac.uk).

CAMBRIDGE IMMUNOLOGY

A new initiative launches to showcase the University's strength and depth in immunology research.

Cambridge has a long tradition of world-leading research into immunology – the study of how the immune system functions in both health and conditions such as diabetes, cancer, rheumatoid arthritis, AIDS and other infectious diseases. Now a new initiative hopes to bring together the numerous groups working in this field to capitalise on current strengths, and to help those outside Cambridge to easily navigate their way around this diverse and exciting area of research.

'Cambridge Immunology will help support immunology researchers across Cambridge, creating a real sense of community, and building new interactions and collaborations,' said Professor Ken Smith, Genzyme Professor of Experimental Medicine and Chair of the Cambridge Immunology steering committee. 'It will also raise visibility of the breadth and depth of Cambridge's expertise in this field to the wider world, including potential students, job applicants and funders.'

Cambridge Immunology will be formally launched at the 'Visions of Immunology' conference in Cambridge on 25 September 2008. To register as part of the Cambridge Immunology community, please visit the website www.immunology.cam.ac.uk, which will be launched in late September.

What are the real costs of outsourcing abroad?

Many UK manufacturers have transferred their production to low-cost regions to reduce costs. But a new study has discovered that these savings are not as substantial as they first seemed.

Cheap labour has been an incentive for manufacturers to outsource their production abroad, but there are many uncertainties and risks involved in having a distance between the host location and the outsourcer. These uncertainties and risks can lead to unexpected costs – for example, rising oil prices affect shipping costs – which can offset any gains made from cheap labour or, in some cases, result in losses to the outsourcer. A recent study by Drs Ken Platts and Ninghua Song of the Centre for Strategy and Performance in the Institute for Manufacturing has investigated the real costs involved in sourcing from China.

To arrive at a complete picture of all the potential costs, they developed a total-cost model covering 15 items of set-up cost and 36 items of ongoing cost. The model was then applied, using in-depth case studies, to nine products sourced from China. They found that the quoted price, on average, accounted for only 65% of the total cost incurred, but there was high variability from product to product. In the worst case they investigated, the total cost was almost four times the quoted price.

The case-study research was followed by a survey into companies' perceptions of China sourcing costs. This, taken with the case studies, suggested that companies tended to underestimate the non-price costs of sourcing from China by about 30%, often underestimating costs for extra warehousing to cope with variable demand, and inspection to cope with variable quality.

The cost data were collected during 2006/7, before the recent oil price explosion, so we might expect that, as transportation costs increase, the ratio of total cost to quoted price will also increase.

For more information, please contact Dr Ken Platts (kwp@eng.cam.ac.uk) or Dr Ninghua Song (ns359@cam.ac.uk).

Montaigne moves to Cambridge

A magnificent new collection at the University Library makes Cambridge a major international centre for Montaigne scholarship.

Cambridge University Library has received an outstanding collection of books relating to Michel de Montaigne (1533–1592), author of the celebrated *Essais,* who famously declared 'I am myself the matter of my book.'

The Montaigne Library was assembled by the Montaigne scholar and financier Gilbert de Botton (1935–2000). Peter Fox, University Librarian, explained: 'The motivation behind Gilbert de Botton's remarkable collection was the desire to recreate Montaigne's library – by buying either Montaigne's personal copies or other copies of works known to have belonged to him. He was able to purchase 10 of Montaigne's own books.'

Among the books is Montaigne's copy of Lucretius' *De Rerum Natura* (1563), an important influence on his life's work. It is covered with Montaigne's annotations, allowing scholars to trace in detail how he read and used his source. There is also a fine set of editions of Montaigne's works, including copies owned by Ben Jonson and Jean-Jacques Rousseau, and an impressive collection of secondary works, which means that Cambridge is now a major centre for Montaigne studies.

Philip Ford, Professor of French and Neo-Latin Literature at Cambridge, said, 'Thanks to Gilbert de Botton's passionate interest in Montaigne, future generations of Montaigne scholars will be able to share in his interest by consulting this magnificent collection in its new home in Cambridge University Library.' A monograph by Professor Ford, published by the University Library, gives further information on the scope and content of the collection.

The acquisition is marked by a conference of the French Department's Cambridge French Colloquia in September 2008, devoted to the 'Librairie de Montaigne', and an exhibition of items from the collection, *'My booke and my selfe': Michel de Montaigne 1533–1592*, which runs until 23 December 2008 at Cambridge University Library.

Portrait of Montaigne by Pierre-Michel Alix (1792)

For more information, please contact Dr Jill Whitelock (jw330@cam.ac.uk), Head of Rare Books at Cambridge University Library, or visit www.lib.cam.ac.uk/exhibitions/Montaigne

Re-interpreting Greece and Rome at The Fitzwilliam

Recent funding will enable collaboration between classicists and museum curators, and shape a major re-display of Greek and Roman art and archaeology.

Scholars from The Fitzwilliam Museum and Faculty of Classics have won a major Arts and Humanities Research Council (AHRC) grant to undertake research that will underpin the re-display of the Museum's Greek and Roman collections. The three-year project grant funds a full-time research assistant and aims to bring university-based research in classical art and archaeology into conversation with museum-based display practices.

Traditional museum displays of Greek and Roman material tend to privilege either a chronological or a thematic approach. The former offers a stylistic history of Greek and Roman art that plays down the original context and nature of the objects, while the latter presents these objects as though transparent evidence for 'daily life'. Both leave out of the picture the role of collectors in shaping museum collections.

Recent research has exposed the inadequacy of seeing the history of art purely in terms of stylistic progression, and has improved our understanding of the importance of changing technology, the complexities of workshop practices, and the role of ancient markets in influencing production. The Fitzwilliam re-display offers an opportunity to re-assess the collections both in the light of these advances and as collections.

'The project will put people back into the history of art and provide an important opportunity to integrate The Fitzwilliam's collections into the study of classics in Cambridge,' explained Dr Lucilla Burn, Keeper of Antiquities and Principal Investigator. 'It will also provide the Faculty with both the opportunity to engage with actual objects and a broader public forum in which to share and transfer their knowledge and expertise,' added Professor Robin Osborne who, with Dr Caroline Vout and Professor Mary Beard, represents the Faculty of Classics component of the project.

The research will be disseminated to the public in an online public-access catalogue and new web pages for 'virtual' visitors. Talks, workshops and family activities drawing on the research will also be an important part of the Museum's education provision for children and adults.

Head of Antinous, Roman c. AD 130–140

For more information, please contact The Fitzwilliam Museum (www.fitzmuseum.cam.ac.uk).

Sharing and researching best practice in human resources

Judge Business School have launched a major new forum devoted to excellence in global human resource management – the Centre for International Human Resource Management (CIHRM).

The Centre will draw on a high-profile network of academics and industry experts to assess the major human resource (HR) challenges, priorities and concerns that face international organisations today. Dr Philip Stiles, Director of CIHRM, said: 'Our partnership approach will provide a forum for intellectual thought-leaders and practitioners throughout the world to collaborate and shape relevant, rigorous research agendas. Our aim is to be a real source of distinctiveness and expertise.'

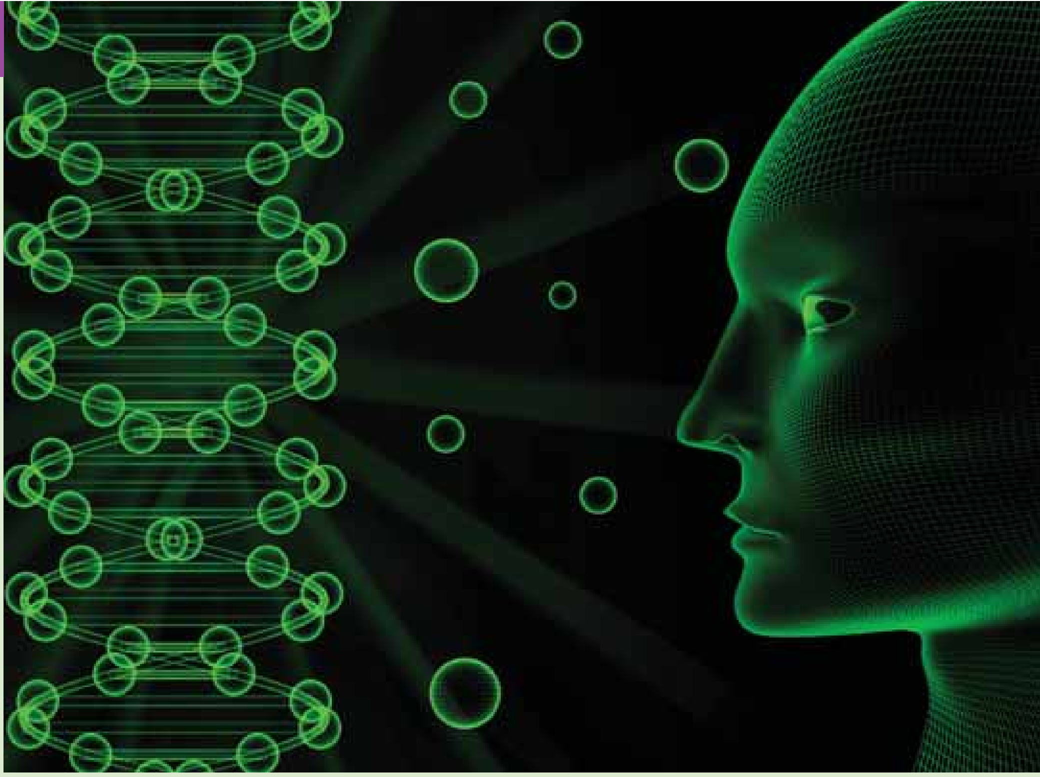
CIHRM will bring together companies and faculty to discuss the latest research findings and debate innovative advances in practice. The Centre already has existing relationships with global companies such as Rolls-Royce, British Telecom, Shell, General Electric, IBM, Coca-Cola, Samsung and Unilever, and other leading academic institutes including Cornell University, Erasmus University and INSEAD.

By developing the Centre's academic partnerships, it will bring together the very best HR researchers to generate fresh understanding of the processes and practices by which international organisations manage their people. This research will be guided by the interests of the companies within the Centre. In addition, CIHRM offers a range of cutting-edge executive education programmes to its corporate partners on organisational development and change issues, as well as consultancy support to assist them with the transition from 'concept to action'.

Dr Stiles explained: 'With companies operating in increasingly difficult environments, key issues such as managing talent, improving employee performance and developing leadership skills are paramount, as well as how to make tough choices such as restructuring, downsizing and offshoring.' Dr Jonathan Trevor, Deputy Director, added: 'Through CIHRM and its international network, we aim to provide our partners with insightful skills and tools to address these issues, leading them and their organisations to improved business efficiency and profitability in an increasingly global and competitive environment.'

For more information, please visit www.jbs.cam.ac.uk/research/centres/cihrm

Single component biology is past; bioengineering has begun



The Horizon Seminar 'Bioengineering' takes place on 1 October 2008. Here, Professor Nigel Slater, from the Department of Chemical Engineering, describes how the influx of ideas and principles from non-biological disciplines is shaping a new biology.

The University of Cambridge has become increasingly aware of the major importance of recent advances at the interface between the life sciences, physical sciences and engineering. A key challenge is to assist the evolution of the established reductionist 'molecular' view of biology into a more quantitative, data-rich and predictive science, with an holistic and integrative understanding of its principles.

Research activities are crossing disciplines in efforts to address complex biological systems and provide technical solutions to current and emerging global concerns. Researchers are using new tools in predictive biology and synthetic biology for bio-product design – seeking to go beyond the analysis of enzymes, metabolic networks and cells to consider functionality and delivery as intimately linked elements of the design process. Developments in Cambridge are breaking new ground in biomechanics, tissue engineering and biomimetics: from strategies for restoring function to the damaged nervous system, to next-generation medical implants that interact therapeutically with the body, to the development of mechanically robust bone-like materials for engineering purposes.

The need to integrate expertise in multidisciplinary research environments is well recognised in Cambridge, and 2008 sees the launch of two new research complexes. The Centre for the Physics of Medicine at the West Cambridge Site brings together researchers from the medical, biological and physical sciences to solve problems in healthcare and cell biology; and the Laboratory for Regenerative Medicine at the Cambridge Biomedical Campus provides a link between stem cell biologists, tissue engineers and clinicians for translating fundamental stem cell research to clinical benefits.

Systems biology also describes a multi-component approach, combining theoretical modelling with real data about the interaction between genes and their products. Arising from this is the need to interpret large datasets of complex biological information. The recently launched Cambridge Systems Biology Centre is enabling research groups from different disciplines to interact closely and develop a long-lasting multidisciplinary research environment.

This Horizon Seminar will showcase the fast-moving landscape of research activities and collaborations in Cambridge. Speakers' presentations will illustrate the diversity of challenges that are being addressed and the novel ideas that are resulting from the integration of skills that characterises emerging bioengineering.

Professor Nigel Slater

The Horizon Seminar takes place at the Centre for Mathematical Sciences, Cambridge, on 1 October 2008. For more information and to book online, please visit www.rsd.cam.ac.uk/events/horizon

Participating speakers

Dr Ruth Cameron/Dr Serena Best, Department of Materials Science and Metallurgy
Professor Athene Donald, Centre for the Physics of Medicine
Sue Dunkerton, Health Technologies Knowledge Transfer Network
Professor James Fawcett, Centre for Brain Repair
Professor Lisa Hall (tbc), Institute of Biotechnology
Dr Jim Haseloff, Department of Plant Sciences
Dr Roman Hovorka, Institute for Metabolic Science
Professor Steve Oliver, Cambridge Systems Biology Centre
Dr Michelle Oyen, Department of Engineering
Professor Roger Pedersen, Laboratory for Regenerative Medicine
Dr David Summers, Department of Genetics

Synthetic biology takes root

Creating circuits from multiple components is routine in engineering. Can living systems be constructed using similar principles?

Living systems are complex, often involve tens of thousands of genetically encoded components, and possess feedback mechanisms for self-organisation, reproduction and repair. They produce functional structures that are many orders of magnitude more complex than the most sophisticated man-made artefacts known today. It is generally accepted that understanding such complex genetic systems requires more than a description of its component parts; knowledge of the dynamic interactions within a system is also essential. The emerging field of synthetic biology aims to employ principles of standardisation and decoupling, well known in engineering, to construct complex biological circuits that behave just like living systems.

Scaling up from microbes

Synthetic biology uses well-characterised and reusable genetic components in combination with numerical models for the design of biological circuits. For microbes, this approach is providing a powerful conceptual and practical framework for the systematic engineering of gene expression and behaviour.

Can the same be achieved for multicellular systems, with their greater diversity of cell types and biochemical specialisation? Of all multicellular systems, plants are the obvious first target for this type of approach. Plants possess indeterminate and modular body plans, have a wide spectrum of biosynthetic activities and can be genetically manipulated. Assembling new feedback-regulated genetic circuits could modify plant form and biosynthetic activities, with the ultimate prospect of using them in crop systems for the production of biomass, food, polymers, drugs and fuels.

DR JIM HASELOFF

Plants provide an excellent target for approaches in synthetic biology

Engineering plant systems

A systematic approach to engineering plants requires a suitable control circuit to be established by combining interchangeable DNA parts, devices and systems. Not only must robust gene expression be achieved at an appropriate level, time and place during the plant's lifecycle, but the circuit must also trigger the expression of suitable genetic markers that alter the characteristics of the organism.

In the Department of Plant Sciences, a unique library of genetic circuits and interchangeable parts (PhytoBricks) is being created for the biological engineering of plant systems. A software environment has also been constructed to model the properties of the multicellular system, describing both the physical interactions between cells and the cells' genetic properties. This allows the design and testing of new morphogenetic programs *in silico*, before creating the plant systems themselves.

