UNIVERSITY OF Southampton

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New Boundaries | Issue 12 | May 2011

Coordination in a crisis

Creating true partnerships between people and computers to tackle global challenges.

Groundbreaking research collaboration
New alliance with Lloyd's Register

A breath of fresh air
World-leading asthma research

Preventing gridlock
Future-proofing our infrastructure

In this issue

Welcome to *New Boundaries*, the University of Southampton research magazine. In this issue, you will discover how our pioneering research is set to create true partnerships between people and computers, helping to tackle some of today's most pressing challenges, such as responding to natural disasters and harnessing renewable energy. Find out more on page 4.

The past year's freezing temperatures, heat waves, and not to mention a volcanic ash cloud, have caused chaos for the UK's transport systems. Southampton researchers are part of a national team working to prevent future meltdown of our infrastructure. Find out more on page 20.

In the light of the recent financial crisis, banking has become a hot topic. International finance expert Professor Richard Werner talks about his research and views on how to recover from the latest banking crisis (page 12).

We are continuing to break new ground through our research collaborations; on page 10, find out about our exciting new alliance with global organisation Lloyd's Register, which will form the largest research collaboration of its kind in the UK. Further afield, discover how we are revolutionising the field of astrophysics by developing new approaches to view the explosive nature of our universe and push back the frontiers of our understanding (page 24).

For more research stories, visit our website **www.southampton.ac.uk/research**

Claire Macdonald
Editor, *New Boundaries*

Please send us your feedback

We are keen to receive any feedback you have about *New Boundaries*. If you have any comments or suggestions, please do send them to **newboundaries@southampton.ac.uk**


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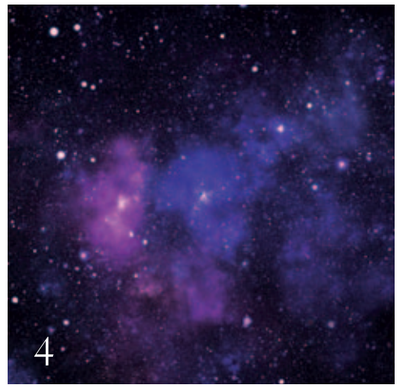
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More highlights

Coordination in a crisis

A Southampton-led research project is set to create true partnerships between people and computers, helping to tackle some of today's most pressing challenges.

The way in which we interact with computers is changing fast. With high-speed internet, social networking and over five billion mobile phone subscriptions worldwide, we no longer need to wait for information to come to us. Through our computers, we are becoming the information providers: following the earthquake in Japan earlier this year, posts on social media sites such as Twitter and Facebook had a vital role in getting information to the emergency services and authorities. Southampton researchers are at the forefront of a new science finding ways in which computers can work intelligently in partnership with people.

"We are fast approaching an 'era of ubiquity' where each of us will become increasingly dependent on multiple smart and proactive computers that we carry with us, access at home and at work, and that are embedded into the world around us," says Southampton's Professor Nick Jennings, who leads the University of Southampton's Agents Research Group – the largest research group of its kind in the world.

This research will profoundly change the way we work with computers: instead of issuing instructions to passive machines, Nick believes we will increasingly work in partnership with agents, highly interconnected computational components that are able to act autonomously and intelligently.

An 'agent' is a piece of software programmed to work for its owner. Agents can be in sensors collecting and analysing information to give the 'bigger picture' of an emergency situation as it develops. Or, in the future, they could be in a smart meter monitoring the energy consumption of your home, recommending how you might adapt your usual routine to reduce both the cost of the energy that you consume and its carbon content. ▸

"The breadth of our multidisciplinary approach, coupled with our focus on industrial applications, means that this research can be expected to be truly transformational."

Professor Nick Jennings,
Head of Southampton's Agents Research Group, Electronics and Computer Science

ORCHID will help the emergency services deal with crisis situations more effectively

"Emergency situations, such as earthquakes, floods and fires, are extremely chaotic, with new information coming in all the time and priorities constantly shifting."

Professor Nick Jennings, Head of Southampton's Agents Research Group, Electronics and Computer Science

ORCHID and ALADDIN

The University of Southampton is leading a new research project – ORCHID – to investigate how people and agents can work together as 'human–agent collectives' (HACs) to manage the response to a disaster and make smart energy meters even smarter.

Funded by the Engineering and Physical Sciences Research Council, and partnering with BAE Systems and Secure Meters UK, ORCHID builds on the success of the ALADDIN Project (Autonomous Learning Agents for Decentralised Data and Information Networks): a five-year strategic research programme also led by Nick. The ALADDIN researchers designed a system of multiple agents working together to give an overall picture of an emergency situation as it developed. The agents, in sensors, cameras and unmanned aerial vehicles (UAVs), were programmed to collect and process data about the situation.

Using techniques such as game theory, the agents negotiated with each other to arrive at a coordinated plan of action – for example sending the correct number of fire engines to where they were needed most.

"Emergency situations, such as earthquakes, floods and fires, are extremely chaotic, with new information coming in all the time and priorities constantly shifting," says Nick. "Computers are much better than people at collecting and analysing large amounts of information – so through the ALADDIN project we have harnessed this to produce systems in which computers work together, share this information and reduce human error."

Since its completion in September last year, ALADDIN has topped the aerospace and defence category in *The Engineer* Technology and Innovation Awards. It was rated as 'outstanding' by its funders, produced around 150 research papers and was granted eight patents. BAE Systems is now applying versions of the ALADDIN algorithms to real-world situations, including optimising the logistics of supply lines and detecting terrorist threats by monitoring social networking sites on the web.

Adding the human element

ORCHID, which started in January, is taking this research a step further: putting the human back into the loop and looking at how humans and computers can most effectively exchange information and work together in partnership.

Picture a future emergency situation such as an earthquake, where a human rescuer on the ground is working with a group of UAVs monitoring the situation from above. The human rescuer might need to know what a building looks like from all angles, in order to decide whether it is safe to enter, and so needs one of the UAVs to take some imagery of that area and send it via a mobile phone. But if there are multiple UAVs with different capabilities already working on other tasks with different priorities, which one should take the picture? ORCHID's vision is that the agents – programmed into the UAVs and other sensors at the scene – could decide this autonomously by negotiating, both with other agents and with people, to achieve the best outcome quickly.

