UNIVERSITY OF Southampton

Institute for Life Sciences

Annual Report

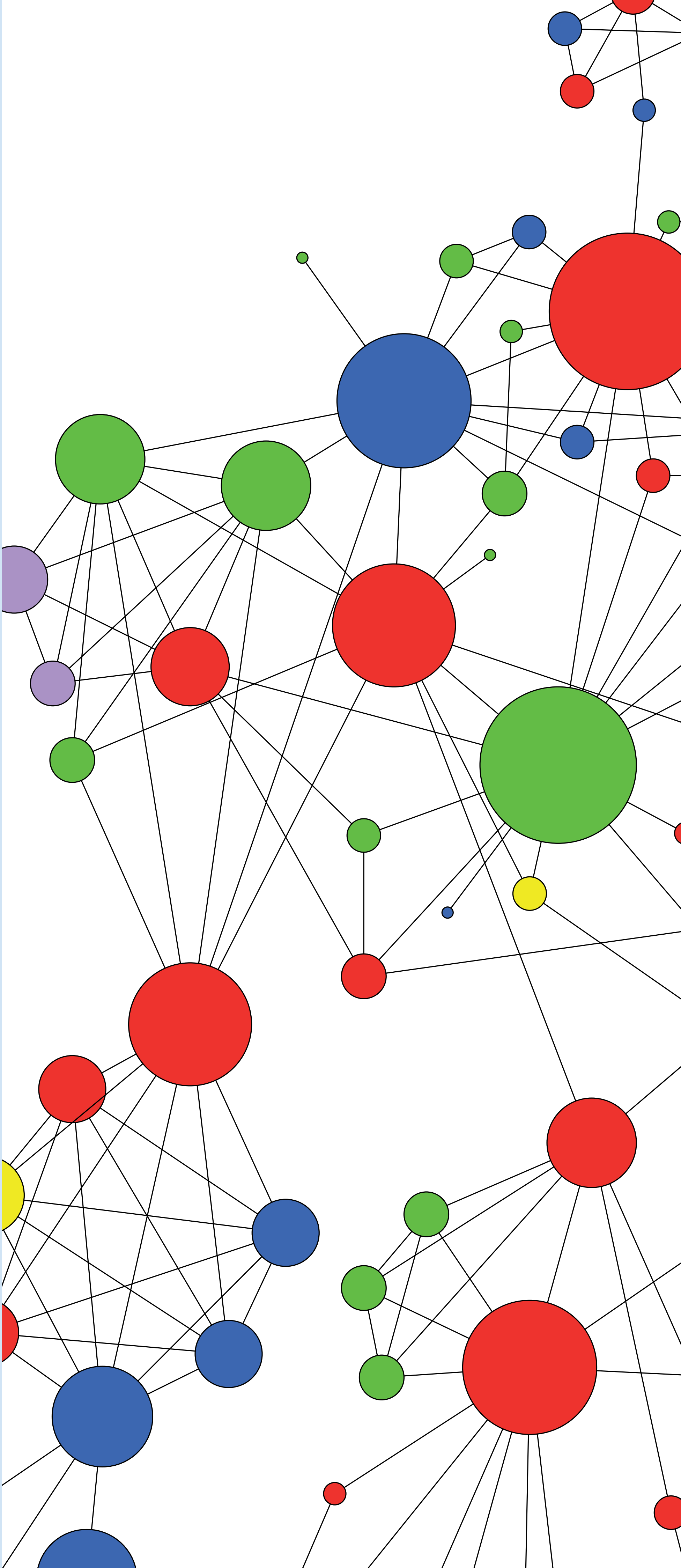
Contents

Cover Image

A neuronal network display for high throughput screening. By Vanessa Hausherr, Julia Sisnaiske, Christoph van Thriel and Jonathon West.

Image (right)

A section of the nodal map of real connectivity created by Dr Ben MacArthur illustrating IfLS supported collaborations between different scientific disciplines.



Solutions in Life Science

Both locally and globally many of the big societal challenges of the next few decades have their solutions in the life sciences. We need powerful new approaches to solving them. Environmental restructuring, food and fuel security, disease resistance and detection, ageing and health care, all will be addressed by integrating different disciplines to produce a convergence on life sciences through biology, medicine, the physical sciences and engineering[1]. This transdisciplinary approach is increasingly recognised as the way forward but what is the route for getting there? The University of Southampton offers a compelling opportunity to chart a new pathway. Known for its international strengths in several fields of study and enterprise the university has unique capabilities to drive a powerful convergent model. It prides itself on its core research excellence: Eight faculties[†] containing world-leading research groups.

The Institute for Life Sciences (IfLS), launched in September 2011, forms one of the corner stones in the university strategy to facilitate cross campus interdisciplinary research and education. The outputs from the IfLS are clearly aligned with current national and societal interests and the university is well placed to play a significant role in the government's 'Strategy for UK Life Sciences'[2]. Additionally, formed to support the university's commitment to change the world for the better through research, education, innovation and enterprise, the Institute has developed six core research themes: Applied Neuroscience, Biofilms, Food Security & Environment, Hybrid Biodevices, Imaging in the Nanodomain and Translational Immunology which have evolved from where the university held critical mass and international impact. Life science at the university is not restricted to those disciplines with a traditional life sciences emphasis and the Institute values the involvement of engineers, physicists, social scientists, health technologist and artists, as important players in generating fresh perspectives on complex biological and biomedical problems.

Over 2012 and 2013 the Institute has developed as a go-to resource for investigators seeking collaborators from other disciplines in the Life Sciences and beyond. IfLS Members (230: PI's with active research programmes) are based in all eight of the university's faculties and share, in proportion to their numbers, the funding opportunities available through the Institute. It has been particularly exciting to see that collaborative interactions between members are not isolated to small disparate groups but rather form a core of interacting networks with clear nodes of activity. These nodes are frequently centred on our theme participants.

Sourcing funds for postgraduate students and pilot projects is central to engaging members and providing opportunities for novel interdisciplinary collaborations. 2012 and 2013 has seen the IfLS build a cohort of 23 PhD students, all engaged in interdisciplinary research. Pilot projects have also been commissioned through competitive review with the aim of catalysing innovative research and increasing the number of grant awards. The portfolio of grant activity seeded by the IfLS is expected to grow over the coming years as programmes and projects mature to funding applications and success. For example, recent IfLS investment in 2011 and 2012 of £300k from the EPSRC Bridging the Gap program has already resulted in successful grant awards of £2.3 million, with subjects ranging from deepening our understanding of the impact of climate change on life in our oceans, to amyloid protein clearance from the brain and quantitative biology.