The future

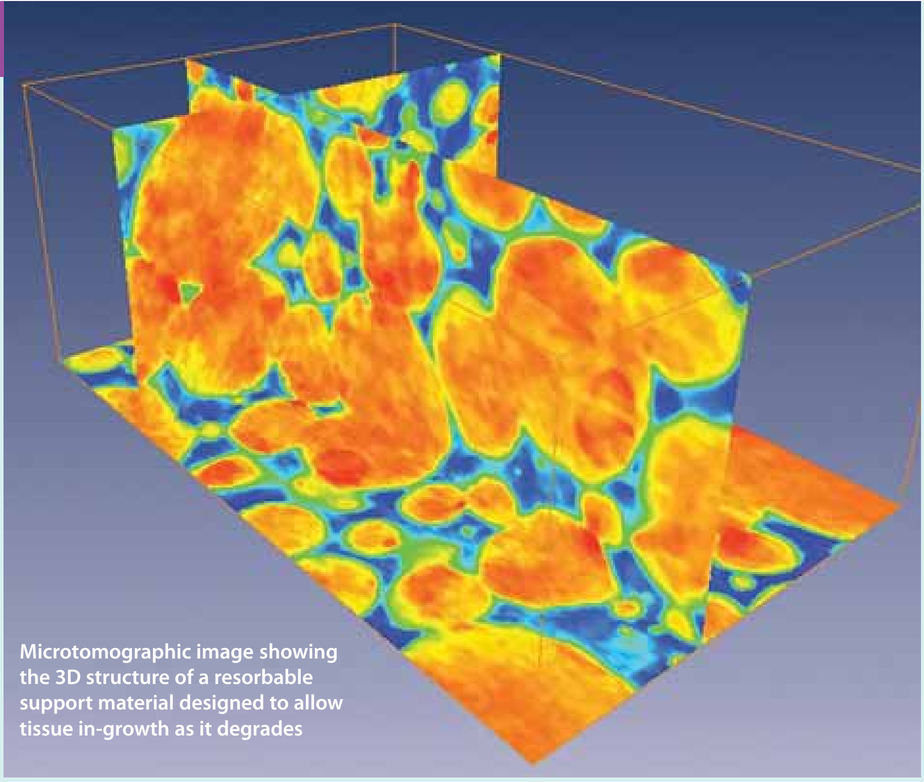
The growing application of engineering principles to biological design and construction marks a practical transition for biological research. As part of this shift, synthetic biology is beginning to offer improved rational design and reprogramming of biological systems. It holds great promise for the future improvements in microbial, plant and animal cell engineering that are clearly needed for the renewable technologies of the 21st century.

Dr Jim Ajioka (left) and Dr Jim Haseloff

For more information, please contact the authors Dr Jim Haseloff (jh295@cam.ac.uk) at the Department of Plant Sciences or Dr Jim Ajioka (ja131@cam.ac.uk) at the Department of Pathology.

An annual, worldwide, open design challenge for students – to design and test a simple biological system from standard, interchangeable parts and to operate it in living cells – is held by the Biological Engineering Division of Massachusetts Institute of Technology (MIT)'s Computer Science and Artificial Intelligence Laboratory. This competition, known as the International Genetically Engineered Machine (IGEM; www.igem.org), has played a special role in the development of synthetic biology as a field in Cambridge, acting as a nucleus for a growing network of researchers to collaborate; scientists from eight departments and three nearby institutes now work together through the Cambridge iGEM project. In 2007, the Cambridge team received Gold Awards and a prize for the best BioBrick (see www.synbio.org.uk).

Next-generation medical implants


LISA EHRENFRIED

Microtomographic image showing the 3D structure of a resorbable support material designed to allow tissue in-growth as it degrades

At the Cambridge Centre for Medical Materials, a highly interdisciplinary approach is meeting the challenge of bioengineering new materials for the human body.

It's easy to take the complex and specialised materials that make up our bodies for granted, until something goes wrong. However, replacement tissue is something that most of us will need at some point in our lives. It might take the form of a permanent implant like a replaced hip or knee or it could be a structure designed to be absorbed as the body heals. Members of the Cambridge Centre for Medical Materials (CCMM), a research group headed by Drs Ruth Cameron and Serena Best, are tackling the many questions that surround the design and engineering of effective medical materials.

Medical materials

The first requirement of a material for implantation is that it is non-toxic. Materials that are biocompatible in this sense can be used successfully, particularly if their mechanical properties match as closely as possible those of the original tissue. However, rather than using an inert structure, what if the material could interact in a positive way with the biological system around it? This could encourage a stronger integration of surrounding tissue with the implant, or even stimulate the regrowth of new specific tissue to entirely replace the implant over time. It is these novel types of medical materials that CCMM research projects aim to deliver.

Tailored tools

The demand for high-performance orthopaedic implants continues to grow, both for the treatment of bone diseases in an ageing population and for sports-related injuries. CCMM is developing materials to replace bone, cartilage, ligament and spinal discs: materials that interact therapeutically with the body; bioactive structures that encourage the tissue's natural function; and scaffolds that provide tailored load-bearing support and yet are porous to allow regeneration of new bone. In particular, methods are being investigated to encourage the patient's bone to bond to orthopaedic implants, which would improve implant lifetime and performance.

The group is also creating guides for nerve regeneration in damaged limbs, to attract and selectively steer neurons in a specific direction and to repel cells that cause scar tissue formation. Artificial mammary gland structures are being built as models for screening new drugs. And further lines of research include the delivery of active agents to the body, both in combination with devices and as pharmaceutical delivery systems in their own right.

Working at the edge of disciplines

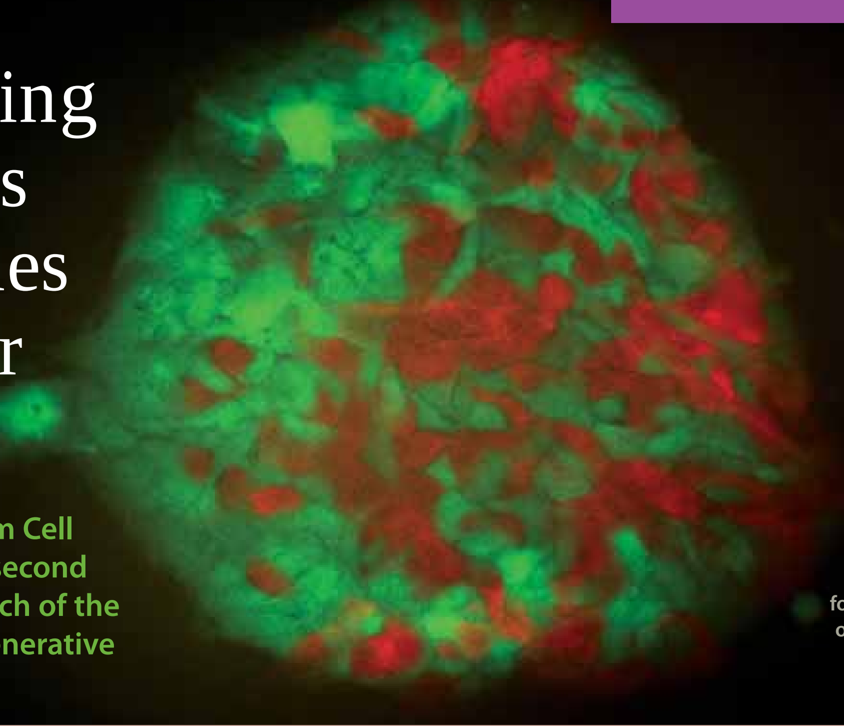
Established six years ago, the group is strongly interdisciplinary and has dozens of collaborations with departments within the University, across the UK and with research bases around the world. This means that new research builds on a wide network of expertise, interlocking the knowledge of material scientists, physicists, chemists and engineers with that of cell biologists, biochemists, pharmacists, pathologists, surgeons, dentists and vets.

There is also a high level of collaboration with the medical devices industry – a must if the new materials developed are to reach the clinic. This has included the creation of spin-out companies; the most recent is Orthomimetics, an award-winning company and the first spin-out from the Cambridge-MIT Institute, which is developing products for regenerative repair (see page 34 this issue). With the right combination of expertise, it's clear that there is huge potential to engineer improved active materials for the next generation of medical implants.

Dr Serena Best (left) and Dr Ruth Cameron

For more information, please contact the authors Dr Ruth Cameron (rec11@cam.ac.uk, Lucy Cavendish College) or Dr Serena Best (smb51@cam.ac.uk, St John's College) at the CCMM (www.msm.cam.ac.uk/ccmm) in the Department of Materials Science and Metallurgy.

Engineering stem cells and tissues for better health



DR ISABELLE BOUHON

A colony of human embryonic stem cells formed from a mixture of cells expressing red or green fluorescent proteins

The Cambridge Stem Cell Initiative enters its second phase with the launch of the Laboratory for Regenerative Medicine.

Imagine a time still some years into the future. You are among the 1 in 10 people who will experience cellular degeneration at the centre of the eye's retina as part of their ageing process. Following your diagnosis and selection as a patient, you enter the Treatment Centre for a transplant to your pigmented retina that will arrest the degeneration and preserve your remaining sight. The transplant has been generated by combining a bioengineered fabric (the scaffold) with stem-cell-derived pigmented retina cells (the cargo), and it will take over the function that has been lost by your own degenerating cells.

Although still hypothetical, this scenario is a realistic goal of the Cambridge Stem Cell Initiative. Launched in 2002, the Initiative brings together stem cell scientists, bioengineers and medical researchers to achieve 'translation' of basic discoveries to therapeutic applications. The University of Cambridge has invested over £30 million refurbishing and equipping two buildings for stem cell research: its first phase, the Wellcome Trust Centre for Stem Cell Research, was launched in December 2006 and is located in the heart of the University's Biological Sciences campus in central Cambridge. The Initiative is now entering its second phase with the launch of the Laboratory for Regenerative Medicine (LRM) on the Addenbrooke's Hospital Cambridge Biomedical Campus.

Regenerative medicine

Cambridge's stem cell researchers have been focusing mainly on understanding the properties of stem cells in 'model systems' that can be studied in the Petri dish. These provide a vital source of fundamental knowledge that will underpin future clinical initiatives. With the opening of the LRM in September 2008, this basic knowledge platform is extending into areas needed for successful human tissue engineering, enhancing the University's capacity to deliver novel clinical treatments through stem cell research. Substantial funds have also been contributed to refurbishing and equipping the LRM building by the Royal Society (together with the Wolfson Foundation), the British Heart Foundation (BHF), the Medical Research Council (MRC) and the Isaac Newton Trust.

Engineering for health

Our bodies are constantly changing – they renew and remodel themselves, even daily in some tissues such as intestine, skin, blood and bone. 'Embryonic stem cells' are developmentally powerful because they can form all of the body's approximately 200 different tissues. The regulatory interaction between stem cells and their local environment (known as their 'niche') works somewhat like a point-of-sale inventory system that arranges for new items to be manufactured as pre-existing items are sold or used. Future versions of tissues engineered for clinical applications will ideally share this self-renewing property of stem cells, possibly by incorporating stem cells in their manufacture.

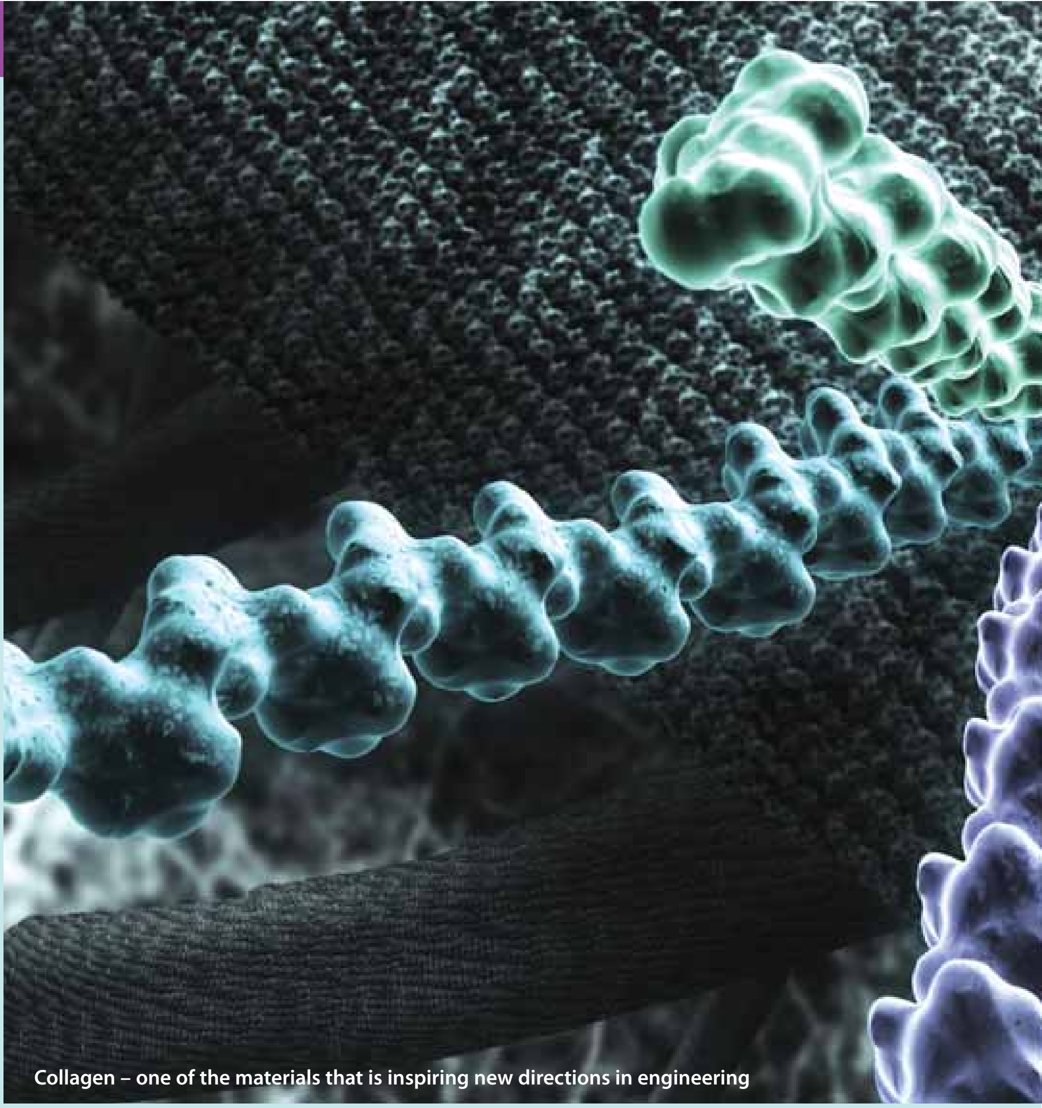
This requires a leap in our knowledge about stem cells and their more specialised descendants. It will be particularly important to learn how stem cells of various types maintain their unique quality of self-renewal, how they regulate production of the more specialised cells that make up most of any tissue or organ, and how they interact with their niche. With its focus on human stem cell medicine, the LRM will contribute to this knowledge, thereby providing a platform for numerous clinical applications. These will include not only cellular transplants, but also cells for drug testing and for the discovery of medicines that improve the function of our body's own stem cells.

Professor Roger Pedersen

The LRM will be named in memory of Cambridge researcher Dame Anne McLaren, whose vision for turning stem cell research into regenerative medicine inspired the Cambridge Stem Cell Initiative.
For more information, please visit www.stemcells.cam.ac.uk or contact the author Professor Roger Pedersen (Medicine@stemcells.cam.ac.uk).

Collagen mechanics: learning from nature

Because of their unique structure, biological tissues exhibit physical and mechanical properties that are unlike anything in the world of engineering.


Collagen – one of the materials that is inspiring new directions in engineering

Mention the word 'biology' and most people think immediately about cells. However, large portions of the human body are non-cellular and are made instead from an extracellular matrix (ECM) that provides much of the structural support around cells. This supportive function of the ECM is especially evident in the connective tissues of the body. Many load-bearing structures such as bones, teeth and ligaments are connective tissues and these have been the focus of recent bioengineering research in Cambridge.

Dr Michelle Oyen, Lecturer in the new Engineering for Life Sciences programme in the Department of Engineering, is studying the mechanical functions of connective tissues. Her research ranges from fundamental science and engineering projects through to collaborative projects with clinicians for developing mechanics-based tools for use in medical practice. The unifying theme of this research lies with the primary component of many connective tissues: the structural protein collagen.

Building blocks of natural materials

Collagen is ubiquitous; this triple-helical protein makes up a quarter of all proteins in the body. It self-assembles from the molecular scale up to large fibre-like structures, creating a hierarchical material with remarkable physical properties. Collagen combines with other ECM components – mainly water, non-collagenous proteins and sugars – and, in mineralised tissues, with bioceramics analogous to earth minerals. These non-living, but cell-derived, materials combine with cells to form living yet mechanically robust tissues.