The £10m project will bring together around 60 researchers from the universities of Southampton, Oxford and Nottingham, together with industrial partners at BAE Systems, Secure Meters UK Ltd and the Australian Centre of Field Robotics.

"The breadth of our multidisciplinary approach, coupled with our focus on industrial applications, means that this research can be expected to be truly transformational," says Nick.

ORCHID: it's all in the name

The project is entitled ORCHID as a metaphor for how a system can flourish by benefiting from different parts – for example many species of orchid plants live non-parasitically on trees, sharing nutrients so that both systems benefit. In ORCHID, this idea is extended to how humans and computers could interact to optimise communication, information and service technologies.

"ORCHID is a truly ambitious project that brings together a number of world-class research groups to tackle a timely challenge that could transform the relationship between humans and computers."

Professor Nick Jennings, Head of Southampton's Agents Research Group, Electronics and Computer Science

The project team will also be looking at ways to effectively harness the information people provide through social networking sites. "When a disaster happens – such as the earthquake and subsequent tsunami in Japan – there is a huge amount of information to process from CCTV, satellites and people on the scene sending information via social networking sites," says Southampton's Dr Alex Rogers, part of the ORCHID team. "Information provided by people, including the real-time amateur radiation monitors that have popped up online since the earthquake, throws up a number of important challenges. We need to consider the provenance of that information – how much we can trust it – and how to classify it."

The team will also be looking at how volunteer power could help to analyse the reams of data. "There are some types of information that people are better at analysing than computers – such as classifying images into different types," says Alex. This approach is already commonplace on websites such as Galaxy Zoo, in which volunteers from around the world, in their own homes, can help to classify the hundreds of thousands of images of galaxies that come from the Hubble telescope. ORCHID researchers will be investigating how these techniques could be used to get the correct information to emergency services faster.

Towards a smarter grid

Many of us already have smart meters in our homes to monitor our energy use. These are set to become much smarter as renewable energy becomes embedded into our lives over the next few years.

"With the global target to cut carbon emissions by 80 per cent by 2050, we will soon be using a lot more renewable energy, and because of its intermittent nature – wind turbines only generate power when it's windy and so on – this will have a huge effect on how we manage our energy supplies and how we pay for them," says Alex. The price of energy fluctuates on a supply-and-demand basis: when it is in plentiful supply, the prices are lower. ORCHID's vision is a 'smart grid' where people and computers work together to get the best deal for the homeowner, in both energy price and efficiency. Agents can be programmed to learn about the energy consumption behaviour in a household, bringing together multiple sources of data, such as temperature sensors inside and outside the house and local weather forecasts on the web. They could also manage the storage of energy within home storage batteries, or even the batteries of our electric cars.

"People are inextricably part of this system," says Alex. "We are the ones using the energy, and paying for it, so we need to retain some control over it – and we will obviously have to have the flexibility to drive away in our electric cars when we choose to, regardless of what the agent has planned."

When it comes to using energy more efficiently, human behaviour is a key consideration. Previous studies have shown that people who save on energy costs by insulating their home may be less careful of being energy efficient in other aspects of their lives. Even comparing energy use with a neighbour can backfire: "If someone tells you that you are using less energy than everyone else in your street, you might well become less careful and start to use more," says Alex. The ORCHID team is looking at how a smart meter can give positive feedback to encourage people to continue saving energy.

"ORCHID is a truly ambitious project that brings together a number of world-class research groups to tackle a timely challenge that could transform the relationship between humans and computers," says Nick. "I'm looking forward to leading this outstanding group and further enhancing the world-leading position of computer science at the University of Southampton."

For more information, visit **www.southampton.ac.uk/research**

Groundbreaking research collaboration

The University of Southampton is joining forces with Lloyd's Register to form the largest research collaboration of its kind in the UK.

Over the next three years, a new, state-of-the-art technology and training campus will be created in Southampton. This new hub will enable University engineers and students to work on joint projects with staff from Lloyd's Register, a not-for-profit company whose global business focuses on the marine, transport and risk management sectors.

The alliance will work on innovations in transport, energy and the environment. It will aim to identify and tackle the challenges that businesses and communities worldwide face in these areas, such as the need for cleaner fuels, 'greener' ships, safer work environments and more dependable infrastructure. Teams of scientists, engineers and industry experts will work together to find the best solutions to these challenges.

Ships consume five per cent of the world's oil and a cause a considerable proportion of our greenhouse gas emissions. It's essential that we make ships 'greener' and reduce their impact on the environment," says Professor Ajit Shenoi, an expert in ship and boat design, production and operation at the University of Southampton.

Southampton researchers are already pioneering new approaches to the greening of ships, with current research focusing on how to reduce the drag and fuel consumption of ships by improving their shape, materials and coatings, as well as developing alternative propulsion and fuel sources from renewable energy. The new alliance with Lloyd's Register will mean this research can be rapidly applied to real-world applications.

Vice-Chancellor Professor Don Nutbeam comments: "This marks the beginning of a groundbreaking collaboration between the University of Southampton and one of the world's leading knowledge-based organisations.

"Building on our 40-year history of collaboration in ship science, marine and energy-related projects, we will extend our cooperation to create new technologies that address some of society's most pressing problems, as well as providing our students with unique opportunities to interact with real-time development projects and connect directly with potential future employers."

Work will start on the £116m campus, known as the Southampton Centre of Excellence, this September, and it's due to open for business in 2014. The University has received funding from the Higher Education Funding Council for England (HEFCE) and the South of England Economic Development Agency (SEEDA) to enable the new Centre of Excellence to take shape.

At the heart of the Centre will be a new Maritime Institute, which will bring together Southampton's wide range of expertise in maritime engineering, ocean science, law and business, and strengthen links with existing marine businesses on the south coast. It will also include the Lloyd's Register Group Technology Centre, the cornerstone of the organisation's global research and development network.

"The Institute aims to stimulate innovation, create new businesses and establish the city of Southampton and the wider south Hampshire region as a place for inward investment in the marine sector in the UK," says Don. "This is great news for the University and for Lloyd's Register. It's also excellent news for the city, the region and for UK plc. Research and innovation are key drivers for building a strong knowledge economy, and we know that governments around the world are looking to collaborations such as ours to help secure a strong economic future."