The IfLS has sought to project the University's strategy beyond the local campuses to have a regional impact in research and enterprise. Through the Wessex Life Science Alliance and Academic Health Sciences Network, we are increasingly involved in supporting and encouraging medical research and translational activities. Our international impact has included participation in the award of one of two prestigious Diamond Jubilee International Visiting Fellowships for collaborative research on microbial communities with the Woods Hole Oceanographic Institute.

The IfLS fosters life sciences networking in both formal and informal settings. In addition to our established seminar programs, 2013 saw the launch of the monthly poster gatherings. The IfLS now hosts an annual conference in September; in 2012 the conference centred on the Wessex Life Sciences Alliance. Our 2013 conference is on "Reproductive Biology – from gametes to systems, and between generations" and forms part of our BBSRC Excellence with Impact program.

It has been an exciting couple of years for the new Institute. Our foundation is now well set and our interactions across the university are focussed and productive. We are making a significant contribution to the culture and strategy of the university, growing on the back of the faculty strengths in collaborative life science research. Throughout Wessex there are exciting opportunities to take our technologies and academic perspectives into small and medium sized enterprises. We intend to grow this impact over 2013 and 2014.

Our first annual report represents the results of our approach so far with case studies detailing the exciting and high impact research happening here at Southampton and benchmarking our achievements to date. It is a dynamic picture that is constantly evolving into a progressive future.

Professor Peter Smith
Director Institute for Life Sciences

† Business and Law, Humanities, Health Sciences, Natural and Environmental Sciences, Engineering and Environmental Sciences, Medicine, Social and Human Sciences, Physical Sciences and Engineering.

1 The Third Revolution: The Convergence of the Life Sciences, Physical Sciences, and Engineering. Massachusetts Institute of Technology.

2 Strategy for UK Life Sciences, Department for Business and Innovation Skills, Office for Life Sciences, Cameron December 2011

Making breakthroughs in Neuroscience

Here at the University of Southampton we are breaking important new ground in the field of Neuroscience. For example, our researchers are making discoveries that could revolutionise the way Alzheimer's disease is treated.

What is more, our discoveries could also lead to the prevention of Alzheimer's in people whose lifestyle or family history places them at particular risk of developing the condition.

These important findings, facilitated by the Institute for Life Sciences, are largely thanks to our interdisciplinary approach to scientific research, which in this case saw a medical researcher join forces with a computer vision expert, and even an engineering specialist, to unlock some of the brain's deepest secrets.

The story so far

Alzheimer's disease arises because the brain is not equipped with lymphatic vessels to remove metabolic waste, known as amyloidal plaque, in the same way other parts of the body remove waste.

This apparent deficiency led medical lecturer and researcher Dr Roxana Carare to form a research team whose task it was to investigate how a healthy human brain removes amyloidal plaque in the absence of lymphatic vessels.

Her first breakthrough came when she demonstrated that amyloidal plaque and other metabolites are normally eliminated along very narrow channels in the walls of blood vessels – proving that there was indeed a mechanism for waste disposal, known as perivascular drainage.

But it wasn't until she collaborated with Professor Mark Nixon, who is an expert in computer vision here at the University of Southampton, that Dr. Carare made her second breakthrough.

Professor Nixon brought with him cutting edge computer vision technology, which enabled the pair to demonstrate that Alzheimer's sufferers have a different pattern of branching of blood vessels in the brain compared to non-sufferers.

This discovery prompted the researchers to ask whether some of us have a pattern of perivascular branching that places us at a greater or lesser risk of developing Alzheimer's disease. After all, there was already evidence that age, lifestyle, genome and diabetes could be factors that influence blood vessel configuration.

The team then enlisted the talents of Dr. Jurgita Zekonyte, an engineering research fellow from the University of Southampton, who has been using an atomic force microscope to describe interactions between amyloidal plaques, the walls of blood vessels, and genome, to better understand why the gene ApoE4 appears to increase the risk of developing Alzheimer's.

Dr Carare said: "For the genome-specific stage of the research we were fortunate enough to gain added support from the IfLS EPSRC Bridging the Gap pilot project fund.

"This enabled us to gather data which resulted in a successful BBSRC grant to look more closely at the capacity of the channels for perivascular drainage."

On reflection

As pioneers of perivascular drainage science, the research team led by Dr Carare is making scientific strides of international significance.

Right now research institutions across the globe are following our lead and building on our discoveries, making an effective therapy for Alzheimer's a distinct possibility.

In the United Kingdom alone there are more than 800,000 Alzheimer's sufferers.

This means that the development of an effective therapy could save UK health and social care services billions of pounds in the future.

Furthermore, an effective therapy would also mean a better quality of later life for all those who would have developed this debilitating and distressing condition, which has a profound effect on both sufferers and their families.

Dr. Carare said: "The discoveries we have made are largely thanks to the interdisciplinary nature of our research, which was facilitated by the Institute for Life Sciences."

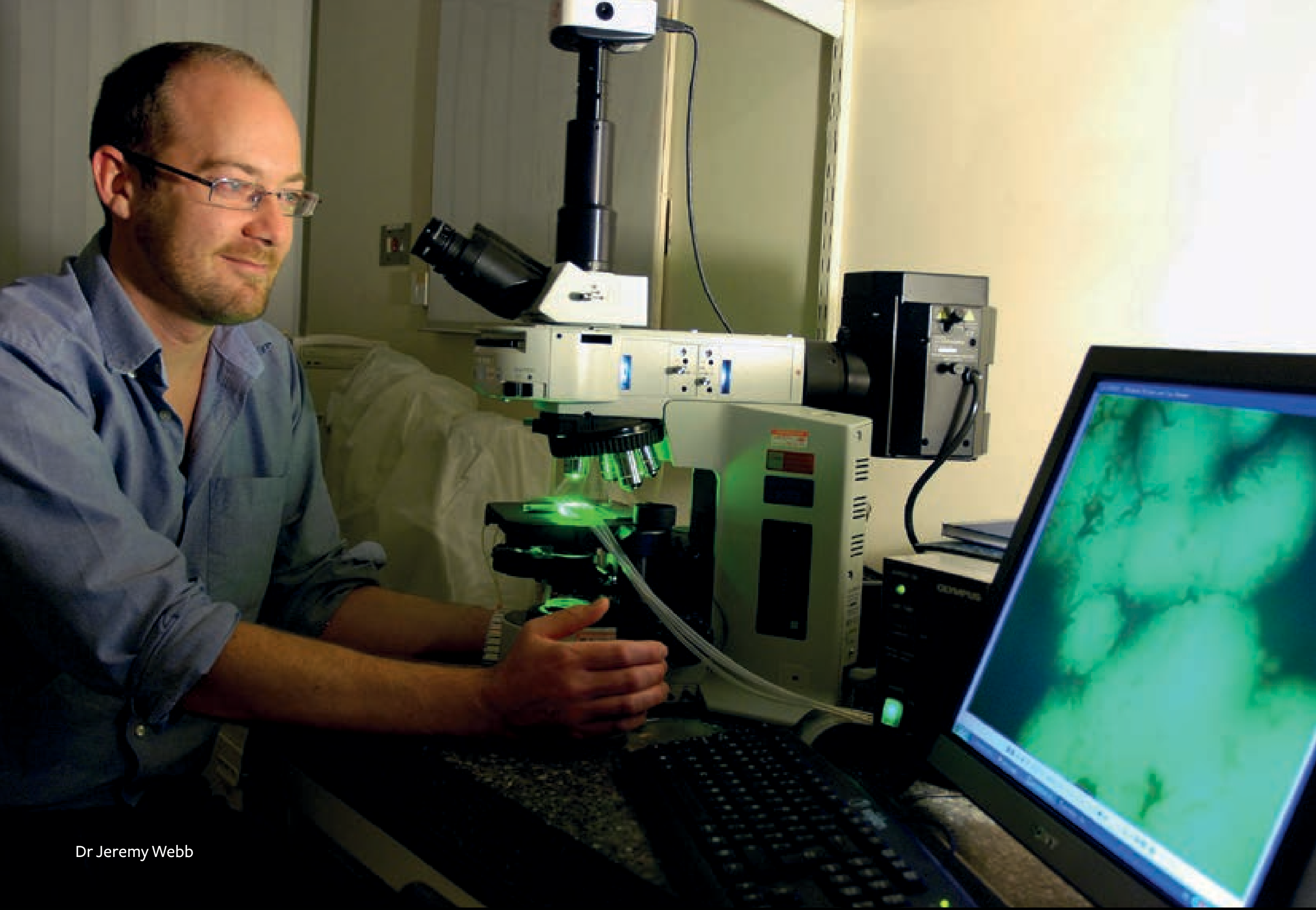
"Years ago I would never have believed that I would one day be working with an engineer or computer scientist to make important discoveries about the brain."