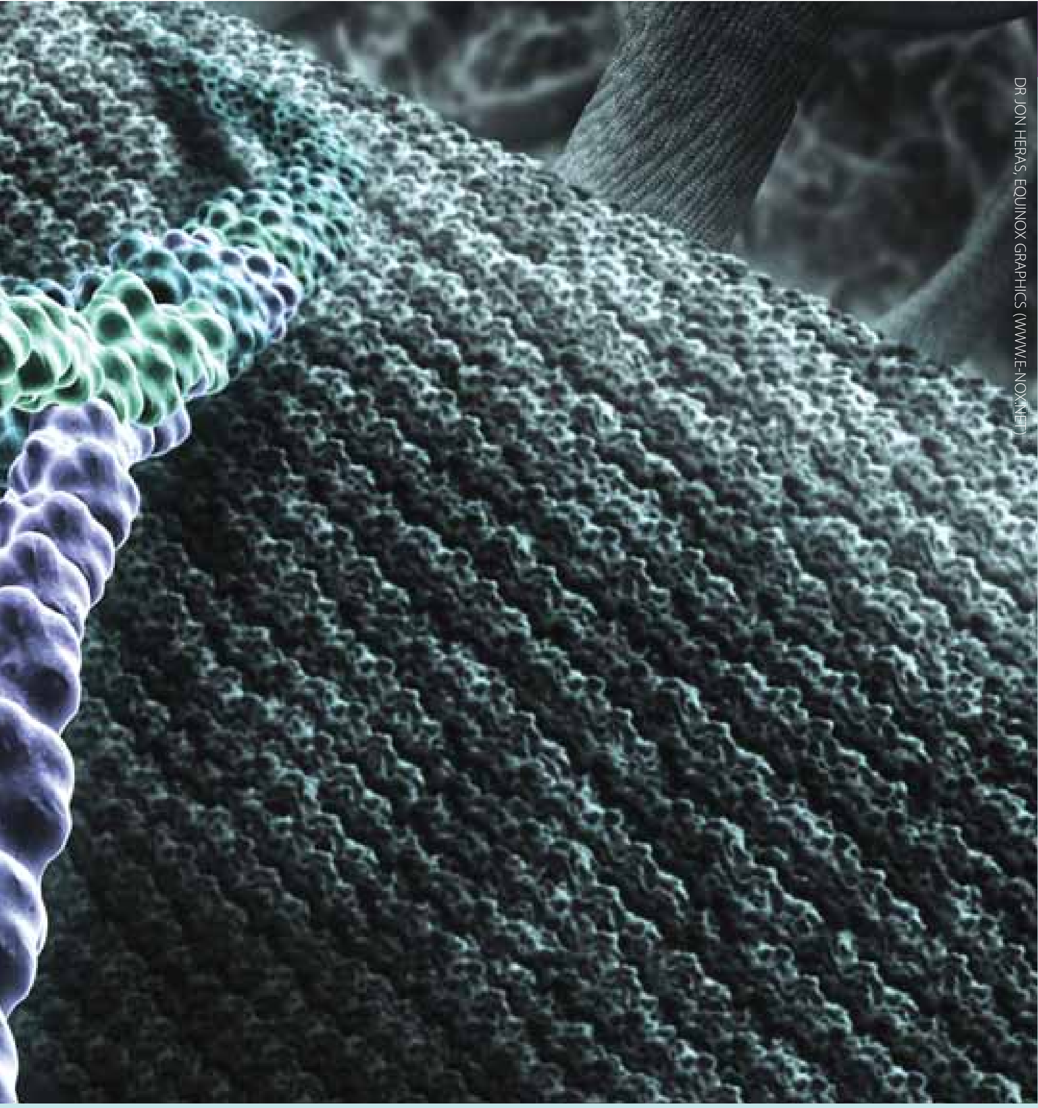
Collagen takes on different roles in different parts of the body. In structural tissues, like bones and ligaments, it's found in rope-like fibres that provide resistance to stretching and tearing forces. In cartilage, which is mostly loaded in compression, collagen has more of a 'holding' function, with the fibres arranged rather like a basket, retaining other hydrated proteins and sugars. In the lens of the eye, collagen is crystalline, organised precisely for optical transparency. In fact, there are over 20 different types of collagen in the body, and it is not even known precisely what functions they all fulfil.

Mechanics in medicine

The study of the biomechanical properties of collagen and ECM is a particularly exciting and fast-growing field in reproductive medicine. One aspect of Dr Oyen's research has been to examine the physical properties of the ECM in the amniotic sac, the membrane that ruptures (the 'breaking of waters'), signalling imminent birth.

Rupture occurring before full-term gestation results in approximately a third of all premature births. Following the first-ever set of rigorous bioengineering studies on placental membranes, Dr Oyen and clinical colleagues at the University of Minnesota concluded that the phenomenon is due to localised damage, not widespread overall membrane deterioration, and that diagnostic techniques may be developed to detect localised thinning and ECM damage for intervention into premature birth.

This project is taking a new direction since Dr Oyen's arrival in Cambridge. By teaming up with researchers at the



DR JON HERAS, EQUINOX GRAPHICS (WWW.E-NOX.NET)

newly opened Centre for Trophoblast Research (www.trophoblast.cam.ac.uk), she will be able to examine placental development from an engineering and mechanics perspective.

Mimicking nature

Nature clearly creates dynamic, mechanically functional tissues that are different from anything engineers have made. As an example, cartilage, which forms the gliding surface that permits joint movement, is approximately 75% water and only 25% collagen, sugar and other proteins, and yet its stiffness and shock-absorbing capability make it comparable to solid rubber. Moreover, the cartilage-on-cartilage sliding interface has lower friction than ice sliding on ice.

In fact, when engineers design materials, uniformity and simplicity are often prized. Engineering materials do not always feature the multi-level hierarchical organisations found in protein-based materials, nor do they exemplify the dramatic spatial non-uniformity that has been found to strengthen natural materials. So, by learning from nature, novel engineering systems might be developed that utilise the principles found in natural materials – a field of technology that has been termed biomimetics.

In some instances, biomimetics takes the form of direct imitation, as in the case of a nanocomposite of mineral and proteins similar to natural bone. For cases of major bone defects, such as occurs through trauma or cancer, a bone-like material that is biocompatible can be seeded with cells to form a 'tissue-engineered' construct and implanted within the body. However, if you consider just how lightweight, yet stiff, strong and tough, a bone-like material is, why not use it for other structural applications such as architecture? This is a challenge that Dr Oyen is investigating.

To do this, you need to go back to first principles – how the material forms. With funding from the Royal Society, Dr Oyen is examining biomineralisation and the formation of mechanically robust bone-like materials. The work differs from tissue-engineering approaches in that there is no cellular component and the end applications are viewed as being remote from medicine. Although a large number of groups have considered the synthesis of biomimetic materials, far fewer have taken a primary angle associated with the measurement of mechanical properties. Dr Oyen views the materials as successful when they replicate both bone composition and mechanical behaviour.

Inspirational materials

It is also possible to abstract ideas from nature without directly imitating the materials themselves. As examples, key concepts that could guide the formation of 'bone-inspired' materials include: composite materials with a very large stiffness mismatch between the phases; materials that form from room-temperature deposition of a ceramic onto a self-assembled polymer; materials with up to seven different levels of hierarchical organisation; and materials that are self-healing. Each of these concepts could be applied to a system that is not protein based, and ongoing research both at Cambridge and across the world is incorporating these types of principles for materials development.

Compared with many branches of engineering, biomimetic engineering is comparatively new. In this rapidly expanding field, the lessons learnt from the physical and mechanical properties of natural materials such as collagen and bone offer great promise within an engineering framework. Not only is this sure to make a difference to 21st-century healthcare, but there are also ways in which engineering will itself benefit from the abstraction of ideas from nature.

Dr Michelle Oyen

For more information, please contact the author Dr Michelle Oyen (mlo29@cam.ac.uk) at the Department of Engineering.

Materials on the horizon

The Horizon Seminar 'Materials' takes place on 9 December 2008. Here, Professor Lindsay Greer, Head of the Department of Materials Science and Metallurgy, highlights the vital role of materials research in meeting many of today's challenges.

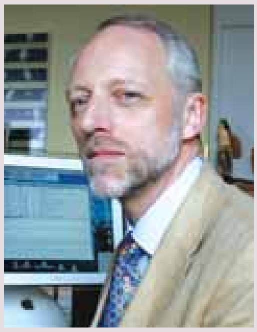
Today, just as clearly as in the Stone Age, Bronze Age and Iron Age, it is the materials available to us that advance, and yet also limit, our technical reach. Civilisation has been transformed by the advent of new materials: silicon that is ultra-pure and virtually defect-free provides the basis of modern electronics; glasses with ultra-low attenuation are used in optical-fibre telecommunications; nickel-base superalloys are essential for efficient jet engines; superconducting composite wires are used to obtain the high magnetic fields necessary for medical magnetic resonance scanning; and electrically conducting polymers are the basis for an emerging family of low-cost, low-power-consumption flexible displays.

Given the near-ubiquitous importance of materials, it's no surprise that materials research is diverse and growing in its range and capabilities. This research drives innovation, where better materials enable technological advances, which in turn demand more of material properties. Across Cambridge, researchers are concerned with improving the performance, durability and efficiency of existing materials, and with finding new generations of materials with extraordinary properties.

The science of materials has a vital role to play in today's priority research areas and worldwide 'grand challenges' such as energy, sustainability, the information revolution and health. It is a field in which the University has long played a key part and continues to produce research leaders of world rank.

Cambridge has also been particularly active in generating spin-out companies to apply these new materials, such as: energy-efficient methods of metal extraction (Metalysis), flexible polymers for displays and logic circuits (Cambridge Display Technology and Plastic Logic), scaffolds for tissue regeneration (Orthomimetics), carbon-nanotube fibres (Q-Flo), and magnetic materials for green refrigeration (Camfridge). There is also extensive engagement with industry on other levels: several company-supported laboratories are embedded within the University, working on materials relevant for topics such as aeroengines, electronics and pharmaceutical delivery.

The materials field is intrinsically cross-disciplinary, with bridges to chemistry, engineering, physics and earth sciences, and increasingly also to biology and medicine. This Horizon Seminar will provide a window on Cambridge's contributions to materials science by bringing together individuals engaged in relevant research from across the University, providing a timely opportunity to experience some of the energy and innovation in Cambridge's broad-based materials research.



Professor Lindsay Greer

The Horizon Seminar takes place at Magdalene College, Cambridge, on 9 December 2008. For more information and to book online, please visit www.rsd.cam.ac.uk/events/horizon

Participating speakers

Professor Jeremy Baumberg, Department of Physics
Professor Bill Clyne, Department of Materials Science and Metallurgy
Professor Stephen Elliott, Department of Chemistry
Dr Andrea Ferrari, Department of Engineering
Professor Lindsay Greer, Department of Materials Science and Metallurgy
Professor Wilhelm Huck, Department of Chemistry
Professor Colin Humphreys, Department of Materials Science and Metallurgy
Professor Ulli Steiner, Department of Physics
Professor Alan Windle, Department of Materials Science and Metallurgy

PROFESSOR JEREMY J BAUMBERG, SUMEET MAHAJAN, PROFESSOR PHIL N BARTLETT

Squeezing more from light: coupling nanoscience and photonics

Cambridge's new NanoPhotonics Centre is creating novel properties of light and matter at the nanoscale.

Sensing molecules by light using a substrate of nanoscale gold voids

Most components in our bodies are fantastically sophisticated assemblies of molecules working on size scales from atoms to cells to organs. As optical materials, however, they are inert transparent jelly. But can this assembly be adapted to build the optical devices of the future? Our knowledge of how such structures can self-assemble on the nanometre scale – on the order of a billionth of a metre in size – is expanding at the same time that we are discovering the extraordinarily rich possibilities of making new nanomaterials that have unusual optical properties.

The intricate arrangement of metals, glasses and active light emitters in three-dimensional architectures controls how photons of light interact with them; nanophotonics is the study of how photons behave with materials at the nanometre scale. The recent explosion of interest in this discipline heralds entirely new ways of manipulating light for applications ranging from healthcare to energy production. Co-opting the processes honed in the natural world for making tuneable optical materials is one of the aims of Cambridge's NanoPhotonics Centre, funded by the Engineering and Physical Sciences Research Council (EPSRC) and opened in April 2008.

Photonic crystals and artificial opals

The trick in nanophotonics is to internally 'chop up' materials on the size scale of the wavelength of light, which is several hundred nanometres for visible light. Light can become schizophrenic in such environments, flipping from one constituent into the other depending on its exact colour. So-called 'photonic crystals' have allowed researchers at the Centre to make super-prisms that separate the colours of light thousands of times more widely than glass, enabling new generations of optical chips for biosensing.

Recently, new ways have been found to squeeze together regular plastic nanoparticles in ways that assemble them into regular photonic crystal stacks on the nanoscale – the resulting sheets are artificial opals with intense iridescent 'structural colour' coming purely from their internal structure. Such materials might be used to replace toxic dyes and often exhibit unusual properties: for instance, it is possible to extrude photonic threads that change colour dramatically when stretched.

Towards meta-materials

Coinage metals such as gold or silver are also unusual optical environments as they can trap light, which surfs along their surface. Light in this form is compressed so that the critical dimensions for nanostructuring drops to tens of nanometres. Such structures can act as aerials for light, greatly enhancing absorption and emission by single molecules or nanoparticles. A whole new class of 'plasmonic'- or 'meta'-materials is emerging that combines nanostructured metals with active and passive materials to produce novel effects, such as: sub-wavelength imaging for viewing working nanomachinery inside living cells; ultra-high-sensitivity spectroscopy to watch surface catalysis in real time; ultra-small lasers that require minimal energy to turn on; and electromagnetic cloaking to hide objects from view.

The NanoPhotonics Centre

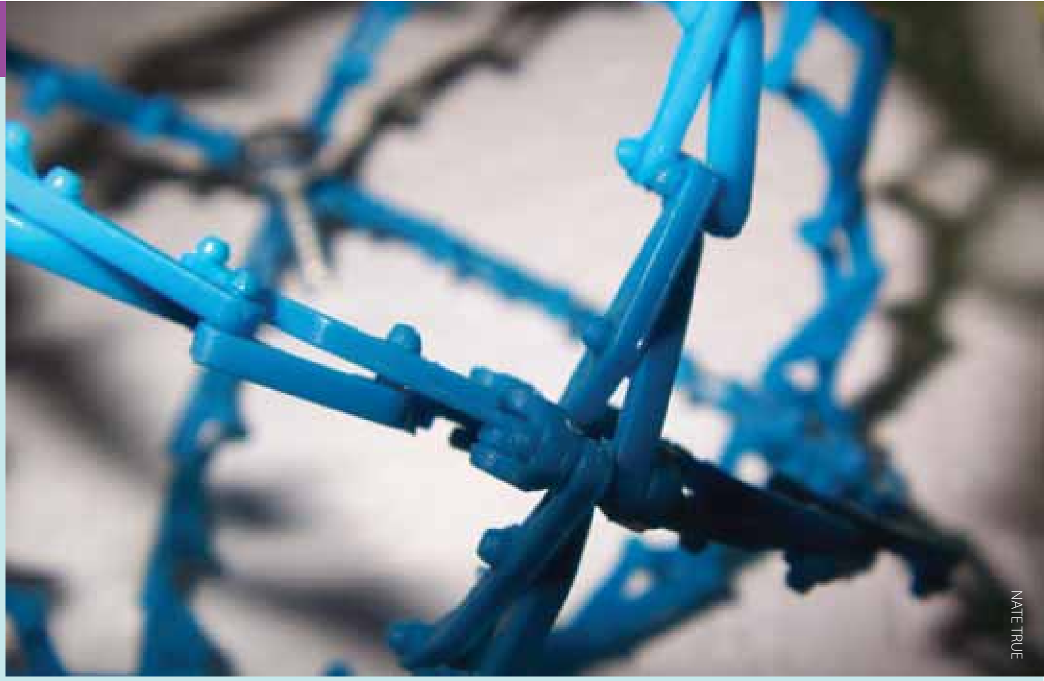
Turning this combined vision of advanced physics and novel nanomaterials into practice at the purpose-built state-of-the-art laboratories of the NanoPhotonics Centre requires diverse interdisciplinary partnerships. Interactions between electrochemists, polymer and materials scientists, device engineers, biochemists and healthcare professionals around Cambridge are becoming fruitful and widespread, and are yielding unexpected and exciting research directions. Just as important are the Centre's interactions with industrial partners (including Kodak, Renishaw and Merck) who are interested in this rapidly expanding research area. Not only does this encourage research to focus on the practicality of manufacturing nanomaterials on the large scale, but it also effectively brings NanoPhotonics out of the lab and into our hands.

Professor Jeremy Baumberg

For more information, please contact the author Professor Jeremy J Baumberg (jjb12@cam.ac.uk), Director of the NanoPhotonics Centre (http://np.phy.cam.ac.uk), at the Department of Physics.

Atomic yoga: the new physics of flexibility

A UK-wide collaboration led by the Department of Earth Sciences is uncovering the counterintuitive properties of flexible materials.



NATE TRUE

Some materials are capable of flexing in very strange ways, like the collapsible toy sphere shown above

Fuelled by rapidly developing electronics and telecommunications industries, the global demand for high-performance materials is insatiable. In the UK alone, annual turnover associated with the design, manufacture and processing of materials exceeds £200 billion – income that relies on devising smaller, faster, stronger, cheaper and increasingly eco-friendly technologies. The challenge faced by the scientific community is that of meeting this demand by identifying new materials with ever more extreme capabilities.