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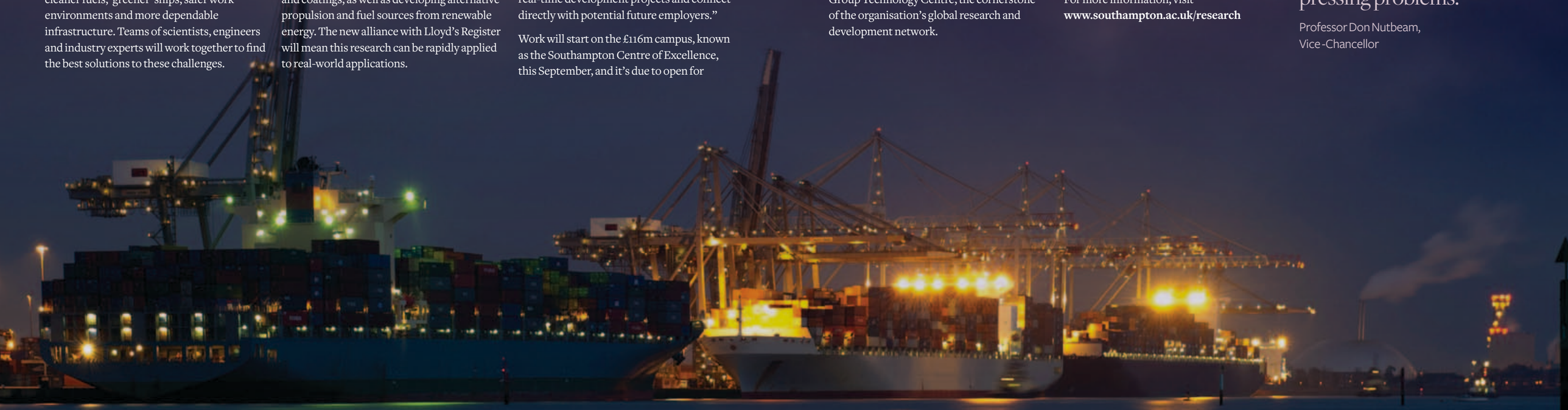

Credit creation to credit crunch

Professor Richard Werner is Chair in International Banking at the University of Southampton. His 2005 book, *New Paradigm in Macroeconomics*, predicted the collapse of the UK banking system and property market. Richard gives *New Boundaries* an insight into his research and views on the current financial crisis.

Q *What does your current research involve?*

At the Centre for Banking, Finance and Sustainable Development, our aim is to focus on the impact banks have on the economy, particularly on sustainable growth and development. This area has had little recognition up until now and our Centre is the first to systematically analyse the links between banks and the economy. My own research particularly focuses on banking crises.

Q *How did you see the UK banking crisis coming?*

Banking crises follow a familiar pattern; the one we have just had was entirely preventable. The 'property frenzy' that lasted until 2007 was a key indicator. If banks lend large amounts to economic activities that don't contribute to the country's gross domestic product (GDP), such as risky 'sub-prime' mortgages, this is unsustainable and will result in a banking crisis.

Q *What exactly is a banking crisis?*

To understand banking crises you need to understand credit creation. Most people think there is such a thing as a bank loan, but this is not true. When a bank 'lends' money, it has the right to create the money, or credit, out of nothing. When this money is used badly, for example lost in risky speculative activities, the bank's balance sheets no longer balance, using up equity and quickly busting the bank. As banks are linked, and usually do similar things, we get a banking crisis.

Credit creation is a concept that the public knows practically nothing about– for good reason. If people knew about it they would rightly argue that money creation is a public privilege and this right shouldn't be given to individual banks to use for their own benefit.

Q *What is the best way to resolve such a crisis?*

A banking crisis can be resolved at zero cost to the taxpayer, meaning there is no need for the painful budget cuts we are now experiencing. The central bank could step in and purchase the non-performing assets – such as sub-prime mortgages – from the banks at face value without raising taxes or cutting any spending elsewhere. This process doesn't create any money so there is no inflation cost as a result of this.

This is a key recommendation, which I published in the 1990s. At the time only one American economist listened to this advice: Ben Bernanke, who is now the Chairman of the United States Federal Reserve. This is exactly what he did in September 2008 and as a result the American banking system was bailed out in a cheaper fashion than in many other countries. Of course the problems were bigger in America so they didn't have the option of using tax payers' money.

Q *What's the best way to prevent future banking crises?*

To take the privilege of creating money away from individual banks and give it to the government or the central bank only, so that money is only created in a transparent way that benefits society.

We also need a structural reform of the banking sector. Ninety per cent of the UK banking sector is controlled by five banks; this concentration means that small and medium sized companies (SMEs) and local communities find it difficult to get funding. By comparison, in Germany, small locally headquartered banks make up 70 per cent of the banking system. I would argue that this is why the economic performance in Germany has been consistently better than the UK for many years. Smaller banks are not interested in risky speculation and they will support small companies that have good products or innovative ideas. This leads to much more stable growth.

Other solutions include reducing government debt, which could be done using the right monetary policy, and restricting bank credit for speculative transactions.

Q *What are your views on bankers' bonuses?*

Bankers' bonuses should only be paid when banks create credit that contributes to the country's GDP. There should be no bonuses for bank credit given to destructive activities, such as financial speculation. At the moment this is happening in the UK and it is wrong.

I don't agree that cutting bonuses would lose banking talent. There are too many bankers in the UK and often it's the less bright bankers who are attracted by the big money. If the 'talent' we are attracting with bonuses is creating the 'boom and bust' cycles, this is not the talent the economy needs.

Bankers like 'big deals' because their bonuses are usually a percentage of the deal size. I feel the relationship should be inverse: the bigger the deal, the smaller the bonus, to encourage banks to support SMEs.

Q *How does Southampton rank in this field?*

Our MSc in international banking is highly respected and is one of the leading MSc courses of its kind in the UK. It is also one of the few courses in the UK that teaches the topic of credit creation.

The diversity we have at Southampton is a great asset: as a broad-based research university we have world experts in many fields and this brings opportunities to work in an interdisciplinary way. As a banking expert, it's helpful to get a fresh perspective from people from other disciplines such as accountants, social scientists and engineers whose techniques can be applied to banking analysis.

For more information, visit **www.southampton.ac.uk/research**

A breath of fresh air

A Southampton-led clinical trial could pave the way to a new treatment for virus-induced asthma attacks. *New Boundaries* speaks to Professor Stephen Holgate about this latest trial and the University's world-leading asthma research.