Professor of Neuroscience Lindy Holden-Dye, who is the outgoing leader of the Southampton Neuroscience group, known as SoNG, said: "This is an excellent example of how investment by the University of Southampton in the Institute for Life Sciences is bringing together research experts from diverse disciplines to tackle some of the really challenging mental health problems facing society."

Find out more, visit **www.southampton.ac.uk/ifls/appliedneuroscience**

"This is an excellent example of how investment by the University of Southampton in the Institute for Life Sciences is bringing together research experts from diverse disciplines to tackle some of the really challenging mental health problems facing society."

Professor Lindy Holden-Dye



Dr Jeremy Webb

Working together to exploit new discoveries in biofilm research

At the University of Southampton we have one of the largest concentrations of biofilms researchers in Europe.

These scientists come from a range of disciplines and are brought together through the Institute for Life Sciences to create a world class team that is greater than just the sum of its parts.

Our biofilms research covers three distinct areas: molecular mechanisms and evolution; environmental engineering and health impacts; and translational clinical applications.

By discovering more about biofilms we are able to move forward in tackling a whole range of challenges. After all, this research field has tremendous impact across a range of scientific areas, including: medicine, industry and the environment.

Where do we find biofilms and what can we learn from them?

Biofilms are groups of cells that bind together on a surface; the plaque on your teeth is an example of a biofilm. These groups of cells benefit from collective strength, which can make them 1,000 times more tolerant to antibiotics than single cells.

Consequently they cause many types of hard-to-treat infections. Recent data from the United States cited over half a million deaths and $94B direct healthcare costs annually due to biofilms. This calls for an important 'paradigm-shift' for future antibiotics. Ideally, they should be effective against the biofilm lifestyle of bacteria or be combined with adjunctive strategies that can break up biofilms.

In the UK biofilms are probably best known for contributing to infections like MRSA and C-diff'. These so-called superbugs often form biofilms on man-made surfaces, including surgical implants and external equipment like catheters, which compound problems caused by these infections.

Bacteria in biofilms become highly differentiated from free-living bacteria and exhibit a developmental sequence, forming a complex extracellular matrix and three dimensional multicellular structures. Once established, biofilms also achieve regulated dispersal events; therefore allowing them to spread and re-colonise surfaces – perpetuating their life cycle as a result.

Finding ways to stamp out this life cycle is a key factor in mitigating the threat posed by potentially deadly hospital superbugs.

By achieving this we could radically reduce the risk of infection and also relieve pressure on healthcare services.

Molecular mechanisms and evolution

This first area of study involves lab work at molecular level to understand more about the individual cells and how they operate together as a resilient and prolific bacterial community over time.

One project resulting from this strand of research adopts a new approach to vaccine development that targets the unique antigenic properties associated with biofilm aggregations using our new knowledge about biofilm ecology. This work was initiated by funding from the Bill and Melinda Gates Foundation.

More generally, biofilms research also presents an interesting model system to help us further understand the origins of multicellularity and cell cooperation found in higher living organisms.

The molecular mechanisms and evolution division is led by Dr. Jeremy Webb, who works alongside biological sciences research colleagues, Dr. Ivo Tews , Dr. Patrick Doncaster, and Dr. Lex Kraaijeveld. These scientists' work is further aided by their collaboration with electronics and computer science expert Dr. Richard Watson, who adds computer modelling know-how to the team.

Environmental engineering and health impacts

This second area of research has seen interdisciplinary research teams led by biological scientist Professor Bill Keevil, together with colleagues in engineering, working to investigate the best ways to remove biofilms, and even how to prevent them forming in the first place.

These scientists have now acquired the ability to computationally model and control microbial communities, enabling them to make accurate predictions about biofilms' future behaviour. And that's not all...

Work is also underway to develop and test new surfaces with anti-biofilm properties, which could eventually exclude the possibility of biofilms forming in drips and other hospital equipment.

This work has enormous potential for partnerships to be forged with leading enterprise organisations that aim to manufacture the next generation of clinical surfaces.

Clinical translational applications

This third area involves Southampton based researchers working with clinical academics at Southampton University Hospital to apply biofilm research findings to medical practice. For example, a current pilot clinical trial involving cystic fibrosis patients uses research into how bacteria within biofilms can be encouraged to break apart.

Research is also underway on persistent biofilm infections such as chronic sinusitis and glue ear. Furthermore, a new collaboration between Health Science's Professor Mandy Fader and Professor Bill Keevil is investigating ways to prevent biofilms forming in urinary catheters.

All members of this group are engaged in clinical translational research and work closely with Dr. Saul Faust, Dr. Luanne Hall-Stoodley and Dr. Rami Salib in the Clinical Research Facility at University Hospital Southampton. This is where research findings are transposed into clinical applications for the benefit of service users: in this case reducing the likelihood that they will become infected with antibiotic tolerant bacteria.

Find out more, visit
www.southampton.ac.uk/ifls/biofilms

"Scientists come from a range of disciplines and are brought together through the IfLS to create a world class team."