Dr Andrew Goodwin, a Trinity College Research Fellow in the Department of Earth Sciences, has been tackling this problem by designing materials with ultra-flexible atomic-scale structures. Just as a collapsible toy sphere has entirely different properties from those of the plastic from which it is assembled, so too can these ultra-flexible materials break all the rules that 'traditional' systems are forced to obey.

Shrinking from the heat

One such rule, known to all who have struggled with a stubborn jar lid, decrees that materials should expand when heated. More often than not, this is bad news for industry. Mirrors used on satellites change dimensions simply on passing through the Earth's shadow. Small daily variations in ocean temperatures limit the quantity of data that can be transmitted through optical fibres laid on the sea floor.

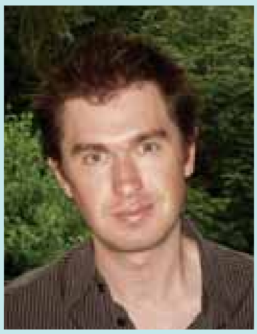
Quite the opposite occurs in a remarkable material called silver hexacyanocobaltate, which Dr Goodwin showed actually shrinks when heated. Assembled from long chains of cobalt, carbon, nitrogen and silver atoms, silver hexacyanocobaltate has a flexible structure that at the atomic scale looks just like garden lattice fencing. When heated, the lattice dimensions change very quickly – but an expansion in one direction is forced to produce an equally strong contraction in another direction. The contraction is so rapid that even a very small amount of silver hexacyanocobaltate is capable of compensating for the usual thermal expansion of 'normal' materials. Good news for industries where thermal expansion remains a fundamental problem.

Push and pull

It turns out that this strange new physics is not limited to thermal expansion alone. Squeeze most materials – or, to be more precise, apply an equal pressure in every direction – and, naturally enough, their dimensions decrease. But squeeze silver hexacyanocobaltate and its lattice-like structure folds up, collapsing in one direction but actually expanding in another. Far from an academic curiosity, this bizarre *pressure-induced* expansion has important applications in pressure-measuring devices, such as those used to determine aircraft altitudes and to monitor meteorological variations.

Silver hexacyanocobaltate is just one example of what is emerging to be a diverse and exciting family of materials. Understanding flexibility and its consequences in these compounds is an important problem in materials science. Dr Goodwin is addressing this problem with Professor Martin Dove in the Department of Earth Sciences and Dr Mark Calleja in the eScience Centre, using a range of experimental and computational techniques. The multidisciplinary, UK-wide collaboration also includes researchers at the ISIS Neutron Facility at the Rutherford Appleton Laboratory near Oxford, the University of Oxford's Department of Physics and the University of Durham's Department of Chemistry.

This approach of designing architectures in which flexibility plays new and varied roles is far from child's play; instead, it promises the sort of materials with extreme properties needed to meet the increasing demands of key global industries.



Dr Andrew Goodwin

For more information, please contact the author Dr Andrew Goodwin (alg44@cam.ac.uk) or Professor Martin Dove (martin@esc.cam.ac.uk) at the Department of Earth Sciences. **This research was published in part in *Science* (2008) 319, 794–797 and is supported by a Natural Environment Research Council (NERC) eScience grant.**

Advancing the surface technology of materials

Research at the Gordon Laboratory is opening up an important new area for the surface engineering of materials.

Coated alloys are used extensively in demanding environments

For nearly a century, materials manufacturers have known that metals exposed to demanding environments can be protected by a simple yet extremely effective process known as anodising. By immersing metals such as aluminium, titanium, zinc and magnesium in a solution that conducts electricity and applying an electric current, the natural oxide on the metal surface thickens and creates a protective outer layer.

Although anodised layers are typically only a few microns in depth and are porous, this simple process can alter the surface appearance of a metal and, importantly, vastly improve its resistance to corrosion and wear. Today, anodised metals enjoy varied and far-reaching applications stretching from construction, through the automotive industry, to consumer products.

More recent modifications have improved this process still further: by using stronger electric fields in a process known as plasma electrolytic oxidation (PEO), thermal and electrical protection can now be added to the list of attributes. Coatings produced in this way on aluminium, for instance, incorporate a very hard, crystalline phase of aluminium oxide called corundum – known in its naturally occurring form as the minerals sapphire and ruby – that is second only in hardness to diamond.

Lightning strikes

As the electric field is increased to achieve these harder, thicker and more durable coatings, localised electric discharges or 'sparking' occurs – perhaps best likened to micro-lightning strikes within the forming coat. In the past decade, attention has focused on what exactly is happening during sparking. How do these phenomena dictate the microstructure of the coating material? Is it possible to control them and even to use them to influence the properties of the oxide coat? Questions such as these are being investigated by Professor Bill Clyne in the Gordon Laboratory, Department of Materials Science and Metallurgy, in close collaboration with Dr James Curran seconded from Keronite International Ltd (www.keronite.com), a Cambridge-based industrial manufacturer that is pioneering PEO technology.

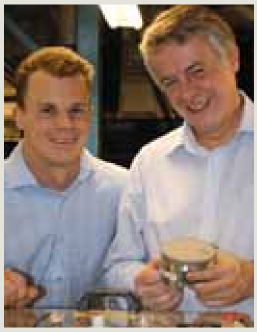
Taming the spark

The phenomenon of sparking has historically been regarded as destructive, imposing a limit on the growth rate and the thickness of anodised layers, and generating defects and microcracks in the material. But, as research in the Gordon Laboratory has progressed, it's become clear that the discharges can in fact be 'tamed' and used beneficially. So long as a suitable electrolyte and electrical control circuitry is employed, the discharges can be made to occur repeatedly in a controlled fashion over the surface of the component, and the conditions of high local pressure and temperature within the resulting plasma can be used to modify the structure of the growing oxide layer and enhance its properties.

Controlled coatings

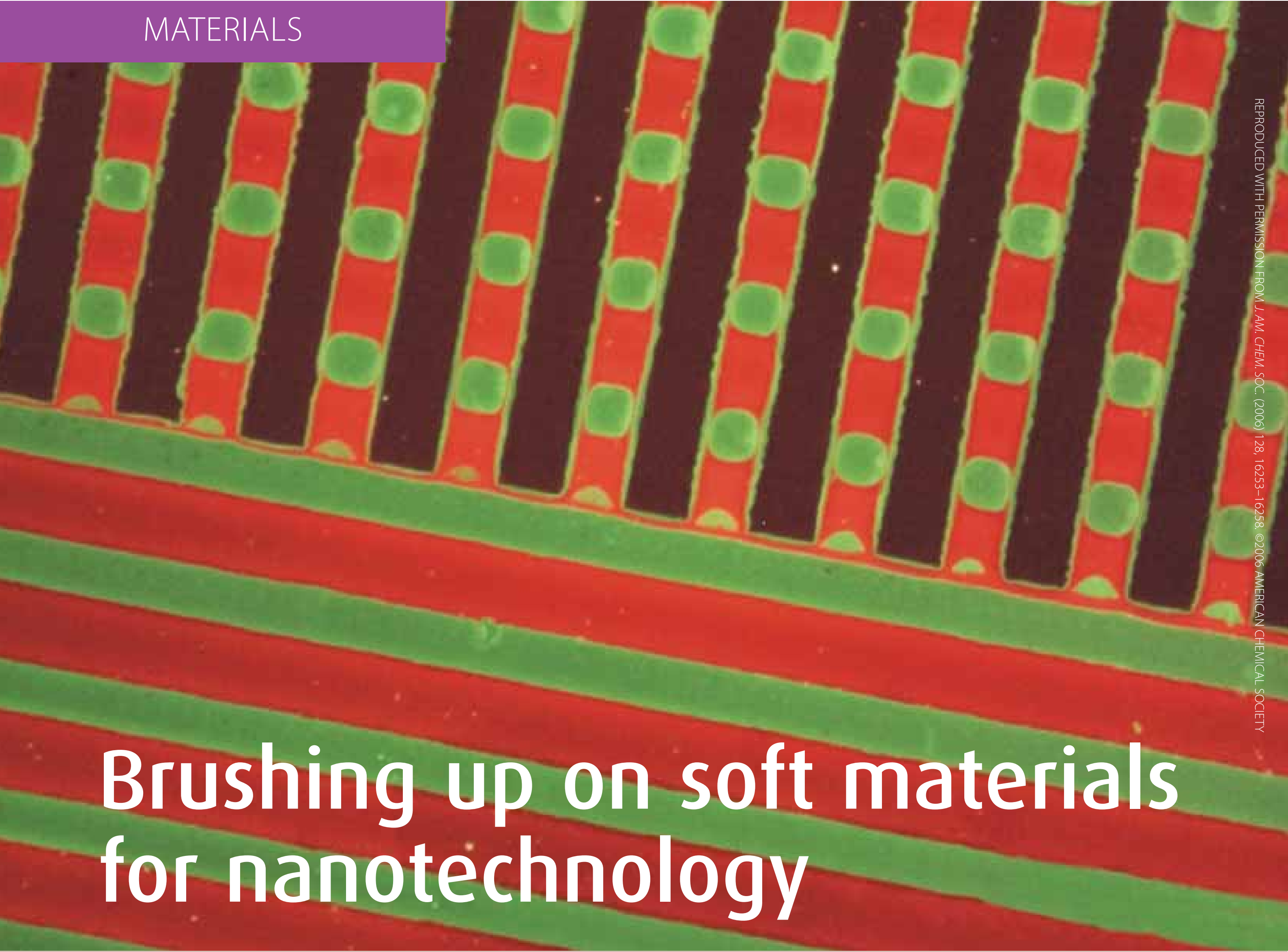
Rather than being unwanted defects, the ultra-fine, interconnected porosity and networks of microcracks within PEO coatings appear to play an unsung role. The researchers have found that this porosity is essential for the process to continue. In fact, the so-called defects actually confer important beneficial effects on the coatings, improving their thermal insulation, enhancing their strain tolerance (giving better adhesion) and leading to excellent 'keying' with overlays such as paints and sealants.

The focus now has turned towards analysing the electrical and spectroscopic characterisation of discharges at the level of single events, with the aim of developing a process model that has the capability of predicting and controlling the microstructural features that determine coating properties. With the benefit of research such as this, PEO coatings of the future will afford greater degrees of durability in demanding environments.



Dr James Curran (left) and Professor Bill Clyne

For more information, please contact the authors Professor Bill Clyne (twc10@cam.ac.uk) or Dr James Curran (jac64@cam.ac.uk) at the Gordon Laboratory, Department of Materials Science and Metallurgy.



Brushing up on soft materials for nanotechnology

Fluorescence image showing patterned polymer brushes attached to a surface

Taking their cue from the building blocks of life, Cambridge chemists are assembling polymers that move.

Biological cells are among the most complicated devices imaginable. They store information, translate it into function, perform an enormous range of chemical transformations, respond to heat and light as well as mechanical and chemical stimuli, and perform physical movement. Yet none of these actions is driven by electricity or controlled by software, and the 'devices' are not fabricated using lithographic techniques or other engineering tools. Instead, cells rely on chemical energy and efficient chemical reactions to drive their complex machinery.

The machinery itself is principally made up of functional assemblies of building blocks, or monomers, which together form larger polymers such as DNA, RNA, proteins and cellulose. Although man-made devices are increasingly sophisticated (one can think of modern-day computers, memory devices, miniature robots, and so on), they are not even close to approaching the level of complexity observed in cells. Can lessons be learned from nature's successes in self-organising and self-assembling building blocks into functional entities that run on chemical energy?

The softer side of nanotechnology

To design and fabricate devices that merge principles from engineering with biological design rules for cellular machinery, a step change is needed in our understanding of how soft materials are assembled and organised into functional materials. Soft nanotechnology is an emerging area of science that aims to do just this: by understanding and exploiting polymeric (and small molecule) building blocks, the goal is to form functional devices that can mimic some of the properties of biological systems. To do this, we need to understand how to synthesise these building blocks, how to assemble them and, most importantly, how to incorporate functionality.

It is clear that the building blocks used in biological systems are far too complex to synthesise *de novo*. Research in Professor Wilhelm Huck's group in the Melville Laboratory for Polymer Synthesis, Department of Chemistry, is therefore aimed at exploiting the properties of synthetically accessible polymers. Synthetic polymers have been around for some time – one has only to think of plastic, nylon and polystyrene to understand how important and commonplace synthetic polymers are today. Not only are polymers inexpensive and easy to use, as it turns out they also provide remarkable flexibility in the field of soft nanotechnology.

One important aspect of the group's research is based on the introduction of architectural order to the polymers at the nanometre scale. Essentially, it is the arrangement and confinement of individual polymers in relation to each other and to the surface that supports them that holds the key to expanding their functionality.

'Hairy' surfaces

A good example of novel properties arising from confinement are polymer brushes. These are best imagined as hair growing out of a surface: the polymers assemble at high density, with little space between them, and are 'rooted' at one end to a surface. Like real hair, the synthetic conditions can be tailored so as to make short, long, curly or very straight hair. Of course these structures are at molecular lengthscales that can be 10,000 times smaller in diameter compared with a human hair.

Polymers normally resist stretching and would prefer to form a curly carpet. It is possible to switch this polymer carpet layer between stretched (straight) and collapsed (curly) states via a wide range of physical and chemical triggers such as temperature, light, salt and pH. Not only does the transition change the properties of the polymers but it also changes the level of interactions between neighbouring chains. Crucially, this has the added effect of changing the properties of the surface, including wettability, roughness and stiffness.

Harvesting the effect of these simple movements opens up a whole new area of applications in the area of 'nanoactuation'. By growing the polymer brushes on flexible, microfabricated cantilevers (a structure supported only at one end, like a balcony), and allowing the brushes to switch from stretched to collapsed, the cantilevers bend to relieve the surface stresses that are generated inside the polymer brush layer. If these conformational changes are used as a way of transforming chemical energy into mechanical work, then you have the basis of a 'nanoactuator'. Work in collaboration with Professor Ulli Steiner in the Cavendish Laboratory in Cambridge is currently extending the actuation properties of polymer brushes to explore the possibility of fabricating molecular 'conveyor belts' based on the directional movement of polymer brushes. Potential applications for these types of surface modifications are in microfluidics, where valves actuated by polymer coatings could be used in self-regulating fluidic devices.

In addition to industrial applications, such as protective coatings and polymer photovoltaic devices, other applications are to be found in the world of biology, especially in the area of ultrasensitive detection systems for viruses and bacteria. And, in an interesting twist, actuation in polymer brushes driven by chemical signals (instead of electrical signals) brings us much closer to understanding actuating principles found in nature. For example, in the pond-dwelling protozoan *Vorticella*, the hair-like stalk that anchors it is able to coil and uncoil like a spring and, similar to the situation with polymer brushes, the rapid contraction is a result of forces restoring a collapsed state between neighbouring polymeric building blocks.

Tailored soft materials

Ultimately, the group hopes to shrink dimensions much further and really operate at the lengthscales of biological machinery inside living cells. Some of the current work is geared towards arranging brushes into nanoscale (35 nm) patterns and studying the transition from the collective behaviour of 'infinite' carpets to individual polymer chains. These studies are very important to provide general guidelines for the design of materials that are based on nanostructured polymers because it is far from obvious how the properties of soft materials deviate when structured or confined at small lengthscales. The group's results strongly indicate that many of the properties change considerably because, unlike bulk materials, the individual chains are all in a slightly different environment.

To exploit soft materials to their full potential, it has become increasingly important to determine how these materials can be interfaced with micro- and nanofabricated electronic devices. But future applications of soft nanotechnology are not necessarily all at a very small scale. For example, the next generation of materials for tissue engineering will require 'smart' scaffolds that have the right mechanical and chemical properties, combined with biocompatibility, surface chemistry and degradability. The group is currently working on nanocomposites formed from blending polymers and inorganic particles with the right surface coatings and has identified several that form excellent scaffolds for the growth of stem cells that differentiate into bone cells.

The lessons learned from model studies on polymer brushes provide us with new tools to finely tailor the properties of materials. In the future, we will see many more soft materials that are engineered at the nanometre level to provide a level of complexity and functionality that makes these materials interact with biological matter in a completely new way.

Professor Wilhelm Huck

For more information, please contact the author Professor Wilhelm Huck (wtsh2@cam.ac.uk) at the Melville Laboratory for Polymer Synthesis, Department of Chemistry.

Delman Gwirgis, a Neo-Aramaic-speaking storyteller from Golaysor, Armenia

Endangered dialects of Aramaic

Current estimates suggest that a language dies every two weeks. Here, Geoffrey Khan describes the documentation of a group of dialects before they are lost forever.

Over 6000 languages are currently spoken worldwide but many are in danger of dying out. Some dialects are lost through political upheavals, scattering populations whose children grow up speaking the language of their new home; for others, social tensions persuade communities to lose one dialect in favour of another. Unlike the loss of biodiversity, this type of endangerment goes largely unnoticed and yet the loss of linguistic diversity, and the history and knowledge that languages embody, is equally as lamentable.