Asthma is one of the most common chronic conditions in the developed world, affecting one in 11 children – and it is on the increase. Winter months can be a particularly worrying time for asthma sufferers because cold and flu viruses trigger more frequent asthma attacks; this could all change thanks to a phase II clinical trial, led by Southampton researchers in partnership with the spin-out company Synairgen.

By studying the cells from the lining of the lungs, Southampton researchers discovered several years ago that people with asthma are unable to fight off colds and flu as effectively as people with healthy lungs. Professor Stephen Holgate, a world-class researcher and leader in the medical community who has been researching asthma at Southampton for the past 35 years, explains: "Our most exciting discovery so far has been that asthmatics don't make enough of a type of protein – interferon beta – in their airways, which would normally defend them against viral infections such as the common cold. This led to our establishing a University spin-out company, Synairgen, in 2004 to develop a treatment to make up the deficiency."

The researchers are now trialling an aerosol spray of interferon beta to boost the immune system of people with asthma. Due to be completed at the end of this year, the phase II clinical trial includes volunteers with asthma who will be dosed with interferon beta when they catch a cold or flu. If the treatment proves effective, it could significantly improve the quality of life for people with severe asthma and reduce the number of patients admitted to hospital with asthma attacks in the winter months.▸

Southampton research is improving the lives of people with asthma

A translational approach

Over the past 30 years, Southampton researchers have been translating fundamental science to clinical practice to improve the lives of people with asthma. The interferon beta clinical trial is just one example of this. Stephen explains: "Doing medical research to benefit patients directly has been at the core of our philosophy since this medical school was founded." With strong links between the medical school and the hospital trust, Southampton remains uniquely poised to move discovery science into clinical trials, leading to a smooth transition of research in the laboratory to its application in the clinic.

The award of special facilities to Southampton has been a great help in pioneering respiratory research, explains Stephen: "Our Wellcome Trust clinical research facility was one of five awarded to medical schools around 10 years ago and more recently the University was one of three centres in Britain to be awarded a Biomedical Research Unit for respiratory and nutrition research." With the consent of volunteer patients, these facilities give researchers access to tissue samples from routine procedures for the study of diseased cells, enabling them to find out what has gone wrong in conditions such as asthma.

Having consent to use tissue samples for research has enabled Stephen and his colleagues to make fundamental discoveries about asthma. "The interferon beta discovery emerged precisely because we are able to study disease in human tissue rather than in animal models," explains Stephen.

More recently, Stephen's team has now shown that interferon beta can also protect against influenza viruses, particularly avian flu and swine flu – and through the Biomedical Research Unit they will soon be running a further clinical trial to investigate how effective the treatment is for groups – such as diabetics, asthmatics, pregnant women and children – who are most at risk if they develop influenza.

Stephen himself has played a key role in the University's translational research. Since the late 1970s, he has been striving to find the cause of allergic asthma – the most common form of the condition. This year he was awarded a CBE in the New Years Honours for his services to clinical science.

Building on success

Respiratory research at Southampton has had many successes over the years. For example, in 2000, Stephen's team identified the first novel asthma gene – *ADAM33* – which they reported in the journal *Nature* in 2001. Over the past 10 years the team has studied the gene in detail, improving the knowledge base on how it can cause asthma to develop in young children. "We have shown that this gene can become abnormal at very early stages of life – even in developing babies in the womb. It's one of a series of genes the environment modifies in early life to make asthma more likely to develop in children. The gene is also involved in making the disease more chronic and severe," says Stephen.

Researchers are now building on this work to discover what makes asthma a chronic condition that persists throughout life; they are making exciting links between respiratory research and developmental science, with new studies looking at ways to prevent children developing asthma by controlling diet in pregnancy and early childhood. "This links to an area of science that the research community is very excited about: epigenetics – the study of how the genes are switched on by the environment. We're looking at what it is in early life that switches on these genes and makes children asthmatic," says Stephen.

Exchanging ideas with the research community around the world has been key to the success of Southampton's respiratory research. "Southampton is among the top five in the world in asthma research; one of the most powerful things to enable this is the fact that over the last 20 years a lot of very talented people from across the world have come to do their training at Southampton, bringing with them originality and fresh ideas," explains Stephen.

"Several of our researchers have also won awards to spend two or three years in the best laboratories in the world. When they come back to Southampton they bring new techniques to apply to human-based discovery science, which is a tremendously successful model," he adds.

Multidisciplinary research and partnerships with industry and charities also play a key part. Many Southampton PhD students are funded jointly with charities, industry and other academic units at the University of Southampton, such as Biological Sciences, Chemistry and Engineering Science. This is leading to fresh ideas and the development of new diagnostic tests by bringing expertise together across the disciplines.

Respiratory research at Southampton is certainly in good health. "I am still at Southampton after 35 years for a very good reason: this university has a huge amount to offer. You can do as much and more here to develop your research career as any other institute in the world."

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> Stephen Holgate, Professor of Immunopharmacology

Helping children to read

Dr Hazel Blythe completed her PhD at Southampton in 2007. Now in her fourth year as a postdoctoral research fellow, Hazel explains the impact her research is having in helping children to learn how to read.

Q *What are the main aims of your research?*

We're investigating reading in teenagers with permanent childhood hearing impairment (PCHI). Previous research has shown that, on average, a 17-year-old with PCHI has a reading age of nine years. We will look at how well teenagers with PCHI, and also teenagers with dyslexia, can identify printed words on the basis of their speech sounds when they are reading silently. This is something that we know skilled adult readers do, for example identifying the word 'train' when they look at 'trane'. By recording the movements of their eyes as they are reading, we can build up a detailed picture of which words children are looking at and how long they spend looking at them. This shows us how cognitive processing of language occurs in real time.

Q *What impact will this research have on society?*

There are already many successful literacy intervention programmes for children with dyslexia. These are largely based on increasing children's awareness of the speech sounds associated with the letters within printed words. If we find that individuals with PCHI show the same pattern of difficulties as the teenagers with dyslexia, this would suggest that the literacy interventions designed for children with dyslexia could also be used by those with hearing impairments. If the two groups show distinct patterns of difficulties, this suggests that new literacy interventions need to be developed for children with PCHI.