Fungal biofilm formation by *Aureobasidium pullulans*

Dr. Sumeet Mahajan (above); A label-free coherent Raman image of mouse macrophage cells laden with surfactant (*shown in green; false colour*) from collaborative work with Dr. Jens Madsen (right)

Aiming to save lives using advanced imaging to help with diagnosis

Early detection is a critical factor when treating all kinds of fatal and non fatal diseases successfully. That is why our researchers are constantly working to develop new cell imaging techniques to detect problems: marking them out as leaders in the pursuit of more modern diagnostic methods.

Right now scientists from several different disciplines are working together towards a common vision that one day GPs will be able to screen people for serious illnesses in their surgeries using advanced imaging techniques.

In practical terms this would mean no referral, no hospital visit, no second opinion, far fewer invasive procedures and, most importantly, no delay in diagnosis. Plus, it would help to relieve the strain on hospital resources – saving vast sums from the health budget.

The techniques

It has long been possible to detect the presence of a particular molecule in a cell or group of cells by tagging them with an indicator label. However, such a strategy cannot be used with humans as it is highly intrusive, or involves toxic dyes that can lead to the malfunctioning of cells, preventing analysts from seeing the full picture.

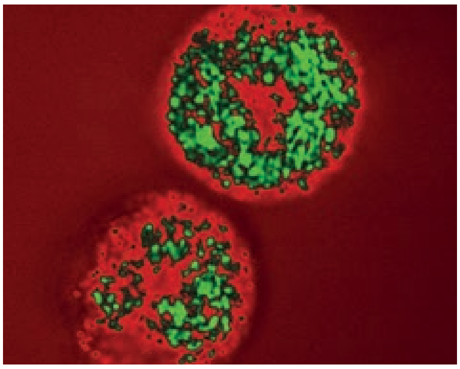
Because of this researchers led by Dr. Sumeet Mahajan are using tiny nanomaterials, which are typically made of gold or silver and decorated with chemicals that attract the type of molecules for which they are testing.

The team then uses state-of-the-art optical imaging lasers to see what is attracted to the nanomaterial. From the way the light scatters, which is enhanced at least a million-fold due to antennae-like effect of the nanomaterial, the researchers can tell whether a particular molecule is present or not. Using this method they have been able to achieve remarkable sensitivities – right down to single molecule level.

Dr. Mahajan's team is also perfecting a technique called Coherent Raman Spectroscopy, which uses two laser beams to make molecules vibrate in unison. This collective vibration creates a distinct signature that can be analysed to accurately identify and rapidly image the molecules that are present. This allows creation of molecule maps of live cells or tissue without any intrusive procedures, and over prolonged periods of time if required.

The interdisciplinary element

Our activities in this field rely on the expertise of a wide range of research fellows from several different disciplines. This has enabled us to earn our status as one of the world's foremost institutions for imaging research, especially in upcoming non-conventional techniques.



For example, this ongoing work has so far benefitted from the knowledge and skills of laser experts Dr. Jonathan Price and Professor David Richardson from the Optoelectronics Research Centre.

In addition, physicist Dr. Antonio Kanaras, is lending his world class talent to create the nanomaterials, along with electrochemistry expert Professor Phil Bartlett. But all this technology and know-how doesn't only exist in the research lab.

Already, imaging techniques developed here at Southampton are being trialled to study drug effects in worms by neuroscientists Professor Lindy Holden-Dye and Professor Vincent O'Connor in the Centre for Biological Sciences, and by Professor Tony Postle and Professor Howard Clark at Southampton General Hospital to study respiratory diseases and therapeutics.

What the lead researcher said:

Internationally recognised bio imaging and spectroscopy expert Dr. Sumeet Mahajan said: "The aim is to develop this kind of non invasive label-free imaging to the point where it is readily available in hospitals and even doctors' surgeries to help with diagnostics."

"However, the techniques that we are developing are also useful when it comes to developing new drugs to fight a whole range of diseases."

"By playing optical tricks you can get enough information to observe the presence of different molecules without damaging the cell; therefore giving us a much better idea of what is going on."

"All of this groundbreaking work was made possible by the Institute for Life Sciences. Without the interdisciplinary boost that they have provided, developing technology as well as working on applications to 'real' problems would have been almost impossible."

Find out more, visit
www.southampton.ac.uk/ifls/imaging

Bridging boundaries to secure excellence in life sciences: The Wessex Life Sciences Alliance

The Wessex Life Sciences Alliance (WLSA) is a new body that aims to take the collaborative ethos already established here at the Institute for Life Sciences and extend it by forging a series of relationships with nearby organisations.

It is hoped that through these relationships our strengths in biomedical areas like immunology, vaccinology and genetics can be brought to bear on the scientific assets of our region for the greater good.

For example, the WLSA is currently working closely with hospital trusts in both Southampton and Salisbury to pioneer new health technologies that could one day be commonplace in the fight against disease.

Then there is its association with national research facilities in Wiltshire, including Public Health England Porton, where it has enhanced collaborative research and development activities.

The WLSA is also involved with Local Enterprise Partnerships and local authorities: aiming to secure life sciences opportunities in education and research to help ensure that top students and researchers of the future do not leave the region for want of opportunities.

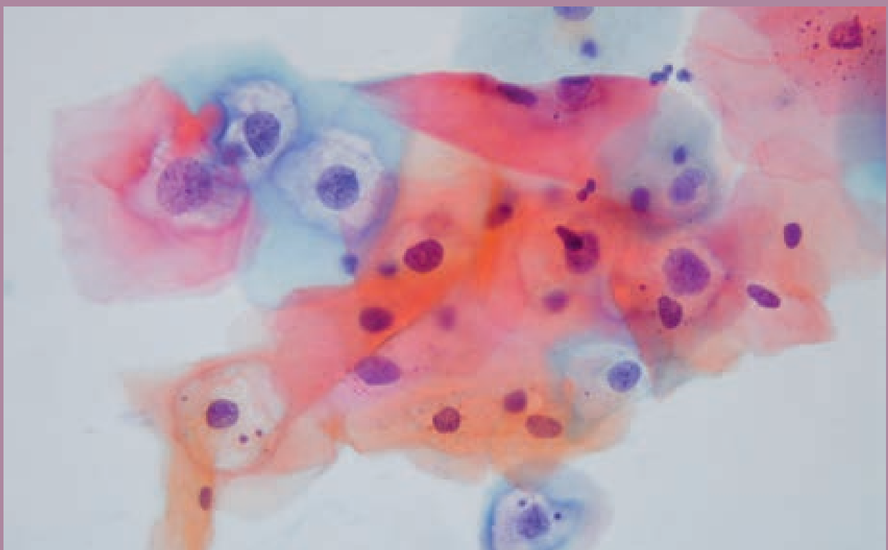
Importantly, the alliance has received financial backing from a number of sources; not least Sir Christopher Benson who has donated two studentships to help advance its medical work.