There is now a great urgency in the task of systematically documenting one group of dialects, whose roots lie in the ancient Semitic language of Aramaic, before their imminent demise. Since October 2004, Geoffrey Khan, Professor of Semitic Philology in the Faculty of Asian and Middle Eastern Studies, has been directing a research team in an Arts and Humanities Research Council (AHRC)-funded project that is preserving this knowledge in an entirely new way.

Ancient roots

Aramaic has survived into modern times as the spoken vernacular language in various areas of the Middle East. Neo-Aramaic, as it is known, consists of a very diverse range of dialects that today differ considerably from earlier literary forms of Aramaic. In many cases, the dialects exhibit types of linguistic forms that are unique within Semitic.

The group of dialects spoken in south-eastern Turkey, northern Iraq, north-western Iran and the adjacent region of the former Soviet Union, known as North-Eastern Neo-Aramaic (NENA), exhibits particular diversity, comprising over 100 dialects spoken by Christians and Jews. Remarkably, those spoken by Christians are in all cases different from those spoken by Jews, even when the two communities have lived side by side for centuries.

Vulnerable voices

The NENA group of dialects are particularly vulnerable because of the great upheavals that have been suffered in the 20th century by the Jewish and Christian Aramaic-speaking communities in the region.

Jewish communities left the region in a mass exodus in the 1950s and now live, for the most part, in Israel. As for the Christian communities, a large proportion have been displaced in the past century: in south-eastern Turkey, for instance, virtually all the village communities were destroyed in the First World War and the survivors forced to flee their villages; and in northern Iraq, many of the Christian villages have been lost more recently through political disturbances in the region.

These catastrophes, together with a policy of Arabicisation by an Iraqi government intolerant of linguistic minorities, have driven a large number of Aramaic-speaking Christians out of the Middle East to make a new life in other countries. The diaspora have settled throughout the world, particularly in North America, Australia and western Europe. Such upheavals have brought the majority of the NENA dialects to the verge of extinction.

Tracing the last surviving speakers

To arrive at a systematic description of the surviving NENA dialects, much of the data have to be gathered in field-trips and it has become a major task to locate informants for many of the dialects. This applies all the more so to the most endangered dialects of the group, some of which have only a few surviving speakers, all of whom are advanced in age. For example, after a long hunt, Professor Khan finally managed to locate the final speaker of one dialect in Auckland, New Zealand. He was a man in his 90s who had originally come from a small village in northern Iraq. Similarly, the remaining half-dozen speakers of another dialect have been found, this time in a village in Armenia to which their ancestors had migrated from eastern Turkey at the beginning of the 19th century.

In the case of some of the NENA dialects, the surviving speakers remember the dialect of their parents imperfectly. Vocabulary relating to material culture is particularly prone to disappear quickly after the displacement of the communities from their rural villages in the Middle East. The physical deterioration of the speakers can also be a problem; elderly speakers often lack enough teeth to pronounce some words properly, especially those with dental consonants.

Having found surviving speakers, the process of describing an undocumented spoken language consists of more than simply recording an individual's speech. There is an analytical dimension in which a linguist must use various means of questioning to tease out the complete structure of the language. Some cases turn out to be more arduous than others: one informant had great difficulty with the plural imperative of the verb 'to open' (i.e. the order 'open!' addressed to a group of people), insisting that this was not possible, since more than one person is not needed to open a window or door.

The most successful means of working with informants has proved to be through informal, friendly relationships, without any payment of fees. On one occasion, however, an informant was clearly conscious of the financial value of his knowledge and insisted on charging $2 for every grammatical form. Owing to the complex nature of his dialect's verbal system, it became clear that the description of this particular dialect would be beyond the means of the available research funding!

Linguistic fingerprinting

In most cases, the speakers have no knowledge of the migration history of their ancestors. The grammatical structure of the dialects, however, is a 'linguistic genome' and one fascinating aspect of this project has been the finding that dialects sometimes contain evidence of population movements. In Azerbaijan, for instance, the Turkish language had an impact on the verbal system of the Aramaic dialects of the region. This influence can still be seen today in Aramaic dialects that are spoken a long way from Azerbaijan, as far as the Mosul plain in Iraq.

Preserving for future generations

A key and innovative element to this project has been the NENA database (NENAD), a tool developed by an IT team to accommodate and process the diversity of the dialects in the NENA group. The web-based resource allows efficient retrieval of linguistic data and audio recordings for individual dialects, of which over 70 have now been documented. Comparative displays of data from all the dialects in the database can be created, and a 'smart' version of the traditional dialect atlas displays the distribution of grammatical features across the dialect area.

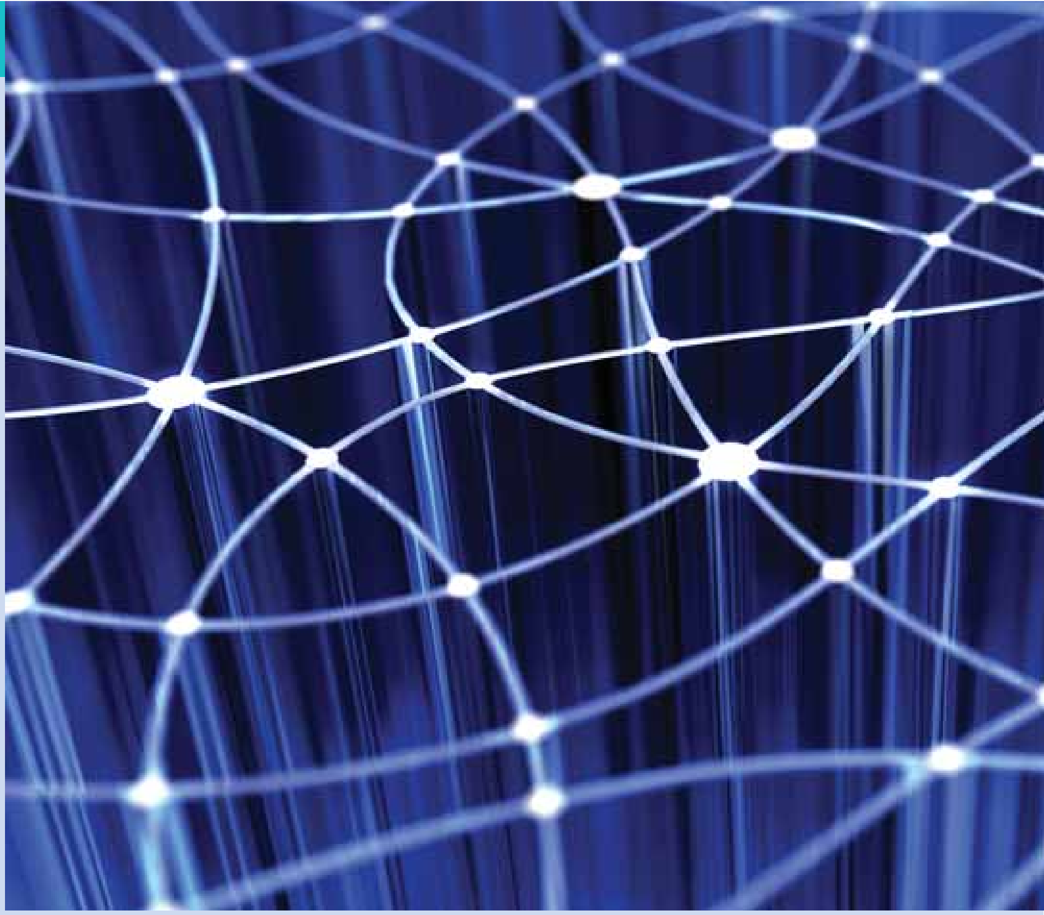
Of course, linguists in most cases cannot keep endangered languages alive, given that the risk to the language is often rooted in social and political issues, but they *can* create records that are detailed and sophisticated enough to allow analytical study by future researchers over decades to come. By preserving the world's rich history of linguistic diversity, we can enhance our collective understanding of human language and the peoples that have spoken them.

Professor Geoffrey Khan

For more information, please contact the author Professor Geoffrey Khan (gk101@cam.ac.uk) at the Faculty of Asian and Middle Eastern Studies or visit the NENAD website (http://nena.ames.cam.ac.uk/index-new.php).

Terrorist groups, guerrilla movements, drug smuggling: Mette Eilstrup-Sangiovanni asks whether examining the structural weaknesses of illicit networks holds the key to combating them.

Clandestine networks: how dangerous are they?



In a networked organisation, decision-making and action are dispersed through informal, horizontal ties among its members

Networks appear to be defining relations everywhere in today's globalised societies: international bankers, financial regulators, law enforcement officials, even legislators cooperate informally across borders to share information and coordinate policies. But networks are not confined to the realms of international politics and finance. Arms dealers, drug traffickers, money launderers, people smugglers, terrorists and other sundry criminals, enabled by the newest technologies, increasingly organise into sprawling global networks like that of the infamous al-Qaeda organisation.

Dr Mette Eilstrup-Sangiovanni, based in the Centre of International Studies, has been researching the structural properties of networked organisations in international politics. Understanding the strengths and weaknesses of networks might open the door to more effective forms of international governance and more innovative ways of combating transnational criminal and terrorist groups.

Networked crime and terrorism

Networks feature prominently in today's international security landscape. According to many policymakers and pundits, the primary confrontation in world politics in the 21st century is no longer between states but between states and terrorist networks such as al-Qaeda, drug smuggling networks like those in Colombia and Mexico, and insurgent networks such as those in Afghanistan and Iraq. And states are widely reputed to be losing the battle. For example, Peter Clarke, who leads the anti-terrorist branch of London's Metropolitan Police, described the networks of radical Islam as 'large, fluid, mobile, and incredibly resilient.' It is this fluid structure that is said to provide terrorists and criminals with multiple advantages, including adaptability, mobility and covertness, and which makes them difficult for more-stable, hierarchical states to combat.

Just how do networks differ from hierarchies? Networked organisations are flat and decentralised, with decision-making and action dispersed among multiple actors enjoying significant local autonomy and relating to each other through informal, horizontal ties. Hierarchies rely on top-down command, authoritative rules and legal arbitration; by contrast, networks are self-enforcing governance structures disciplined by reputation and reciprocity. Consequently, networks tend to be based on direct personal contacts among people who share similar backgrounds and goals, and who trust one another.

Most current literature on clandestine groups assumes that networks, due to their informal, flexible design, are better than hierarchies at learning, innovating and responding to new situations. However, Dr Eilstrup-Sangiovanni's research suggests that the many advantages claimed for networks in their competition with hierarchical states rest on a poor understanding of the network form. Scholars and policymakers have tended to overestimate the strengths of clandestine networks through drawing parallels to the world of the 'company', where networked modes of organisation have proved highly adapted to the fast-moving global marketplace. Yet, clandestine organisations – whether they are terrorist groups, guerrilla movements or drug smuggling enterprises – face a unique set of constraints that distinguish them from their legal, commercial counterparts and which limit their effectiveness.

An historical approach

Although most observers assume that today's transnational networked threats are new phenomena, opposition to the state has in fact often taken a networked approach, as illustrated by the decentralised Greek resistance to the

Ottomans in the early 19th century, by the sprawling International Anarchist Movement in the late 19th century, and by the Muslim Brotherhood's loosely organised, dispersed resistance to the Egyptian state in the 20th century. Drawing on such historical and contemporary examples of participation in underground movements, terrorism and insurgency, and organised crime, Dr Eilstrup-Sangiovanni's research has identified structural weaknesses in illicit networked organisations connected to their growth, decision-making and internal cohesion.

Restricting growth

Clandestine networks often find it difficult to grow their ranks. Because illicit networks cannot depend on the legal system to resolve disputes, they are crucially dependent on interpersonal trust. It is easier to generate trust in small groups when the 'social distance' between actors is short, and chains of action are not extended. This favours small networks.

It is also easier to generate trust when actors are homogeneous in outlook, lifestyle and culture. This is why recruitment to clandestine networks mostly proceeds through pre-existing networks of personal relationships. Terrorist groups tend to rely on bonds of family or friendship, and contemporary drug trafficking largely occurs within ethnically homogeneous groups, where kinship generates trust among criminals. These recruitment practices also restrict the potential size of clandestine networks.

Making decisions

The absence of centralised leadership in clandestine networks makes decision-making difficult, particularly with regard to complex decisions such as resource allocation, tactics, and whether and when to use violence. A lack of centralised control also makes networks susceptible to internal strife. Once made, decisions may not be respected as readily due to the lack of an authoritative stamp. As a result, resources may be used poorly, contradictory tactics selected and activities carried out that serve parochial short-term interests rather than the larger mission. Moreover, internal security is often fragile in clandestine networks, leaving them open to infiltration.

The absence of central authority may also lead to strategic and tactical errors because local autonomy means operations can go forward without evaluation, coordination and sober assessment of the overall benefits and risks. A good example is the Madrid bombings in 2004: lacking central oversight and screening of activities, the Madrid group's efforts to recruit members and acquire arms brought them into contact with police informants; the bombs they used were of poor quality; and an unexploded bomb provided information that led to arrests just days after the bombings.

Confronting clandestine networks

Analysing the progression of al-Qaeda exemplifies the importance of understanding how networks are structured. Since the attacks of 11 September 2001, al-Qaeda has evolved from a fairly centralised command-and-control organisation, running training camps and occupying territory in Afghanistan, into a diffuse transnational network of associate groups and ad hoc cells.

Many believe al-Qaeda's transformation has made it a more formidable enemy, better capable of growing its ranks and avoiding detection. But decentralisation and segmentation have also exposed al-Qaeda to the gamut of organisational dilemmas associated with a networked structure. As it becomes more networked, al-Qaeda appears to be losing unity, cohesion and the ability to act collectively. Al-Qaeda's most successful operations, including the September 11 attacks, took place when the organisation adopted a hierarchical structure. In the aftermath of 9/11, al-Qaeda was forced to segment into smaller operational units, and affiliated groups have started to act on their own initiative without central approval and guidance, leading to poorer security practices. Al-Qaeda's increased reliance on informal links to global jihad groups around the world also appears to be leading to fractiousness as groups differ in their understanding of overall goals and strategy.

Attention to these and similar weaknesses has important implications for counter-terrorism policy. Through understanding the structural weaknesses of clandestine networks, it is hoped that states can improve their strategic thinking about how to combat them.

Dr Mette Eilstrup-Sangiovanni

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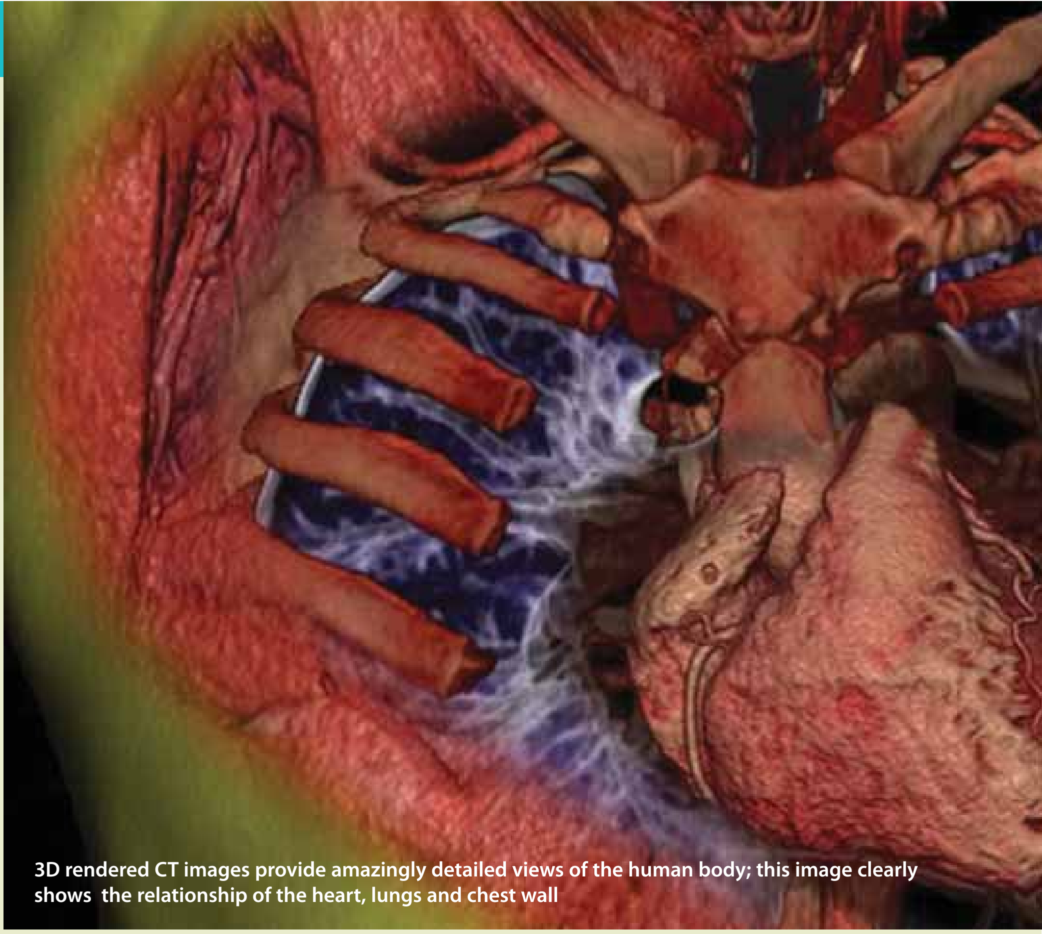
This research, and related research on transgovernmental security networks, received funding from the Airey Neave Trust.