Q *What sparked your interest in this topic?*

Throughout my academic career, I've always been interested in children's reading development. In 2009, I met a group of researchers in Medicine who are interested in the consequences of early diagnosis and intervention for individuals with PCHI and their development. I started discussing ideas with them and with colleagues in Psychology about reading development and, in particular, the ability to associate printed words with speech sounds. I was shocked when I found out how much difficulty individuals with hearing impairments are faced with when learning to read.

Q *How did your PhD at Southampton lead into your current research?*

My PhD research focused on children's eye movements when they are reading, and linking these eye movements to their psychological processing of language. There is a vast literature on skilled adult readers' eye movements, but extremely little work has been done using this technique with children.

Now we have a better understanding of how typically developing children's eye movements are different to adults when they are reading, we can build on this knowledge to examine different groups of children with various forms of atypical development.

Q *What do you enjoy most about your work?*

I love the 'hands on' aspects of my work, getting to meet lots of families, and I believe that this work will, in the long term, help children learn to read.

Q *What is the biggest challenge?*

Persuading young people to sit still for long enough for us to get good quality recordings of their eye movements!

Q *Why is Southampton a good place to do this type of research?*

The University of Southampton has cross-disciplinary links and specific expertise that makes it a unique and ideal environment in which to conduct this research. We also have several eye tracking laboratories that are among the best in the world; in particular, we have the Mobile Research Unit (MRU) – a custom-built vehicle, purposely furbished as a high-grade experimental laboratory. The MRU allows us to take our eye trackers out and about, enabling us to collect data from participants very conveniently at their schools during the day.

Q *What do you think about the University's multidisciplinary approach?*

The University's multidisciplinary approach makes it a great place for early career academics to develop their interests. I am a member of the Southampton Neuroscience Group (SoNG) which really facilitates communication between researchers in different faculties. This project is very much interdisciplinary, and the research team – from Psychology and Medicine – has combined expertise in eye movements, reading development and hearing impairment which makes us ideally placed to conduct this work.

Q *What opportunities are there at Southampton for early career academics?*

I've had a really wide range of opportunities in the last few years, including training courses – such as media training, team building and grant writing – plus international research collaborations in the USA and China. Most recently, I've been awarded a place on the University's Researcher Talent Development Programme. Southampton has been a fantastic place for me to start my career.

Q *What have been your biggest achievements so far?*

Completing my PhD and helping to establish the new eye movement laboratories are both high on my list of achievements. More recently, Professor Simon Liversedge, Professor Colin Kennedy and I have been awarded a grant from the Leverhulme Trust that will allow me to continue this research for the next three years. I see this as a fantastic opportunity to make theoretical developments with the potential to impact on people's lives.

For more information, visit **www.southampton.ac.uk/research**

Preventing gridlock

The past year's freezing temperatures, heat waves and volcanic ash cloud have caused chaos for the UK's transport systems. Southampton researchers are part of a national team working to prevent future meltdown of our infrastructure.

National infrastructure systems – energy, transport, telecommunications, water and waste – in the UK are in urgent need of an update to meet the needs of our changing world. As we have seen in the last year alone, these networks are vulnerable to changes in the weather: the volcanic ash cloud last April caused chaos for air travel around the world, while freezing temperatures last December made road, rail and air travel impossible in some areas of the UK; meanwhile, thousands of people in Northern Ireland were left without drinking water when pipes burst after a sudden thaw.

Southampton researchers are now part of a world-leading multidisciplinary team of engineers and scientists tackling this issue head on. The UK Infrastructure Transitions Research Consortium (ITRC) came together in January; over the next five years, it aims to develop a new generation of tools to help 'future proof' our infrastructure.

Engineers, climate scientists, social scientists and economists will come together and look at the system as a whole to understand the complex interdependencies between the networks and how they have evolved to respond to changes in our lifestyle. The ITRC brings together world-leading experts from the universities of Southampton, Newcastle, Oxford, Cardiff, Cambridge, Leeds and Sussex, as well as government and industry. Southampton researchers are leading in the areas of transport, waste and complexity.

"This is one of the few chances we have to act in time to mitigate the major threat of climate change," says Professor William Powrie, Dean of Engineering and the Environment. "The project brings a double benefit because not only are we responding to the challenge, but by viewing the system as a whole we are doing so efficiently and with the minimum of resources."

A changing world

Much of the UK's current infrastructure was built in the nineteenth and early twentieth centuries. Since then the economy and population have grown rapidly, and our lifestyles have changed, putting intense pressure on the system.

For example, since the 1930s, there has been a great deal of development in our transport infrastructure, especially in new roads between towns and cities, making travel between them ever easier, quicker and more popular. This has influenced people's decisions on where to live and work; whereas in the early twentieth century people needed to live close to their workplace, we now have the option to commute long distances by fast train and motorway. The past 20 to 30 years have seen a catalytic effect of improved transport infrastructure on development, for example the massive development and growth as a result of Heathrow Airport, the M4 corridor and Bristol Parkway railway station.

We need to find solutions quickly to ensure our transport infrastructure can keep up with our needs. ▸

"This is one of the few chances we have to act in time to mitigate the major threat of climate change."

Professor William Powrie, Dean of Engineering and the Environment

Our supercomputer, *Iridis3*, enables our researchers to model and address some of today's most pressing challenges

"It took a generation for us to transition to the networks we have today from the time the need for radical change was perceived, whether we are looking at motorways, modern railways or modern waste management.

"External drivers such as population growth, climate change, and energy and resource security are now moving so quickly that we don't have a generation to make the next set of infrastructure changes," says William. "Rather than making incremental adjustments to our existing infrastructure, we need to make transformational changes to accommodate whole new modes of use such as electric cars and very high speed (400 km/h) trains. The ITRC will foster precisely the kind of bold thinking and vision that is needed to drive these changes."

Partly as a result of our improving standard of living, we are now faced with an urgent need to find low-carbon solutions to meet the 80 per cent reduction target for greenhouse gas emissions by 2050.

Future climate change could have a dramatic impact on our infrastructure, with weather becoming more extreme. At Southampton we have been at the forefront of climate research for many years: the project brings this expertise together to help prepare the UK's infrastructure to adapt to a range of possible outcomes, under the leadership of Professor Robert Nicholls, Deputy Head of Civil Engineering and the Environment and a member of the Nobel Prize-winning Intergovernmental Panel for Climate Change.