The WLSA was created by leading IfLS scientists Professor Peter Smith and Professor Iain Cameron, and held its first conference at the University of Southampton in 2012.

Professor Smith said: "The WLSA is based on the IfLS model and provides a focal point and catalyst for a vibrant life sciences community.

"It is a useful vehicle that will enable us to go beyond the boundaries of the University of Southampton and nurture further life sciences research and enterprise in our part of the United Kingdom."

Find out more, visit
www.southampton.ac.uk/ifls/enterprise/wlsa



Human *Papilloma* Virus
Anton Page, Biomedical Imaging Unit, Southampton General Hospital

Unlocking secrets of the immune system to help fight disease

Translational immunology researchers here at the University of Southampton have made important discoveries about the immune system, which could lead to the development of much more effective vaccines for fighting both infections and cancer.

What is more, this group of scientists has also published findings that may lead to the early diagnosis of a serious autoimmune disease; therefore enabling doctors to take steps to prime the immune system of sufferers sooner in order to guard against life-threatening conditions.

Both these studies have benefitted from the close collaboration of researchers from a range of disciplines, who were brought together through the Institute for Life Sciences to address some of the most challenging aspects of how our immune system works.

By combining disciplines we are helping to open the door to a new era of immunological research, which could result in scientists one day acquiring the ability to radically manipulate the body's defences to fight disease.

Hunter-killer T-cells and the whistle-blowing MHC I molecule

Cytotoxic T-cells are white blood cells that protect us against infection and cancer. By understanding more about how they operate we are edging closer to discovering new ways to optimise the immune system so that it can attack a whole spectrum of diseases more effectively.

The job of T-cells is to recognise and kill infected cells by identifying tell-tale fragments of antigens, known as peptides, which appear on the cell surface. This happens thanks to a molecule called MHC I that binds onto them.

MHC I molecules select only a handful of peptides to bind onto, and it is these peptides that have the greatest likelihood of stimulating an immune response from the hunter-killer T-cells.

Now, if we knew how MHC I selected peptides then we would be able to predict how our immune system would react to specific microbes and tumours, which in turn would help us to make better vaccines.

During their work researchers here discovered that peptide selection depends on the way MHC I molecules shape-shift over very short timescales, and that this directly affects the outcome of cancer vaccination in a way that can be predicted accurately.

Professor Tim Elliott, who is Deputy Director of the Institute for Life Sciences and based at Southampton General Hospital, said: "This work was only possible by combining experimental cellular biochemistry with mathematical modelling and structural biology.

"The Institute for Life Sciences has allowed me to co-locate part of my research group with my structural biology colleagues, and only a stone's throw from our collaborators in Chemistry: helping us to develop a strong collaboration with Microsoft Research UK as a team."

Peptide-generating enzymes and their role in immunity

Researchers led by Dr. Edd James have found that one of the enzymes responsible for generating peptides exists in many variant forms, with each one of us only having a maximum of two enzyme variants. This means that individuals can differ greatly in the way they make peptides.

Alongside clinical colleagues working at the Southampton Centre for Biomedical Research at Southampton General Hospital, they have shown that people with an autoimmune disease called ankylosing spondylitis only have a subset of all possible combinations, making them more vulnerable to illness.

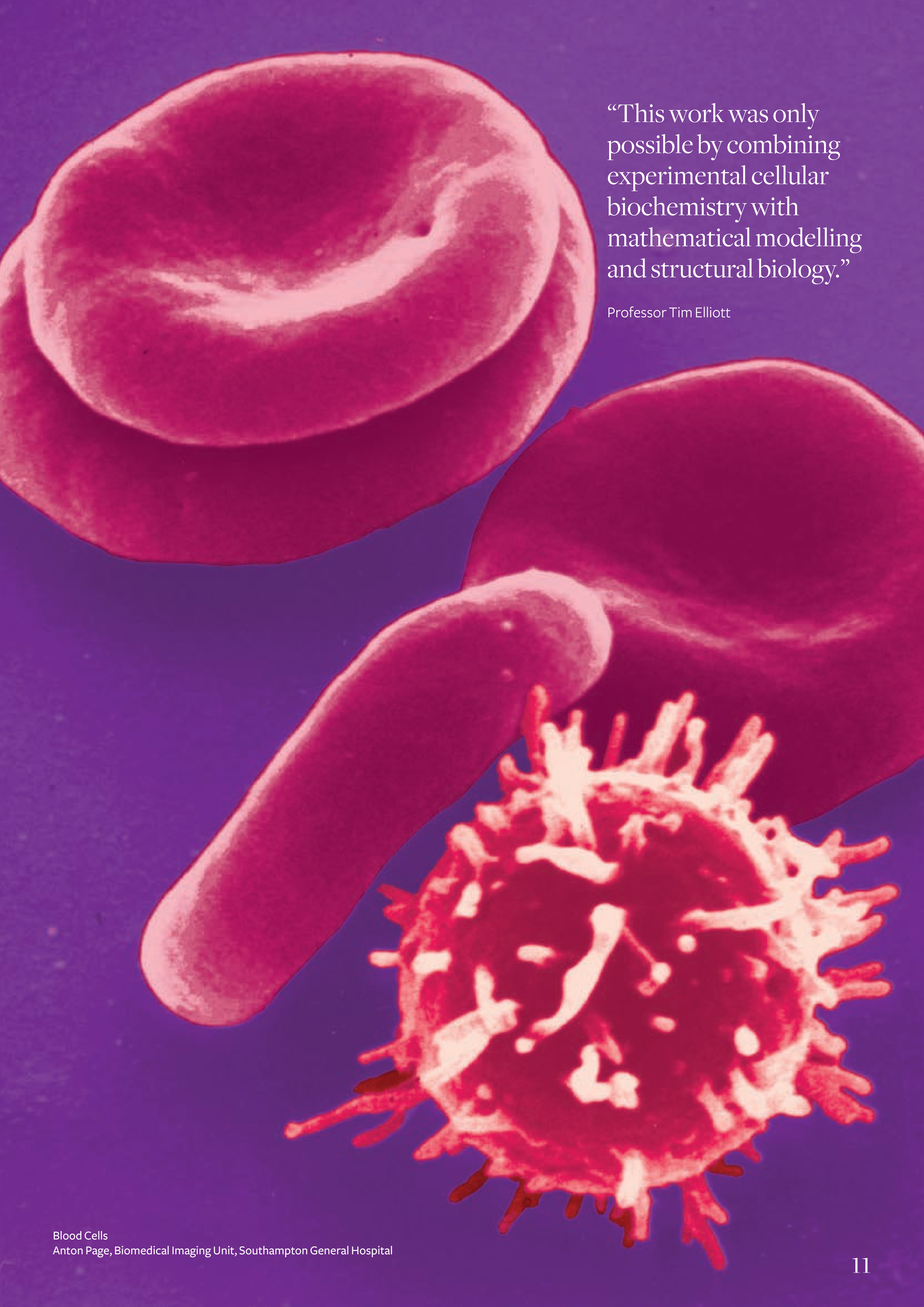
As a result, our scientists are now exploring the possibility that this shortfall might be the reason certain people develop the condition. But even if this is not the case, these findings could help to identify patients with this disease at a very early stage; therefore alerting medical practitioners to begin vital ameliorating therapy sooner.