Expanding horizons for medical imaging

Medical imaging in Cambridge is pushing the boundaries in diagnosis and therapy as well as helping scientists within their own disciplines.



3D rendered CT images provide amazingly detailed views of the human body; this image clearly shows the relationship of the heart, lungs and chest wall

Medical imaging has developed at an astonishingly rapid speed since the first discovery of X-rays in 1895. Today, imaging is a crucial part of the biomedical sciences and a mainstay of medical practice. No longer a scarce resource, imaging is often the first port of call for diagnosis, and now increasingly for treatment. The modern-day repertoire of imaging techniques has widened from X-rays and now embraces ultrasound (US), computed tomography (CT), magnetic resonance imaging and spectroscopy (MRI/MRS), and nuclear medicine (NM; a term that includes positron emission tomography, PET).

In Cambridge, a close cooperation between research and medicine sees experienced researchers with technique and body system expertise, many of national and international acclaim, collaborating directly with specialty-based clinicians. A principal aim of much of this research is to translate novel imaging-based diagnostics and treatments from the laboratory into clinical practice, and to use imaging methods to monitor their effects.

Imaging for diagnosis

Medical imaging is nowadays relatively non-invasive for the patient and also speeds up their medical care. In the Department of Radiology, imaging techniques are being refined for diagnosing abdominal pain, cranial and spinal problems, early lung cancer, inflammatory bowel disease and arthritis, to name but a few conditions that are benefitting from these non-invasive diagnostic procedures. Image-guided strategies are replacing formal open surgical diagnostic procedures for many diseases. And, where direct injection of contrast material was previously required to visualise the lymphatic system, lymph nodes can now be directly visualised in three-dimensional images on ultrasound, CT, PET/CT and MR.

Imaging for therapy

As well as breaking new ground in how medical conditions are diagnosed, ongoing research is enabling the replacement of some forms of therapeutic surgery. This has been achieved in several conditions through the development of novel image-guided techniques that allow drainage of acute abdominal and pelvic abscesses. In breast malignancy, sophisticated percutaneous image-guided methods have been extended to incorporate therapeutic excision using wide-core needle biopsy, and this may, in time, replace conventional methods of breast surgery.

Imaging can inform surgeons, helping them to decide whether to operate, as well as enlighten the patient and guide surgical planning. These improvements to therapeutic surgery have been made possible through triage studies on acute surgical admissions using rapid multi-detector CT, providing surgeons with a pre-operative specific diagnosis and location of disease.

Towards novel imaging techniques

New and innovative uses of imaging are being pioneered and evaluated in Cambridge for a plethora of disease conditions. In patients with atherosclerosis, lesions in carotid arteries are being assessed using a variety of techniques that can also determine the degree of associated inflammatory change. Important nerve tracts are being delineated in relation to brain tumours, potentially improving tumour resection and radiotherapy outcomes and predicting likely impairments following surgery; and neuroradiologists are developing rapid techniques for evaluating patients with stroke. New functional methods such as MR perfusion and diffusion are being evaluated for assessing early solid tumour response to therapy (e.g. in gynaecological tumours). For diffuse liver disease, a range of quantitative techniques for measuring body and hepatic fat distribution are also being assessed.

Medical imaging across Cambridge

Cambridge is fortunate in having excellent cross-sectional imaging facilities that benefit from a close integration between National Health Service (NHS) departments and academic imaging departments spread across the city.

In the University's **Department of Radiology**, located at Cambridge University Hospitals NHS Foundation Trust, Addenbrooke's Hospital, an impressive inventory of imaging tools has been assembled thanks to research collaborations both with industry (GlaxoSmithKline) and with charity (Cancer Research UK; CRUK). The Department of Radiology houses numerous modern full-capability US systems, along with three multi-detector CT systems, four state-of-the-art 1.5 Tesla (T) MRI systems and one 3T MRI system. Two of the MRI systems have full multi-nuclear spectroscopy capability. These NHS-based machines are all used extensively for research as well as for routine NHS work. All machines are linked by a sophisticated network to a central picture-archiving computed storage (PACS) system, allowing practitioners at different physical locations to access the stored images.

Also used extensively for research as well as for routine NHS work are the gamma cameras within the NHS **Department of Nuclear Medicine**; the imminent arrival of a PET/CT unit in this Department, funded with a grant from the recent successful National Institute for Health Research (NIHR) Biomedical Research Centre bid and industrial support, will be predominantly used for research. Comprehensive research agreements with the vendors underpin the ability to develop and evaluate new technology and applications on these systems.

The **Wolfson Brain Imaging Centre** (WBIC) is a research facility attached directly to the Addenbrooke's Hospital Neuro Critical Care Unit and is dedicated to imaging function in the injured human brain. WBIC facilities include state-of-the-art MRI/MRS systems (two of them 3T systems), PET research capabilities, two cyclotrons and a PET radiochemistry laboratory with some 15 radioligands currently available for studying patients with acute brain injury.

The University is currently refurbishing a laboratory on the Cambridge Biomedical Campus that will provide the **School of Clinical Medicine** with small animal imaging systems to support phenotyping and molecular imaging studies for metabolic, endocrine, neuroscience and cardiovascular medical research. In addition to a 4.7T preclinical MR and microPET, it will also house an experimental PET/MR system.

The Medical Imaging Group in the **Department of Engineering** is developing new techniques for freehand three-dimensional ultrasonic imaging. Working closely with various members of the School of Clinical Medicine, the Group is researching ways to improve the visualisation and measurement of tumours and more accurate targeting of the tumour site, allowing reduced radiation doses with fewer side effects.

The **Cambridge Research Institute** (CRI), funded by CRUK, has recently developed an Imaging Section and there is close liaison between its imaging scientists and those elsewhere on the campus. Imaging goals at the CRI include using MRI and MRS for the evaluation and design of novel tumour therapies, including immunotherapy, anti-vascular and gene therapies. Such research will increase understanding of the biology of cancer and the determination of tumour-associated MR parameters for diagnosis, prognosis and monitoring of therapy.

There are further imaging facilities at the Medical Research Council (MRC)-funded **Cognition and Brain Sciences Unit**, an internationally leading centre for research in the cognitive sciences and neurosciences. With dedicated 3T functional MRI and 306-channel magnetoencephalography facilities available on site, the Unit has particular strengths in the application of neuro-imaging techniques in the context of well-developed neuro-cognitive theory.

Expanding horizons

Imaging is very much at the forefront of modern medicine, and any successful biomedical campus today is underpinned by first-class radiology and pathology. Despite the immense breakthroughs afforded by medical imaging, we seem to be nowhere near exhausting the vast potential of these techniques. For all stages of patient care, from screening to diagnosis, delivering therapy to monitoring outcome, the medical horizons for imaging continue to expand.

Professor Adrian Dixon

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Virtual violins

Why does one violin sound different to another? Investigating this question has brought together researchers from music, engineering, experimental psychology and computer science.

Violins crafted 300 years ago by the master violin-maker Antonio Stradivari sell for millions of pounds on the rare occasion they reach auction; what is it about their quality of sound that makes them prized above all others? Indeed, is their sound actually discernibly different? Any experienced violinist knows that some violins respond to their bow better than others: what determines which violins are difficult and which are easy to play? Questions such as these have fascinated musicians and scientists since the 19th century.

To get to the heart of the riddle there is an added complication: sound is in the 'ear of the beholder'. In fact, although much is now known about the acoustics of the violin, and how this is influenced by the way it is made, virtually nothing is known about how human capacities for perceiving, discriminating and judging violin sounds match up to their acoustical features. This is a very significant gap, as perceptual judgements obviously define what makes a violin different from, say, a cello, just as it makes one violin different from another, for listeners, performers and violin-makers alike.

A three-year project funded by the Leverhulme Trust that is reaching completion at the University of Cambridge has been intent on filling this gap. The approach has involved collaboration between four departments – Professor Jim Woodhouse from the Department of Engineering, Dr Claudia Fritz and Dr Ian Cross from the Faculty of Music, Professor Brian Moore from the Department of Experimental Psychology and Dr Alan Blackwell from the Computer Laboratory.

Strings and body

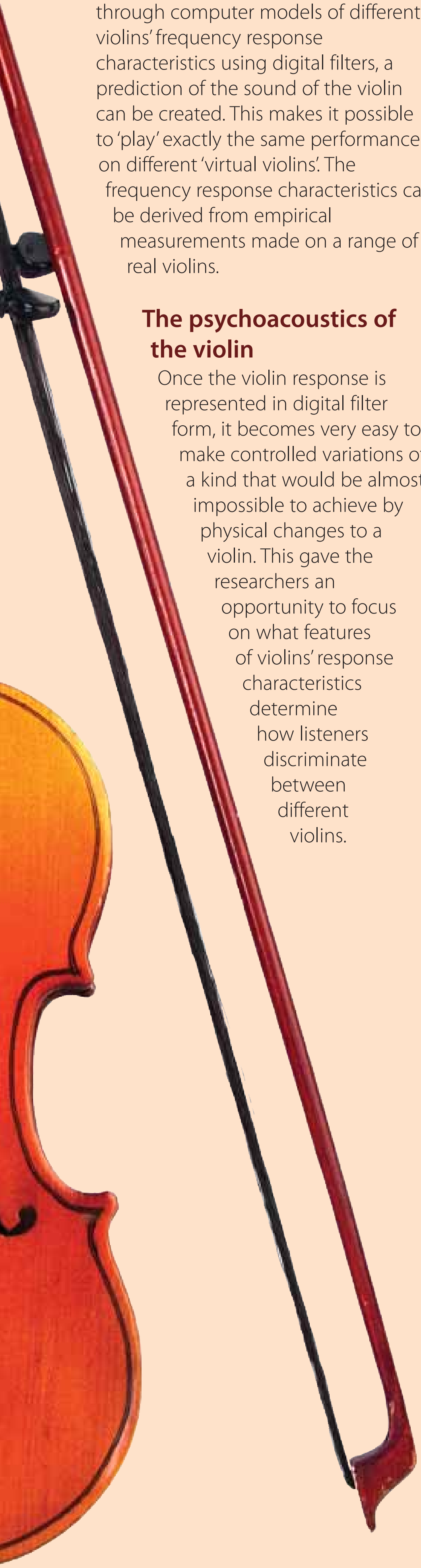
The tone, pitch and loudness of a violin are the product of many components: drawing a bow across tightly stretched violin strings forces them into complex harmonic vibration; a significant fraction of this acoustical energy is transmitted, via a structure called the bridge, into the violin body. Here, the sound is amplified by the vibration of the wooden box and the air inside it.

The team's approach relies on the fact that the acoustical behaviours of the strings and the violin body can be treated separately, and that it is the latter that distinguishes different violins. In fact, on its own, a string makes hardly any sound and the acoustical behaviour is much the same from one instrument to another. The main acoustical feature that 'colours' the sound in ways that are unique for each violin is the way in which the violin body responds to the different frequencies input from the bridge and radiated from the body. This characteristic transformation is known as the violin's 'frequency response characteristic'.

Virtual violins

The first stage of the project was to create a 'virtual violin'. To carry out any comparative study of musical instruments it is important to rule out variations caused by the player. Instead of achieving this by using a robotic violinist that repeats the same piece on a variety of real violins, in this project the tests themselves are virtual.

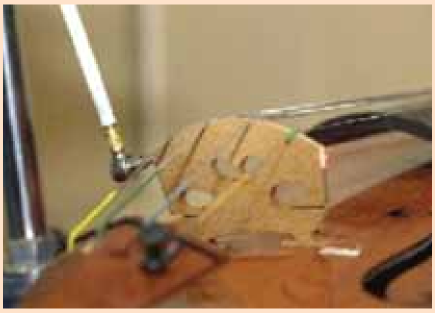
Sensors on a violin bridge record the string waveforms arising as a player performs normally. The recordings are stored as standard force functions, which can then be applied to different violins to hear how they sound without



having to worry about any complications caused by variations in playing. So, by 'playing' these recordings through computer models of different violins' frequency response characteristics using digital filters, a prediction of the sound of the violin can be created. This makes it possible to 'play' exactly the same performance on different 'virtual violins'. The frequency response characteristics can be derived from empirical measurements made on a range of real violins.

The psychoacoustics of the violin

Once the violin response is represented in digital filter form, it becomes very easy to make controlled variations of a kind that would be almost impossible to achieve by physical changes to a violin. This gave the researchers an opportunity to focus on what features of violins' response characteristics determine how listeners discriminate between different violins.



PROFESSOR JIM WOODHOUSE

Recording string waveforms with sensors on the bridge (left) and measuring the violins' frequency response with a small hammer and laser vibrometer (right)

In particular, the psychoacoustical experiments looked at *just-noticeable* differences of alterations made to the acoustical response characteristics of two violins: an excellent violin made by David Rubio and a mass-produced student violin that was informally rated as low quality. Psychoacoustical test methods can be used to find the threshold for detection of any particular change, and also to obtain statistically significant data on quality judgements made by the listeners.

Using groups of listeners that spanned expert string players, expert non-string-playing musicians and non-musicians, it was found for both instruments that the alteration of individual low-frequency resonances needs to be fairly large in order to be perceptible. Even for the listeners who were expert players, a resonance needed to be shifted (in terms of frequency) by about a semitone to be perceptibly different. However, if several resonances are shifted simultaneously, a smaller shift becomes audible.

Testing timbre

The sound of an instrument is not just about pitch and resonance but is also about a somewhat elusive quality known as timbre. It is, in effect, the richness of the sound. Similar to the manner in which a wine taster conveys the flavour and aroma of a fine wine, there are many different descriptors for the timbre of an instrument: from 'warm', 'sonorous', 'clean' and 'free', to 'unbalanced', 'heavy', 'dull' and 'dead'. In fact, a data-mining exercise from *The Strad*, a classical music magazine covering string instruments, came up with a list of 61 words that are commonly used by players, critics, makers and listeners to describe the quality of the sound.

This list of descriptors was used as the basis for a series of experiments in which players located the words in two-dimensional spaces, the results being analysed by multidimensional scaling methods (MDS) to produce maps of families of terms. Some relevant descriptors can therefore be selected on the basis of their distribution in the MDS spaces. This is now allowing the team to test timbre in a more methodical way than has been possible before, asking questions such as: does an increase of amplitude in the frequency range between 650 Hz and 1300 Hz really make the violin sound more 'nasal'?

Probing the mysteries of music

The aim is to provide researchers, violin-makers and repairers with an evidence-based means of assessing what it is necessary to adjust on a violin to achieve improved sound. This rigorous analysis of descriptors and their relations will not only be useful to specialists in discussions with performers, but will also have pedagogical value and might lead to new ways for composers and arrangers to annotate musical scores. Perhaps one day, when describing how one violin sounds different to another, we will be able to say exactly why.