A complex system

The key networks that make up the UK's infrastructure are inextricably connected; but that's not the whole story. Our infrastructure also has a social element: it needs to be flexible enough to adapt to our behavioural changes. "Sometimes these can be changes for the better; for example, an unforeseen outcome of setting up a food waste recycling programme in Eastleigh, Hampshire was that once people started separating out their food waste they realised how much food they were wasting, and the amount of food waste decreased dramatically," says William.

To address global challenges such as climate change, it's essential that researchers view systems such as infrastructure, ecosystems and financial markets, as a whole.

"Using the University's £3m supercomputer, the most powerful university-owned supercomputer in the UK, we will be modelling the long-term needs for infrastructure and how this might be achieved," says Dr Seth Bullock, Director of the University's Doctoral Training Centre (DTC) in Complex Systems Simulation. At the DTC we are training the next generation of research leaders who will be able to solve the global challenges that affect us all using the latest technologies and techniques in analysing complex systems.

A history of expertise

Southampton is one of the leading institutions in Europe for infrastructure research and this new project is underpinned by a strong fundamental science and engineering base.

"Over the past few years we have been doing significant fundamental research on aspects of waste management, rail and road infrastructure and climate change, so in many respects this new project is a way of pulling these results together," says William. Southampton research has led to many developments in infrastructure, including new systems of strengthening cast iron bridges using carbon fibre and plastic composites, which enable infrastructure owners such as Network Rail and the Highways Agency to repair existing bridges rather than replacing them at considerable cost. Our researchers have developed guidance on vegetation management for railway embankments to help reduce the effects of seasonal track movements due to swelling, shrinkage and fallen leaves, as well as possible future climate change. They are also informing government policy – for example on how to effectively generate green energy from biomass using anaerobic digestion.

"This new research will have a major impact on the way we plan and develop our infrastructure over the next decade, which will continue to impact on the way we live our lives for more than a generation," says William. "The importance of this research can't be overstated: it's vital to us all, and will help keep society functioning at the levels of expectation we all have – whatever the future may bring."

For more information, visit **www.southampton.ac.uk/research**

"Using the University's £3m supercomputer, the most powerful university-owned supercomputer in the UK, we will be modelling the long-term needs for infrastructure and how this might be achieved."

Dr Seth Bullock,
Director of the University of Southampton's Doctoral Training Centre in Complex Systems Simulation

New frontiers in astrophysics

A pioneering Southampton research team is working to answer fundamental questions about the universe, including how galaxies are born and how gravity works.

The University of Southampton is playing a key role in the Low Frequency Array (LOFAR) project, a wave of new technology telescopes across Europe that will enable astronomers to view the universe in unprecedented detail. Last September, the UK's contribution to this project, the LOFAR UK station, opened in Chilbolton, Hampshire. The revolutionary new radio telescope station was coordinated by a consortium of more than 20 partner universities, led by Southampton's Professor Rob Fender.

For centuries astronomers have viewed the skies to learn more about the origins of the universe. Early telescopes used only the visible wavelengths of light, but today's telescopes view in the radio, infrared, X-ray and gamma bands – each different wavelength adding more detail to refine our view.

LOFAR UK will help shed light on rare and transient events that are fundamental to our understanding of physics and astronomy – such as galaxies forming and black holes swallowing stars. "Instead of one fixed dish, the LOFAR UK telescope has an array of fixed antennae that pick up radio waves. By linking the data gathered from each antenna, we can build up a detailed picture of the whole sky," Rob, a world expert in astrophysics, explains. "The most amazing thing is that these small antennae can pick up faint radio signals from over 10 billion years ago, when the universe was a fraction of its current size, and these signals can be mapped over the entire sky by the telescope without a single moving part, he adds"

LOFAR UK is made up of 96 radio antennae and 96 radio 'tiles', connected using sophisticated computing and high-speed internet. It will continuously monitor radio waves emitted from the sky in the frequency range of 10–240 MHz.

The telescope is part of the Europe-wide LOFAR project, led by ASTRON, the Netherlands Institute for Radio Astronomy Research. When completed, LOFAR will consist of a network of 5,000 antennae across Europe, making it the largest and most sensitive radio telescope in the world.

Rob has been involved with LOFAR right from its inception 10 years ago, and has been instrumental in making UK astronomy a key part of the project. He is the leader of the LOFAR Transients Key Science Project, which will shed light on how the first stars in the universe were born, enable researchers to better understand cosmic rays, and search for new astrophysical phenomena.

Mapping the whole sky

Rob was recently awarded a €3m European Research Council grant to lead a global project called 4 pi sky (meaning 'the whole sky'). The project team will take three powerful but separate radio telescopes – LOFAR, the Karoo Array Telescope (MeerKAT) in South Africa, and the Australian Square Kilometre Array Pathfinder (ASKAP) in Western Australia – and turn them into a global system for following astrophysical phenomena as the Earth rotates. The team will develop new software to provide a 'detect and alert' system for all three facilities. "For the first time, this will enable us to build up a census of explosive events in the universe," says Rob.

Perhaps the most exciting part of this project is that it will help identify the first sources of gravitational waves, which are fundamental to the theory of relativity but so far have never been detected. "This would be a monumental discovery," says Rob. "To optimise the chances of detecting gravitational waves, we are working with teams at the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the USA and the European Gravitational Observatory (VIRGO) in Germany.

"If VIRGO or LIGO find gravitational waves first, we will direct LOFAR-UK's antennae in that direction to help find out more about them and, crucially, find out how far away they are in order to test Einstein's theory of relativity," he explains.

The team will also collaborate with ground-based optical telescopes and with the orbiting Japanese MAXI X-ray telescope on the International Space Station. This 'multi-wavelength' approach is crucial for viewing the astrophysical phenomena in detail.

The 4 pi sky project, which started in January, will continue Rob's work to inspire and provide opportunities for young astronomers. Four PhD students and four postdoctoral researchers will be involved in the project. They will have the chance to develop novel techniques in partnership with the University of Oxford as well as benefiting from Southampton's extensive partnerships with teams of astronomers around the world.

"This project gives us a unique and exciting chance to dramatically push back the frontiers of our understanding of high-energy astrophysics," says Rob. "Every time such an advance has happened in the past, exciting new discoveries have been made – who knows what we might find this time."