These important discoveries mean that in the future doctors might also be able to identify patients who are at risk of developing immune deficiencies. It also raises the possibility that one day it may be possible to manipulate this enzyme to heighten immunity to infection or cancer. Indeed, the team has shown that targeting this enzyme with new small molecules can induce immunity to tumours in preclinical models.

Professor Elliott said: "By establishing immunology as a key theme within the Institute for Life Sciences and linking it to clinical disciplines that have an immunological component, it has become easy for us to find the right clinicians to work with.

"Furthermore, we have provided them with a point of contact through which to tap into a large and diverse community of immunologists."

Find out more, visit **www.southampton.ac.uk/ifls/translationalimmunology**



“This work was only possible by combining experimental cellular biochemistry with mathematical modelling and structural biology.”

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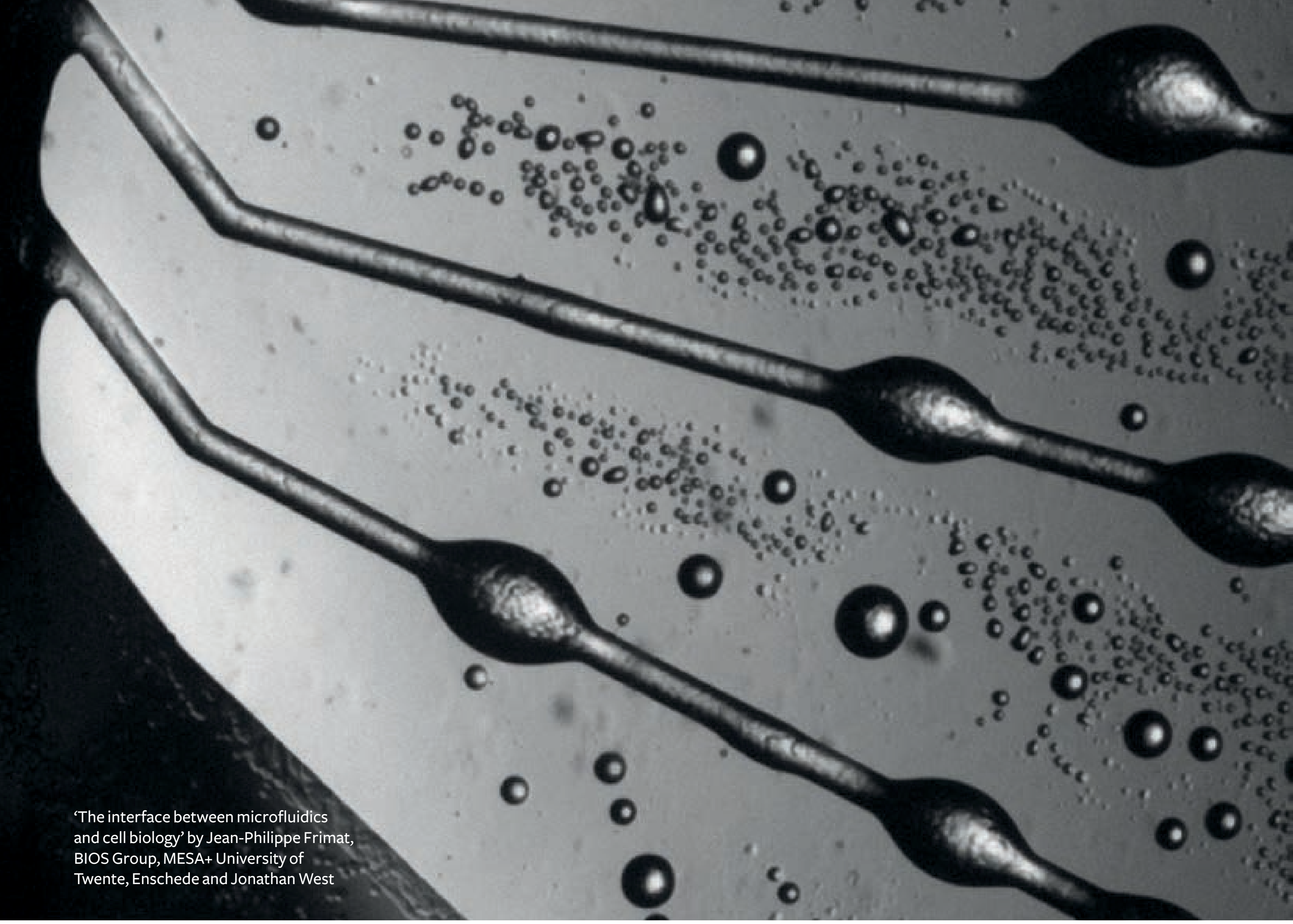
Blood Cells
Anton Page, Biomedical Imaging Unit, Southampton General Hospital



'The interface between microfluidics and cell biology' by Jean-Philippe Frimat, BIOS Group, MESA+ University of Twente, Enschede and Jonathan West

The science of efficiency through miniaturisation

Our scientists occupy the leading edge of research into Hybrid Biodevices: ultra modern technologies that could represent the start of a new era in biological investigation.

Hybrid Biodevices are micro and nanoscale machines that have the potential to transform the way substances are analysed in every bioscience discipline.

In essence, we are finding ways to miniaturise and simplify analytical equipment and methods to make analysis cheaper, more accessible and more efficient.

In the future this could mean quicker diagnosis in hospitals and doctors' surgeries; more expedient research when it comes to drug development; and also much more effective methods of measuring life, chemicals and pollutants in our oceans.

The hardware

Imagine taking a machine the size of the average refrigerator and shrinking it to the size of a microchip. It might sound like something from science fiction, but that is exactly what our researchers have already achieved.

By injecting biological samples into tiny channels surrounded by electrodes, scientists here have demonstrated that substances can be manipulated using a computer. This process is known as digital microfluidics and relies on the same kind of technology found in the latest mobile phones.

All this means that biologists can analyse samples at both cellular and molecular level using the kind of technology that most of us have in our homes already. As a result, large and expensive equipment that requires highly trained staff to operate, such as those used in hospitals to analyse blood and urine samples, might not be required in the future.

The backing

There are several factors that place our scientists in a great position to make breakthroughs in the development of Hybrid Biodevices.