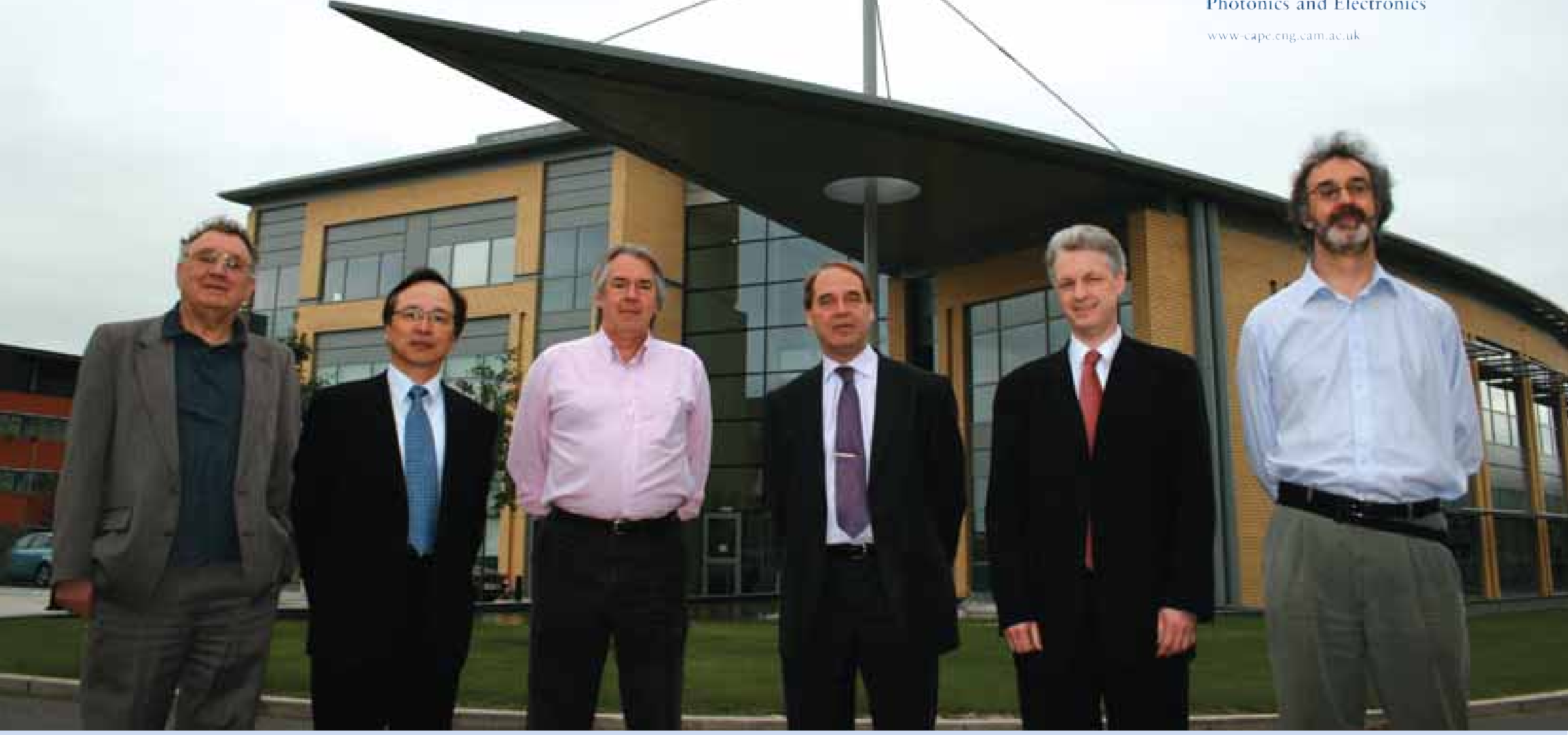
DANIEL OI

Dr Claudia Fritz

For more information, please contact the author Dr Claudia Fritz (cf291@cam.ac.uk) at the Faculty of Music.

Enhancing CAPE-abilities in photonics and electronics

CAPE
Centre for Advanced Photonics and Electronics
www.cape.eng.cam.ac.uk



From left to right: Bill Crossland (CAPE), Shinichi Sasagawa (ALPS Electric), Bill Milne (CAPE), Peter Woodland (ALPS Electric), Ian White (CIKC) and Terry Clapp (Dow Corning and CIKC)

A unique model of industrial–academic partnership is demonstrating how UK R&D can stay ahead of the game in a rapidly moving electronics market.

The fast-expanding advanced photonics and electronics field is dominated globally by large, often non-European, industrial operations capable of investing tens of billions of dollars in research and development. This creates certain challenges, as Professor Bill Milne, Head of the Electrical Engineering Division, explained: 'The problem in Cambridge and the UK is how do you stay involved, engage with global players and maintain a competitive edge in an industry when the bulk of investment is being made elsewhere?' The Centre for Advanced Photonics and Electronics (CAPE), which Professor Milne directs, is Cambridge's answer: a unique way of working with industry involving an equal partnership between the University and a small group of key industrial companies.

Strategic Partners

CAPE, based in a purpose-built building at the West Cambridge Site and housed within the Department of Engineering's Electrical Engineering Division, is now four years into its five-year strategic agreement and has attracted international attention as a model of university–industry collaboration. The two current Strategic Partners are the Japanese company ALPS Electric Company Ltd and the US-based company Dow Corning, with Carl Zeiss SMT as an Associate Member.

An important remit was that the industrial partners be global players with a wide geographical spread and should represent non-overlapping areas of the supply chain (ALPS makes electronic components and Dow Corning is a materials supplier). 'Without this we couldn't hope to have sufficient oversight of the market,' explained Professor Bill Crossland, CAPE Chairman, 'and the fact that Strategic Partners were not in competition enabled us to develop the degree of trust and readiness to share strategy and road-mapping that was needed.'

An imperative from the outset was that CAPE would not be about contract research – instead, the partnership is focused on inventing and developing materials, processes, components and systems that will have a major, long-term impact in photonics and electronics through research effectively jointly commissioned within the partnership.

Uniquely, the governance of CAPE through its Steering Committee is shared between the academic and industrial partners with precisely equal votes. Through CAPE's Strategic Partnership Agreement (SPA), ownership of intellectual property is retained within the University and the industrial partners benefit from preferential licensing. Through this model of closed partnership, the intention is to provide the best and most rapid route of linking breakthrough research to market implementation.

Looking forwards

Getting CAPE off the ground required initial funding of £10 million, raised entirely from its industrial partners (which originally also included Marconi as a founding member), and CAPE remains self-funded. As the Steering Committee now looks forward to the next five years, it recognises the importance of building on this successful partnership, aiming to expand back to four, or perhaps five, Strategic Partners whose business interests retain the cross-supply-chain nature of CAPE. Provision is also made for CAPE Associate companies in special areas of technology; the involvement of Carl Zeiss SMT as CAPE Associate for Electron Beam Imaging has been particularly successful. The SPA already allows for 'Third-Party' projects with companies outside CAPE, which may become important in the recent CAPE initiative on the role of electronics and photonics in the sustainability of the built environment.

Innovation to commercialisation

CAPE's success has been instrumental in allowing Electrical Engineering to bid successfully to create the Cambridge Integrated Knowledge Centre (CIKC), funded by the Engineering and Physical Sciences Research Council (EPSRC). Dr Terry Clapp, one of the CAPE founders and CIKC Director, explained: 'Although the CIKC works very differently to CAPE – it's an open partnership funded with government agency money – the two are highly complementary, with the CIKC providing an integral role in moving proof-of-principle research carried out in CAPE on to the prototyping stage.' Professor Milne added: 'CAPE and the CIKC effectively represent the two poles of how academia can interact with industry. Together, they enable cutting-edge research to be effectively and quickly transferred for the benefit of society.'

This highly successful model is bringing results: two ground-breaking projects have reached important milestones in their development (see side panels). Professor Ian White, CIKC's Principal Investigator and also Head of the School of Technology and Head of Photonics Research in Electrical Engineering, explained: 'These projects are excellent examples of CAPE technologies that have been originated, researched and patented in the University, licensed to our partner companies, and are now being prototyped under the CIKC.'

For more information about CAPE, please visit www-cape.eng.cam.ac.uk

Projecting the future

Imagine a projector the size of a credit card, capable of showing real-time images and expending the minimum of energy. This is the goal of a flagship project at CAPE in partnership with ALPS Electric.

Conventional projectors take a small brightly illuminated image of a scene and then make it larger by projecting it onto a screen. Because the small image absorbs most of the light that illuminates it, the process is extremely energy expensive.

The idea behind the Video Holographic Projection Display System (ViHPS) is to represent the image to be projected by a completely transparent, computer-generated, liquid crystal hologram – it blocks no light, instead representing the image by delaying the light as it passes through. The advantage of these projections is that they reduce the power consumption and the size of the projector, making micro-projectors possible.

Recent developments are creating a new market for highly portable micro-projectors that can be integrated into mobile phones, personal digital assistants and laptop computers.

The facilities for assembling prototype micro-display for holographic projectors have been built up in CAPE with the support of the CIKC. Early tests are now being carried out in ALPS UK on a miniature full-colour projector that will be demonstrated at the ALPS Show in Tokyo in September 2008.

'Within CAPE, our UK engineers engage with renowned academics in Group-funded research, creating new business opportunities for our UK operations.'

Peter Woodland
Managing Director, ALPS Electric (UK) Ltd

ALPS
ALPS ELECTRIC CO., LTD.

Displaying the future

Reflective colour displays that can open up the world of 'electronically controlled print' are a grand challenge for the display industry. A CAPE project in collaboration with Dow Corning has electronic posters within its sights.

Flat-panel liquid crystal display panels such as television screens have finally displaced the cathode ray tube, and the industry is now worth more than $100 billion per year. A large market sector for the display industry lies with street furniture – everything from advertising billboards to displays of public information. But, as yet, no current display technology can challenge good-quality print. To be able to deliver the size and the reflective viewing characteristics of printed media, current proposals are turning to electronic 'e'-ink.

At CAPE, the SiLC project is based on the use of smectic A liquid crystals and coloured dyes. This is a true e-ink technology; one electrical pulse colours the liquid crystal ink and a second pulse clears it. Pictures can remain for many years with no electrical power feeding them.

'Our partnership with CAPE helps Dow Corning accelerate our technology development efforts and provides access to other potential business opportunities.'

Dan Futter
Executive Director for Dow Corning's
Business & Technology Incubator

DOW CORNING

Making connections: what lies beyond the 'terrible twos'?

New research shows that it's not just having conversations with children that matter, it's the quality of the content.

According to the National Institute for Health and Clinical Excellence, the number of children with a diagnosed disruptive behaviour disorder is on the increase. Temper tantrums, aggression and defiance can be 'horribly normal' behaviours for the 'terrible twos', but problems that persist to school age are more worrying. Children with early-onset problems are especially likely to show a persistent prognosis through life, and so understanding the early origins of disruptive behaviour is important for developing intervention programmes.

A long-term series of studies at the Centre for Family Research aims to shed light on the nature and origins of early and persistent problem behaviours. The 'Toddlers Up!' study, funded by the Economic and Social Research Council (ESRC), is tracking the social development of 140 children from two-to-six years of age. Dr Claire Hughes and her colleagues Dr Rosie Ensor and Dr Anji Wilson are interested in how children's cognitive skills and social relationships interact in predicting individual differences in children's behaviour.

Connected conversations

One key finding to emerge from the study is that it is the two-year-olds with poor social understanding (or 'Theory of Mind') who are at risk of displaying problem behaviours at four years and beyond, even when initial problem behaviours and known risk factors, such as exposure to harsh parenting, are taken into account. On the other hand, a well-developed social understanding may help children to be resilient in the face of harsh parenting (commonly associated with raised levels of problem behaviour).

The study also reveals the importance of mother–child conversations. Psychologists have recognised that talking about thoughts and feelings helps children's social understanding. The Toddlers Up! study has shown that this effect is strongest for 'connected' conversations that build on what a child is saying or doing. This finding highlights the potential benefits of parents' efforts to build and sustain conversations with their children – by listening as well as by talking.

Mothers' success in promoting good behaviour also depends on their emotional availability and well-being. Recent findings from the Toddlers Up! study show that effects of maternal education/well-being on children's behaviour are carried by knock-on effects on children's abilities to monitor and control their own actions (i.e. their executive functions). That is, rather than 'naughtiness', some problem behaviours may reflect deficits in children's abilities to anticipate or respond flexibly to challenging situations.

The good, the bad and the socially busy

A new study aim is to consider children's overall social profiles rather than problem behaviours in isolation. 'Socially busy' children who are boisterous but also show redeeming behaviours (such as concern for others) can be quite successful with peers. Thanks to a recently awarded British Academy Postdoctoral Fellowship, Dr Ensor will be able to study these ideas further, for example by exploring whether children's popularity (or rejection) at school reflects their social profiles. It's hoped that this approach might prove useful for evaluating intervention programmes for children at risk of school exclusion.

The transition to school

Starting school is, for many children, their first major life-event. One of the positive messages to come out of this study is that parents can prepare their children for the demands of school life both by helping them to develop self-regulatory skills and by having connected conversations. And, by understanding the early origins of disruptive behaviour, studies such as these should reveal the strategies that might work best to help young children and their families move beyond the 'terrible twos'.

Dr Claire Hughes (left) and Dr Rosie Ensor

For more information, please contact Dr Claire Hughes (ch288@cam.ac.uk) or Dr Rosie Ensor (rad35@cam.ac.uk) at the Centre for Family Research in the Faculty of Social and Political Sciences.

Professor Simon Blackburn

A prolific writer and champion of accessible philosophy, Simon Blackburn was honoured this year by the prestigious American Academy of Arts and Sciences for his significant contributions to academia. His esteemed career has taken him full circle – from his arrival at Trinity College to study Moral Sciences as an undergraduate in 1962, to his return to the same college as Professor of Philosophy in 2001.

Simon Blackburn divides his time between teaching, writing and wrestling with problems of objectivity and truth, particularly in the theory of ethics. He is perhaps best known among his peers for his development of a 'quasi-realistic' method for seeking to understand the nature of ethical attitudes. Although he asserts that his contribution 'was to make myself a nuisance to everyone', the work provided substantial progress in the area and has influenced the way many philosophers think about the properties of ethics and moral judgements.

Throughout his career, Professor Blackburn has achieved a remarkable balance between 'ivory-tower' philosophy and accessible, 'democratic' philosophy. His delivery is understandable to an audience wider than his peer group. Tackling a variety of topics within the philosophy of morality – from ethics to truth, lust to being good – he does so with a celebrated combination of humour and first-rate academia. Lust, for instance, he describes as 'furtive, headlong, always sizing up opportunities. It is a trail of clothing in the hallway, the trashy cousin of love.'

Among his extensive and influential contributions to teaching and research, Professor Blackburn has written the only single-authored dictionary of philosophy (*The Oxford Dictionary of Philosophy*) – comprising some 2500 entries – and in August he published his latest book: *How to Read Hume*. A fitting book for him to write, given the debt he acknowledges to this 18th-century British philosopher: 'David Hume's philosophy has influenced my research enormously – you could say that a great deal of what I've done has been a rediscovery of it, an updating of it for our own time.'

Who or what inspires you?
The great philosophers George Berkeley, Ludwig Wittgenstein and of course David Hume. My wife also is a constant inspiration. It is her exacting standards of writing, borne out of a career in the publishing industry, that have encouraged me with my own efforts. As to what inspires me: poetry and art.

Have you ever had a Eureka moment?
I would say that my first Eureka moment was coming to Cambridge as an undergraduate and finding that philosophy was something I could do and be really interested in. I remember feeling as if I was walking on air for the whole of my first and second term! My second Eureka moment was when I felt I'd discovered the way through something called Goodman's Paradox – it's a set of propositions that seem to be true but can't all be true all together.

What's the best piece of advice you've ever been given?
Don't complain! I remember once I was getting very hot under the collar about what I regarded as a piece of plagiarism and an older, wiser friend said 'let it go – you'll hurt yourself more than you'll hurt anyone else.' Good advice, as it turned out. In general I'd say I pretty much take life as it comes.

If you could wake up tomorrow with a new skill, what would it be?
Music – singing, playing, even just enjoying listening to it more than I do. Other people clearly get an enormous amount of pleasure out of music and I'd love to be able to share in this delight.

What motivates you to go to work each day?
A sense of duty? No not really, but it's true that if I wasn't coming to work every day I'd be thinking about philosophy. I need no motivation to do that – it's just something I find myself doing. I have a very democratic view about philosophy and I think more people could enjoy it if they stopped being afraid of it, stopped worrying about coming up against dead-ends – so I take a lot of pleasure in helping people learn to do that. I think that's why I've never stopped enjoying teaching in 40 years. As regards writing, it is a craft skill, so I suppose I do it for the sheer joy of it.

What is your favourite research tool?
Time and leisure! Take my current research interests – I'd like to develop a pragmatist approach to the theory of truth, about how truth and success in action relate to each other. But it's expensive in terms of time – I need to read what others have said about pragmatism, marshal my own thoughts, present them to my peers to see if I can bear what I'm saying and then write it all down. Part of what makes an honest philosopher as opposed to someone who's going through the motions is preparedness to try it out and go back to the drawing board if it doesn't work. In that sense we are experimental but, unlike empirical scientists, our experimental materials are ourselves and our audience.

Rolls-Royce

Research is the foundation stone for the high-technology products that Rolls-Royce designs and develops for its extremely competitive aerospace, marine and energy businesses. Each market sector sets substantial economic, operational and environmental challenges that call for accurate, long-range, research-based, technology planning.