For more information, visit **www.southampton.ac.uk/research**

"This project gives us a unique and exciting chance to dramatically push back the frontiers of our understanding of high-energy astrophysics"

Professor Rob Fender, Head of Astronomy Research

Mapping global maternal health

Deaths in pregnancy and childbirth are all too common in the poorest countries; Southampton researchers are helping to highlight this global issue.

More than 99 per cent of maternal deaths occur in developing countries: in India alone 63,000 women die every year in pregnancy or childbirth. The vast majority could be prevented by better access to healthcare.

Social scientists Professor Zoë Matthews and Dr Sarah Neal are working on a joint project called the Atlas of Birth, which aims to inform and influence world leaders on improving the health of women, newborn babies and children. Working in partnership with the White Ribbon Alliance for Safe Motherhood and the University of Aberdeen, they are bringing together the latest evidence from the United Nations and the World Health Organization to create accessible maps and policy recommendations in attractive and easy-to-read formats. The Atlas of Birth illustrates the hard facts about maternal deaths around the world. The team has also created a raft of materials to support this agenda to present to decision makers at events ranging from protest marches to world summits.

Funded by the Partnership for Maternal, Newborn and Child Health and the Norwegian government, Atlas of Birth includes statistics on a wide range of issues including maternal deaths, pregnancies to very young girls and midwife contact. "Atlas of Birth will enable advocates across the world to quickly and effectively lobby governments, influence policymakers and inform the media, as public pressure grows to end the tragic and almost always preventable deaths of girls and women in childbirth," says Zoë, Professor of Global Health and Social Statistics.

Zoë and Sarah have calculated that in some countries up to 14 per cent of girls have given birth before they are 16. These new findings, which have been submitted to the Bulletin of the World Health Organization, could form the basis of a new global database on maternal age and pregnancy. Becoming a mother at a very young age is common in developing countries, and girls under the age of 16 are four times more likely to die giving birth than women in their 20s.

Global impact

There are promising signs that maternal health is moving up the international agenda. Recently, new aspects of maternal health – including adolescent births – were added to the United Nations' Millennium Development Goals, and last year the UN Secretary General, Ban Ki Moon, launched a new global strategy for women's and children's health.

"Many advocacy groups have been involved in bringing this issue forward, and Atlas of Birth has certainly been a part of this effort," says Zoë. "In the past, HIV/AIDS has been taken up as a huge UN priority; this has gone some way towards tackling the HIV/AIDS epidemic. The fact that women's and children's health has now been taken up as an issue by the UN is a big step in the right direction."

In response to the new UN global strategy, Zoë and Sarah have been engaging with policymakers and researchers to discuss what the future research agenda for this developing area should be. Most recently, Zoë organised an Economic and Social Research Council-funded seminar on maternal health and poverty hosted in collaboration with the University of Aberdeen. PhD students and early career academics had the opportunity to present their work and discuss the impacts with policymakers. Sarah, a postdoctoral researcher in social sciences at the University of Southampton, comments: "It's encouraging to see that our work on maternal and newborn deaths is seen and understood by policymakers.

"The Atlas of Birth has been a great opportunity for me to learn how to effectively bridge the gap between research and policy; the recent seminar in Aberdeen, attended by policymakers from the WHO, the UK and Norwegian governments, among others, is just one example of how we are engaging with policymakers."

The University of Southampton is home to one of the leading quantitative social science research groups in the UK. "Our statistical expertise and the fact that we are rooted in the social sciences makes us unique in the UK in this field," says Zoë. "Our multidisciplinary approach is also crucial: we have experts in statistics, economics, midwifery and social sciences all working together, as well as opportunities to collaborate with other disciplines across the University, enabling us to bring together a broad range of expertise to tackle this global issue."

For more information, visit **www.southampton.ac.uk/atlasofbirth**

"Our statistical expertise and the fact that we are rooted in the social sciences makes us unique in the UK in this field."

Zoë Matthews,
Professor of Global Health
and Social Statistics

In brief

Improving photosynthesis

A University of Southampton research team is participating in a new £6.11m transatlantic research project to improve the process of photosynthesis.

Photosynthesis allows biological systems such as plants and algae to convert sunlight into food, and over time has produced all the fossil fuels we burn today. However, due to 'bottlenecks' in the process of natural photosynthesis, it has some fundamental limitations.

Four research teams from the UK and the USA, including a team led by Dr Tom Bibby, lecturer in biological oceanography at the University of Southampton, will explore methods to overcome these limitations. This research could lead to increasing the yield of important crops for food production or sustainable bioenergy, and could even lead to the blueprint to make a fully artificial leaf capable of removing carbon dioxide from the atmosphere.

Funding has been awarded by the UK Biotechnology and Biological Sciences Research Council (BBSRC) and the US National Science Foundation (NSF). Tom says: "This is a new way of funding science, bringing people together from both the UK and USA who have expertise and interest in a particular area of research. It's great for the University of Southampton to be involved with this ambitious project."

UK's first totally implanted hearing aid

A woman from Portsmouth has received the UK's first totally implantable hearing aid thanks to the work of the South of England Cochlear Implant Centre (SOECIC), based at the University of Southampton.

The Otologics Carina middle ear implant is special because it is the first totally implantable device to provide hearing with no external components for the user. The device consists of a rechargeable battery, a signal processor and a microphone, which are all implanted under the skin. These are connected to a tiny electromagnetic vibrator which is positioned inside the mastoid bone behind the ear and attaches to the hearing bones. There is nothing on the outside of the head and the ear canal is left open.

Sarah Flynn, Adult Programme Coordinator for SOECIC, explains how the implant works: "It delivers a mechanical vibration directly to the hearing bones. The microphone picks up sound from under the skin and transmits it to the signal processor. The signal processor amplifies the sound based on the user's needs and transmits the amplified signal to the middle ear transducer. The transducer is positioned in a mounting system that allows it to contact and directly stimulate the hearing bones."

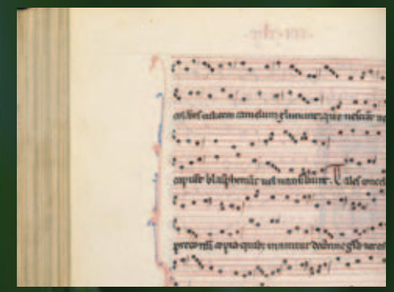
Top of the league in British science

Three Southampton professors featured in the list of '100 most important figures in British science' published in *The Times* newspaper last year.