Chief among them is our state-of-the-art clean room, which is where all nano-scale fabrication takes place. This incredibly sophisticated facility, to which our researchers have unfettered access, is one of the premier clean rooms in Europe.

Then there is our industry backing. For example, we have a substantial interaction with Sharp Labs of Europe, the European research lab of the global electronics giant, which provides significant expertise, along with devices in micro and nano electronics.

Furthermore, we have also benefitted from the help and cooperation of another electronics powerhouse: Phillips.

Last but not least is the funding that comes from Government, including the National Institute for Health Research, the Engineering and Physical Sciences Research Council and the Technology Strategy Board.

These relationships highlight the potential that exists for businesses and government bodies, both small and large, to collaborate with us at the Institute for Life Sciences in order to make ground breaking discoveries that will help to shape the future of scientific investigation.

Interdisciplinary relationships

We benefit from a whole host of collaborative relationships with other scientists, whose chief disciplines include: chemistry, electronics and ocean and earth science. Some of these relationships aid the creation of the technology, whereas others are instrumental in making discoveries about its application.

Our team also enjoys solid links with University Hospital Southampton, whose clinical academics are invaluable when it comes to trialling the new technology and then giving feedback on how it can be improved. In addition, we benefit from a close collaborative relationship with Public Health England.

All this serves to underline and justify the University of Southampton's world class reputation for being at the very pinnacle of the bio-medical engineering research interface.

What the lead researcher said:

Professor Hywel Morgan, Deputy Director of the IfLS, is our lead Hybrid Biodevices researcher. In recent years he has established several patents for technological innovations developed by him and his team.

Professor Morgan said: "Over the next ten years we will see many of these new technologies impact on our lives, by changing the way in which we test for disease or in new and better ways of measuring toxic compounds in the environment."

Find out more, visit
www.southampton.ac.uk/ifls/hybridbiodevices

Bleached Corals (*Porites sp*) in the Persian Gulf

Nutrient starvation as a primary cause of coral bleaching

Professor Jörg Wiedenmann, Head of the Marine Biotechnology Laboratory and the Coral Laboratory at the National Oceanography Centre, Southampton has been leading significant new research into a process that is threatening to wipe out coral reefs, through his project INCORALS. The research investigates how nutrient starvation influences susceptibility of reef corals to a process known as 'coral bleaching'.

Coral bleaching is promoted by global warming. Corals are animals that have a mutually beneficial, or 'symbiotic', relationship with single-celled algae called zooxanthellae, which live in the tissue that covers their calcareous skeletons. The coral supplies the algae with nutrients and a place to live. In turn, the algae offer the coral some products of their photosynthesis, providing them with an important energy source. Research led by Professor Wiedenmann found that elevated nutrient levels can block photosynthetic reactions in the algal cells under heat stress, causing a build-up of toxic oxygen compounds, which threaten the coral and can result in a loss of the algae which can increase mortality of the host.

To date, mass coral bleaching has had already devastating effects on coral reef ecosystems. The INCORALS project is using a range of cutting edge techniques to investigate the detailed mechanisms that underlie the responses of corals and their symbiotic algae to nutrient stress.

"The increasing influx of nutrients in coastal waters due to human activities represents a pressing problem for coral reefs," said Dr Wiedenmann. "A better understanding of the links between disturbed nutrient levels and coral bleaching is vital to develop marine and coastal management strategies that help to ensure future health of coral reefs."

The pilot data for the INCORALS research project which were recently published in the journal *Nature Climate Change* is pioneering in marine biology and has significant implications for coastal management. Through this project and with support from the IfLS, Professor Wiedenmann was recently selected by the European Research Council (ERC) to receive over 1.29 million Euros through the prestigious 'Starting Grant' competition. The 'Starting Grant' scheme is a highly competitive programme aimed at early-career researchers, supporting a new generation of top scientists in Europe.

Professor Peter Smith, Director of IfLS adds 'Jörg was one of the first recipients of an IfLS, EPSRC, Bridging The Gap, award to complete preliminary studies for the ERC application. It's a marvellous example of how that program stimulates exciting and fundable sciences.'

Find out more, visit
www.southampton.ac.uk/ifls/news/coral

Discovering new ways to ensure food security

With the global population predicted to surge to an incredible ten billion by 2050, humankind is facing one of its greatest ever challenges in keeping people fed.

As a result, the United Nations has stated that food security should be one of the top priorities for the international community in this century and beyond.

That is why researchers here at the University of Southampton are looking for food security solutions using the strong interdisciplinary approach advocated by the Institute for Life Sciences.

What is more, our scientists are also working on the ground in Colombia and Malawi to find new ways to ensure that future food production is sustainable.

Winning funding for projects in Colombia and Malawi

Our food security team has won funding from the Department for International Development, the Natural Environment Research Council and the Economic and Social Research Council, under the £40 million Ecosystem Services for Poverty Alleviation (ESPA) programme.

In fact, the University of Southampton is the most successful institution in the world at securing ESPA funds – largely due to the fertile environment for interdisciplinary research that we have worked hard to create.

This money has enabled us to set up projects in Colombia and Malawi to discover more about the sustainable intensification of food production, which can bring tangible benefits to the local population in a relatively short period.

Historically, people in these regions have relied on the forest to provide a range of resources for their communities. For example, if crops failed locals would traditionally use resources from the forest to make up the shortfall. However, with the growth in population, that reliance can have a highly detrimental effect on ecosystems.

The work we do

We use qualitative and quantitative mixed methods to identify the drivers and pressures that lead to food insecurity at the level of a village, region or a country.

Typical drivers include things like population booms, climate change, or more behavioural things like a move towards a meat based diet in developed economies.

Pressures on the other hand are the result of drivers. They include things like a decline in species that rely on forest for their habitat. This in particular can cause disruption to the food chain, with potentially catastrophic consequences for the whole ecosystem.

If pressures are allowed to persist unchecked, regions can reach a tipping point where the environment that people depend on for food is decimated beyond recovery.

In Malawi and Colombia we work closely with communities to understand their behaviours, before using mathematical

Zomba region, Malawi. Simon Wilcock, 2013 modelling to create paradigms of what is happening in their villages/communities. Crucially, we can identify parts of their ecosystem that have areas of critical flow, making them important for a wide range of life-supporting benefits.

This enables us to formulate what is known as a Driving Force Pressure State Impact Response Framework, which provides information and options for management by local communities, as well as regional and national governments. This information is instrumental in helping local authorities take steps to avoid and also reverse the pressures that affect the food supply adversely.

The expertise involved

This project has seen a very broad collaboration of researchers from different disciplines, and is at the cutting edge of interdisciplinary working. In some respects it could be described as post disciplinary working.