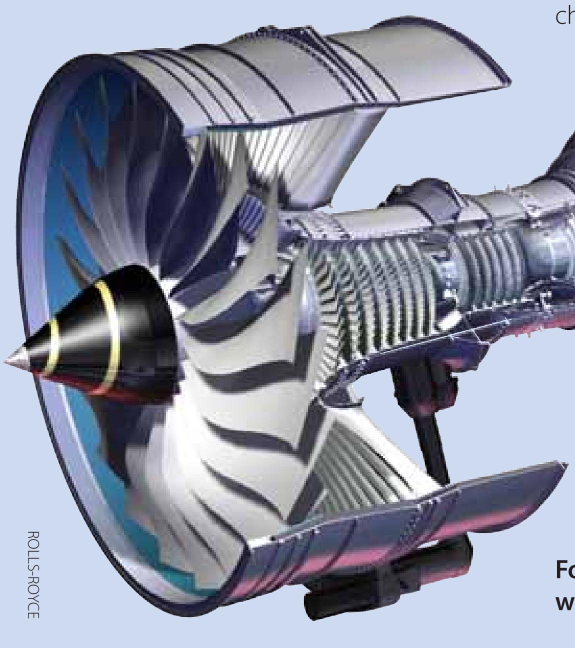
Rolls-Royce spends around £800 million annually on research and development. Its research strategy embraces three 'Visions' addressing the 5-, 10- and 20-year timeframes, which broadly are devoted to technology validation, applied research and fundamental research, respectively.

A key element of the longer-range Vision 10 and Vision 20 programmes is the network of Rolls-Royce-supported University Technology Centres (UTCs). Over the past 18 years, some 29 UTCs (20 in the UK, the remainder in Europe, USA and Asia) have been carefully selected as the very best in their fields to address critical technical areas as diverse as materials, noise, combustion, aerodynamics and manufacturing technology. In cases where UTCs are highly complementary in their research focus, they have been linked together to form University Technology Partnerships (UTPs).

The University of Cambridge, with which Rolls-Royce has deep and long-established research links, plays a key role in the UTC network through three research programmes:

- The Cambridge University Gas Turbine Partnership (UGTP) includes the world-renowned Whittle Laboratory and over 80 projects, such as the Environmentally Friendly Engine (see panel), whose collective purpose is to provide an integrated approach to gas turbine fluid mechanics and thermodynamics.
- The Materials UTC in the Department of Materials Science and Metallurgy conducts research into high-temperature superalloys used in the hottest components of gas turbine engines (see panel).
- The Engineering Design Centre (EDC) in the Department of Engineering provides the Engineering Knowledge Management UTC of a wider UTP for Design. The project is addressing the need to capture, store and retrieve engineering knowledge to improve design processes.

The UTCs and UTPs are highly regarded as models for effective industrial–academic collaborative research. Their long-term nature and real-world challenges bring mutual benefits: Rolls-Royce finds solutions to complex technical challenges; the universities gain an ongoing five-year stability of funding and a greater depth and quality to their academic research; and the science base is broadened by developing a strong pool of highly skilled engineers and scientists.



ROLLS-ROYCE

For more information, please visit www.rolls-royce.com

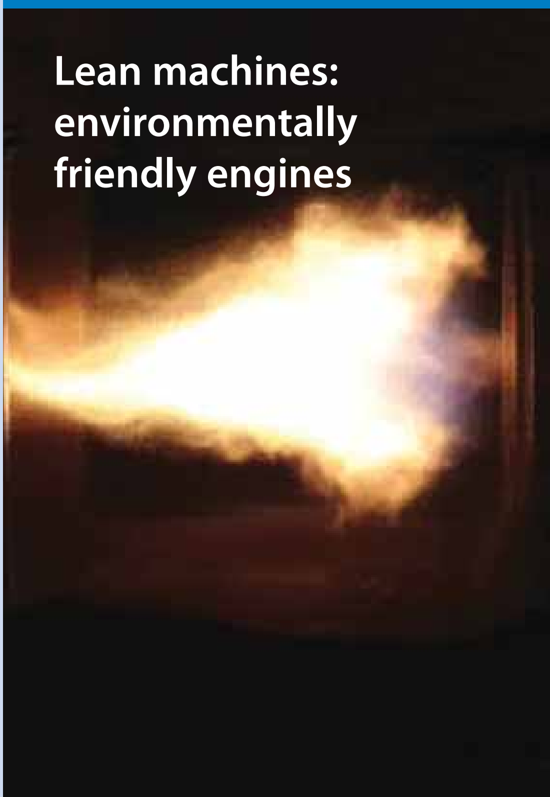
'Super' superalloys: hotter, stronger, for even longer

Only a single class of engineering materials can withstand the extreme conditions deep within a jet aeroplane engine – the nickel-base superalloys.

A team of over a dozen researchers at the Rolls-Royce Materials UTC in the Department of Materials Science and Metallurgy has been studying the properties of nickel-base superalloys with the aim of obtaining the very best from their performance. 'Materials are subjected to incredible conditions in jet engines – the turbine blades, which have walls only a millimetre thick, are whizzing round at 10,000 rpm while gases over 1500ºC pass over their surface,' explained Deputy Director Dr Howard Stone.

By improving the performance of materials used in these highly demanding

Lean machines: environmentally friendly engines



An industrial-grade aerospace gas turbine combustion simulator – the first of its kind in the UK and one of only a dozen worldwide – is ready for 'lift off'.

environments, jet engines can be run at higher temperatures. And, because this reduces fuel consumption, increasing gas temperatures offers a direct method by which emissions from air travel can also be reduced. The Cambridge team conducts research into all aspects of the metallurgy of these materials, from understanding how their properties may be optimised, to ensuring their safety in service, to investigating why failures occur.

The Cambridge Materials UTC was linked five years ago with complementary departments at the Universities of Swansea and Birmingham to form a UTP. 'The UTPs have been very much admired throughout the world, and other companies globally are beginning to emulate the model of having permanent research centres within universities,' said senior academic Dr Cathie Rae. 'It's about building a relationship of trust between the researchers and the industrial partner to mutual benefit.'

With an eye on the future, the lab is now also working towards the development of novel materials to enable more efficient aeroengines to be realised. 'We cover the longer range research area that Rolls-Royce needs,' explained Director Professor Colin Humphreys, who masterminded the original UTC and leads the UTP. 'We've helped to develop new alloys that are currently flying in Rolls-Royce-powered aircraft and now we're developing their successors – the alloys of the future – which will run hotter, stronger, for even longer.'

From left to right: Dr Howard Stone, Professor Colin Humphreys and Dr Cathie Rae

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

Professor Simone Hochgreb and colleagues in the Department of Engineering have built the rig to support the Environmentally Friendly Engine programme, which brings together a UK-wide, cross-sectoral consortium of academic and industrial partners under the leadership of Rolls-Royce. Launched in 2006 under the UK's National Aerospace Technology Strategy, the £95 million programme receives funding from the UK Government's Technology Programme, Regional Development Agencies and Rolls-Royce and its collaborating industries.

The partnership's aim is to take UK aerospace capabilities to the next level of efficiency. 'With no current practical alternative to oil-based fuels for air travel, the aerospace industry is asking how we can burn fuel more efficiently and cleanly,' explained Professor Hochgreb. The goals are impressive: the programme aims to deliver a 10% reduction in carbon dioxide emissions and a 60% reduction in nitrous oxide emissions as a significant step towards the targets for the aerospace industry set for 2020.

Detailed understanding of combustion under realistic conditions is a very challenging area of research in gas turbine engineering, and one that holds great promise in the quest for more environmentally friendly engines. 'In the past, it's been very difficult to set down design rules for fuel injectors because it's the details that matter,' Professor Hochgreb explained. 'This optically accessible rig will now allow us to see what effect small geometry changes have on the flame structure, so that we can move towards designing cleaner and more efficient engines from scratch.'

Although a new area of research, Professor Hochgreb's work falls under the umbrella of the UGTP. With research projects in the Departments of Engineering, Chemical Engineering and Applied Maths, the UGTP's purpose is to create an holistic understanding of the linkages between aerodynamics, noise and vibration, combustion, heat transfer and advanced cycles in turbomachinery.

Director of the UGTP, Professor Dame Ann Dowling, explained: 'The UGTP model – with its two-way information flow and regular contact between research staff, students and Rolls-Royce engineers – ensures that we address the right problems with the right people, and is both exciting and motivating for staff and students.'

PROFESSOR SIMONE HOCHGREB

Professor Simone Hochgreb

Professor Dame Ann Dowling

For more information, please contact Professor Simone Hochgreb (sh372@cam.ac.uk).

NEWS FROM RESEARCH SERVICES DIVISION

New grant teams at RSD

Following a reorganisation of services, each research grant will be supported by the same team throughout its lifecycle.

The research grant lifecycle progresses from application stage to acceptance of the award, activation and administration of expenditure, and final closure. Members of the Pre- and Post-Award Services at RSD help with applying for and securing funding, administering the grant, and offering advice and assistance to researchers, research administrators and sponsors. These services have been reorganised into three grant services teams, each supporting two Schools, so that services can be more joined up and customer focused.

- The **Life Sciences Team** supports the School of Biological Sciences and the School of Clinical Medicine
- The **Physical Sciences and Technology Team** supports the School of Physical Sciences and the School of Technology
- The **Arts, Humanities and Social Sciences Team** supports the School of Arts and Humanities and the School of Humanities and Social Sciences

'By providing services for individual research projects from cradle to grave,' explained Edna Murphy, Acting Director of RSD, 'we can provide more efficient and personal interactions with academics, departments and external organisations alike.'

For further information, please email rsd.enquiries@rsd.cam.ac.uk

Research Funding Roadshow

Cambridge researchers have the chance to meet representatives from the University's major funding organisations at a drop-in session.

RSD hosts its annual Research Funding Roadshow at the University Centre, Mill Lane, on Wednesday 12 November 2008, 10am–3pm. The event provides a chance for researchers to find out more about how funding schemes work, current funding opportunities and 'top tips' for applying for them, all in an informal and relaxed setting. For sponsors, the Roadshow is an opportunity to meet academics across a range of disciplines at the University of Cambridge and Anglia Ruskin University.

A broad range of research sponsors will be attending, some of whom are giving workshops to provide advice specific to their funding schemes. Participants include BBSRC, Cancer Research UK, EPSRC, Leverhulme Trust, MRC, Nuffield Foundation, Royal Society, European Commission (UKRO) and Wellcome Trust.

For more information, please contact Hannah Pawson (email: hannah.pawson@rsd.cam.ac.uk).

NEWS FROM CAMBRIDGE ENTERPRISE LTD

An invention to help repair damaged joints

Continuing our series of the stories behind Cambridge innovations – the pathway to patenting – we hear about a spin-out company whose medical devices are helping the body to heal itself.

In 2007, a staggering 2.5 million joint replacement procedures were performed worldwide. Although these operations are essential to ease pain and restore mobility, recuperation can be long and painful, and the prosthetic joints have a limited lifespan of no more than 17 years. For younger patients, this brings the unwanted prospect of further painful and expensive revision operations. Treatments are needed that can delay or even prevent joint replacement.

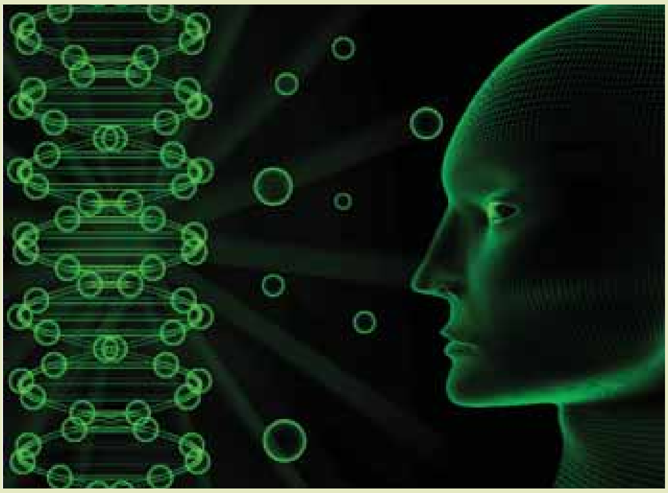
Research that grew from a PhD project into a spin-out company provides the answer through its line of products for regenerative repair. In 2001, Andrew Lynn embarked on a four-year product and preclinical development programme under the supervision of Professor William Bonfield at the Cambridge Centre for Medical Materials and funded by the Cambridge-MIT Institute. Working in collaboration with a team of colleagues from Massachusetts Institute of Technology and Harvard University, he developed advanced porous materials and structures that mimic important tissues found in the body, including those sites with interfaces between bone and soft tissue that are susceptible to traumatic injury.

By 2005, it was clear that the research had produced an effective novel solution that could be patent protected. Cambridge Enterprise filed the patent and licensed the technology to a newly created company 'Orthomimetics', and the following year the company raised over £5 million from institutional and private investors.

Orthomimetics has subsequently been awarded a further £2.1 million in grant funding to develop its technology and has made significant progress since its formation; it hopes to be selling its first product, Chondromimetic, next year following regulatory approval. The implant works by acting as a tissue regeneration scaffold that supports the body's natural repair processes and is intended for cartilage repair following sports injuries and other orthopaedic trauma. By reducing the need for total joint replacement, products such as these will have a major impact on raising the standard of orthopaedic healthcare worldwide.

If you are an employee of the University and would like advice on the patentability and commercial opportunities for your invention, please contact Cambridge Enterprise (email: enquiries@enterprise.cam.ac.uk; Tel: +44 (0)1223 760330; www.enterprise.cam.ac.uk).

FORTHCOMING EVENTS: SAVE THE DATES!



1 October 2008

Horizon Seminar 'Single Component Biology is Past; Bioengineering has Begun'

Centre for Mathematical Sciences, Cambridge

The huge influx of new ideas and principles being brought into biological research by mathematicians, physicists and engineers means we are no longer restricted to reductively studying biology. This Horizon Seminar will demonstrate how bioengineering exploits these new developments, providing technical solutions to current and emerging health and environmental concerns.

For more information, please go to www.rsd.cam.ac.uk/events/horizon or email horizon@rsd.cam.ac.uk

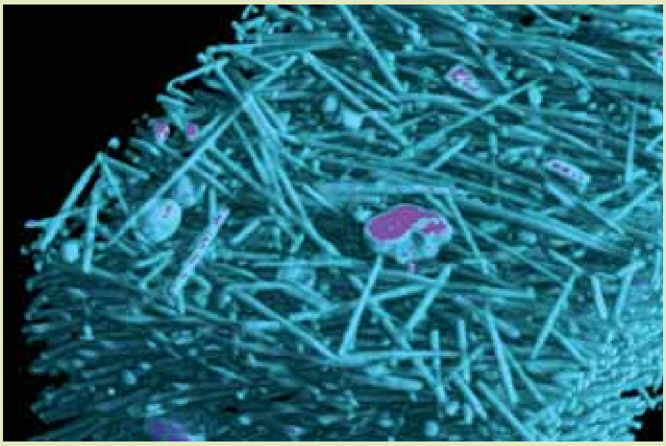
NIGEL LUCKHURST

22 October–2 November 2008

Arts, Humanities and Social Sciences Festival: 'Cambridge Festival of Ideas'

This new festival celebrates arts, humanities and social sciences at the University and its many partner organisations. Over 80 free events will be on offer to visitors of all ages. Activities include everything from Stone Age cooking to Viking culture.

To receive the full programme, please email Joanna McPhee (foi@admin.cam.ac.uk).



9 December 2008

Horizon Seminar 'Materials on the Horizon'

Magdalene College, Cambridge

Materials are fundamental to a host of cutting-edge technologies used in our daily lives: from transport, defence, security, information and communications technology, to advanced manufacturing. This Horizon Seminar will showcase Cambridge's contributions to this fast-moving and innovative field by bringing together individuals engaged in relevant research across the University.

For more information, please go to www.rsd.cam.ac.uk/events/horizon or email horizon@rsd.cam.ac.uk

1 April 2009

Horizon Seminar 'Reproductive Health'

Centre for Mathematical Sciences, Cambridge

This Horizon Seminar will showcase the latest University research into epigenetics, the fetal origins of disease, placental biology and reproductive medicine. By exploring factors that influence the growth and development of the fetus, the Seminar will examine how what happens before birth can continue to affect our health and well-being throughout adult life.

For more information, please go to www.rsd.cam.ac.uk/events/horizon or email horizon@rsd.cam.ac.uk

Horizon Seminars are organised by Research Services Division.

Are there areas of research that you would like to see covered in Research Horizons? We welcome suggestions, feedback and comments: please send ideas to the Editor at Research.Horizons@rsd.cam.ac.uk

Your way into Cambridge

Research Services Division (RSD) helps academics to identify, secure and manage research funding from external organisations.

We identify funding opportunities through our relationships with regional, national and international sponsors and then support academics through every step of the awards process, from applying for a research grant and checking applications are correct, through negotiating contracts to protect the interests of academics and the University, to supporting departments in managing funding throughout the life of a research project. RSD also encourages collaboration between the University and industry, and fosters long-term research partnerships between sponsors and academics for mutual benefit.

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