Web science innovator Professor Dame Wendy Hall featured at number 26 and as the fourth highest placed woman. Professor Sir Tim Berners-Lee, inventor of the world wide web and Professor of Computer Science, is ranked at number 52. At number 56 is Professor David Payne, Director of the Optoelectronics Research Centre, who has carried out world-leading research at the University for over 40 years.

Dame Wendy says: "I'm just thrilled to be in such an eminent list. It is great to have the spotlight put on science in this way. It's a great tribute to the support for research and scientific endeavour at the University of Southampton."

"I am delighted with this accolade. It is stunning recognition of the merits of sustained and generous funding of science from both the University and from the Engineering and Physical Sciences Research Council over several decades," adds David.



Bringing medieval music to life

The University of Southampton has been awarded almost £600,000 from the Arts and Humanities Research Council to research, catalogue and create sound recordings of a lost genre of medieval music that was last performed in the 13th century.

Southampton researchers will lead a project to study, recover and revive the music, known as the conductus, which consists of vocal compositions that merge Latin poetry and music. They will be working in partnership with Hyperion Records and the National Centre for Early Music in York. The project is called '*Cantum pulcriorem invenire*' or 'to find a more beautiful melody'.

The work will result in a monograph published by Cambridge University Press and an online catalogue of the manuscripts, which will be hosted by the University of Southampton. Selected works will be performed by world-class musicians.

Head of Music Research, Professor Mark Everist, comments: "Conductus were performed widely in the 13th century across Europe, but eventually fell out of fashion and haven't been heard for around 700 years. Our performances will bring to life this all but forgotten yet highly significant genre of music, making it accessible to a 21st century audience."

In brief

Protecting our coastlines

Southampton researchers are leading a major consortium project to study past and possible future sea-level rise to help protect our coastlines from future flooding.

The UK coastline has around £150bn of assets at risk from coastal flooding, of which £75bn are in London alone.

"The vulnerability of extensive near-coastal habitation, infrastructure and trade makes global sea-level rise a major concern for society," says project coordinator Professor Eelco Rohling. "By studying how the sea level responded during the warmer periods between ice ages, we hope to obtain a better picture of how much and how quickly sea level may rise as a result of global warming."

The £3.3m project is funded by the Natural Environment Research Council (NERC). "The aim of the new consortium project is to understand better the processes controlling sea-level rise, and, in so doing, put estimates of maximum future sea-level rise on a firmer statistical footing," says Eelco, who is based at the National Oceanography Centre Southampton.

Exploring the oceans

Southampton scientists aboard the royal research ship RRS James Cook have discovered a new set of deep-sea volcanic vents in the Southern Ocean. The discovery is the fourth made by the research team in three years.

The vents are at a depth of 520 metres in a newly discovered seafloor crater close to the South Sandwich Islands in the southern Atlantic Ocean near the Antarctic. "We're finding deep-sea vents more rapidly than ever before," says expedition leader Professor Paul Tyler. "And we're finding some in places other than at mid-ocean ridges, where most have been seen before."

Deep-sea vents are hot springs on the seafloor, where mineral-rich water nourishes colonies of microbes and deep-sea animals. By studying the new vents, the team hopes to understand more about the distribution and evolution of life in the deep ocean, the role that deep-sea vents play in controlling the chemistry of the oceans, and the diversity of microbes that thrive in different conditions beneath the waves.

The discovery is part of a project funded by the Natural Environment Research Council, which involves researchers from the National Oceanography Centre in Southampton, the British Antarctic Survey in Cambridge, the universities of Southampton, Newcastle, Oxford, Bristol and Leeds, and Woods Hole Oceanographic Institution in the USA.

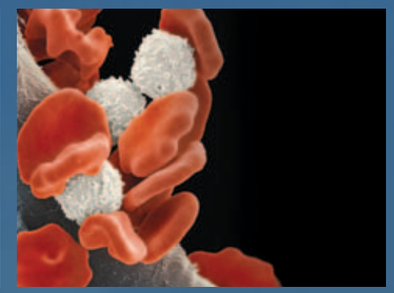
Next generation internet infrastructure

To keep pace with society's ever-increasing data transmission requirements, Southampton is leading a new project to develop the next generation of internet infrastructure. The project has the potential of increasing bandwidth to 100 times the current capacity.

The €11.8m MODE-GAP project is funded under the EU Seventh Framework Programme. It will develop transmission technologies to increase the capacity of broadband networks.

Led by the University of Southampton's Optoelectronics Research Centre (ORC), this collaborative project brings together the expertise of leading industrial and academic organisations across Europe: Phoenix Photonics Ltd; ESPCI ParisTech; OFS Fitel Denmark APS; the COBRA Institute at Eindhoven University of Technology; Eblana Photonics Ltd; Nokia Siemens Networks; and the Tyndall National Institute of University College Cork.

ORC's Deputy Director, Professor David Richardson, comments: "The MODE-GAP project has the potential to revolutionise the way we build and operate future generations of optical networks. Success will require substantial innovation and major technological developments in a number of fields. The consortium partners believe that they are ideally equipped to undertake the work and are looking forward to the many challenges ahead."



New leukaemia cancer vaccine

A new cancer treatment that strengthens a patient's immune system and enables them to fight the disease more effectively is being trialled on patients for the first time in the UK.

The treatment will use a new DNA vaccine developed by scientists from the University of Southampton and a vaccine delivery system created by Inovio Pharmaceuticals. A selected group of volunteers who have either chronic or acute myeloid leukaemia will take part in the trial.

Scientists believe they can control the disease by vaccinating patients against a cancer-associated gene (Wilm's tumour gene 1), which is expressed in almost all chronic and acute leukaemias.

"We have already demonstrated that this new type of DNA vaccine is safe and can successfully activate the immune systems in patients with cancer of the prostate, bowel and lung. We believe it will prove to be beneficial to patients with acute and chronic myeloid leukaemia," comments Professor Christian Ottensmeier, Chair in Experimental Cancer Medicine at the University of Southampton and consultant oncologist at Southampton University Hospitals NHS Trust.

The research is funded by the charity Leukaemia & Lymphoma Research and the Efficacy and Mechanism Evaluation (EME) programme, which is financed by the Medical Research Council (MRC) and managed by the National Institute for Health Research (NIHR).

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