We have been able to call on the skills of climate scientist Professor Terry Dawson, demographer Professor Nyovani Madise, ecosystems modeller Dr. Felix Eigenbrod, and environmental scientists Dr. Malcolm Hudson and Dr. Kate Schreckenberg, who specialises in participatory approaches and governance.

In addition, we have also been assisted by researchers at our partner universities across the world, including Dr. Andrew Jarvis from CIAT in Colombia – a world-renowned institution that is part of the CGIAR network.

What the lead researcher said:

Lead food security researcher, Professor Guy Poppy, said: "At the University of Southampton we benefit from interdisciplinary expertise when it comes to studies into food security.

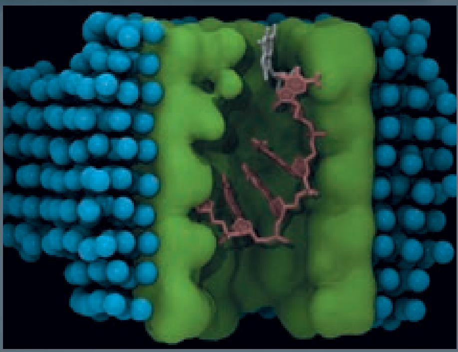
"As a result, we are on the path to providing a viable solution to a serious global problem that no single discipline or institution could tackle on its own.

"Our work is leading to new discoveries about socio-ecological systems and how they can be manipulated to prevent regions reaching irreversible environmental tipping points.

"Ultimately, however, progress will depend on national and regional governments legislating against the factors that we have shown present a risk to food security."

Find out more, visit
www.southampton.ac.uk/ifls/foodsecurityandenvironment

In brief



BBSRC Excellence with Impact: Focussing in on Nucleic Acids (FioNA)

Working across the University campuses and the regional community the IfLS aims to develop collaborative models that address key issues in health, society, and enterprise. These models are centred on areas of excellence, where Southampton and the Wessex region lead at national and international levels. Nucleic Acid research has been identified as a BBSRC funded focus that will benefit from development within the Excellence with Impact program, adding a new dimension to our research activities by generating a new network, tying together areas of excellence, while maturing to deliver enterprise, outreach and policy. Through this programme the IfLS aims to deliver:

- An enhanced profile within the University and external community for BBSRC research activities at Southampton
- A new network of researchers focusing in on nucleic acids, their biology, use in devices as well as biomedical and developmental impact
- An expanded collaborative and sustainably funded portfolio of cross-disciplinary activity
- A leadership group centred around our rising stars
- A vision for community and outreach, enterprise and policy development.

The FioNA community is being built for the long-term, and is planned to be an exemplar of the interdisciplinary research themes that sit at the core of the IfLS and the University strategy of changing the world for the better through our research, education, innovation and enterprise.

Investment in expertise at IfLS

The IfLS has brought together talented researchers from around the world who are breaking new ground across the spectrum of the Life Sciences.

The appointment of these researchers marks the university's continuing investment in expertise to address key issues in health, society and enterprise from an interdisciplinary perspective. Since its inception, the IfLS has acted as a catalyst to enable scientists to work on innovative projects with colleagues across Southampton's academic community.

From left to right:

Dr Martin Fischlechner works at the interface of biological sciences and chemistry. He is researching droplet microfluidics for directed enzyme evolution and composite materials in Southampton's Centre for Hybrid Biodevices.

Ecosystems researcher **Dr Kelvin Peh** is developing innovative tools that can analyse and place an economic and societal value on diverse environments of biodiversity importance. It assesses their importance in regulating the climate, providing water resources and generally enhancing life for the human beings who live there.

Neuroscientist **Dr Mariana Vargas-Caballero** is researching how and why the connections between neurones die in the brains of sufferers from Alzheimer's disease. She is excited at the opportunity to work with Southampton's multidisciplinary neurosciences group which was established in 2001.

Dr Jonathan West bridges research activities in Microfluidics and Medicine. His research focuses on the development of high throughput platforms for single cell analytics, with applications in the areas of Neuroscience, signalling and platelet biology.

Dr Ben MacArthur's research is in the area of systems biology, using experimental and computational techniques to better understand molecular regulation of cell behaviour. Problems of current interest include: systems biology of stem cell fate and cellular reprogramming; analysis of the structure and function of biological regulatory networks; high throughput data analysis and bioinformatics

Dr Nicholas Evans' research focuses on the interaction of cells with their extracellular matrix (ECM). He is interested in how the mechanical properties of the ECM affect the behaviour of stem and progenitor cells at injury sites. His research also examines how Wnt signalling might be harnessed to promote bone and skin regeneration.

Faith Bateman, Hybrid Biodevices laboratory

Studentships – expanding opportunities

The first cohort of IfLS sponsored postgraduate students enrolled in 2012/13 and are now engaged in a diverse range of life sciences research projects. One such student is Faith Bateman who is undertaking an interdisciplinary PhD with the Centre for Hybrid Biodevices and the Translational Immunology Partnership to design a microfluidic device that is capable of viewing immune interactions at the single-cell level. Her research bridges the engineering and immunology disciplines and she is based in both the Cancer Research UK laboratories at Southampton General Hospital and the Centre for Hybrid Biodevices, in the Life Sciences Building, which has specially designed laboratories that allow the integration of electronic devices in a chemical / biological domain.

Faith says "The IfLS enabled the partnership between Engineering and Immunology, and is able to offer the opportunity for students to enter into research that spans different disciplines, giving them the chance to obtain a niche set of skills and share information."

Faith's background in engineering provided her with the analytical skills needed for this research, and the experience gained through the interdisciplinary PhD will enable her to apply them in a medical environment.

She goes on to say "Once I have graduated my degree will allow me to enter into a medical research position requiring engineering solutions, an area that I am really interested in. For me, engineering is not just a subject; it is a way of thinking."

The IfLS is committed to expanding the opportunities it can offer to postgraduate programmes, through interdisciplinary projects where students can be guided by supervisors from different Faculties. To enable this, an annual allocation funds high quality PhD projects submitted through open competition by the University's IfLS Members. 23 IfLS PhD students will be enrolled from 2013/14. Details of other Life Sciences postgraduate projects are available at **www.southampton.ac.uk/ifls/educationtraining**

Selected Publications from Members: 2012–2013

The Institute is a catalyst for interdisciplinary research and training. Working across the university campuses, and the regional community, we aim to develop our collaborative models and address key societal issues and enterprise opportunities. We aim to train our scientists and policy makers to address their world from a cross-disciplinary perspective.

Cell, Molecular and Medical Sciences

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Statistical mechanics of pluripotency.
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A cyclic peptide inhibitor of HIF-1 heterodimerization that inhibits hypoxia signaling in cancer cells.
Journal of the American Chemical Society 135(28):10418–10425.

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High resolution synchrotron imaging of wheat root hairs growing in soil and image based modelling of phosphate uptake.
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Nature In Press doi:10.1038/nature12168

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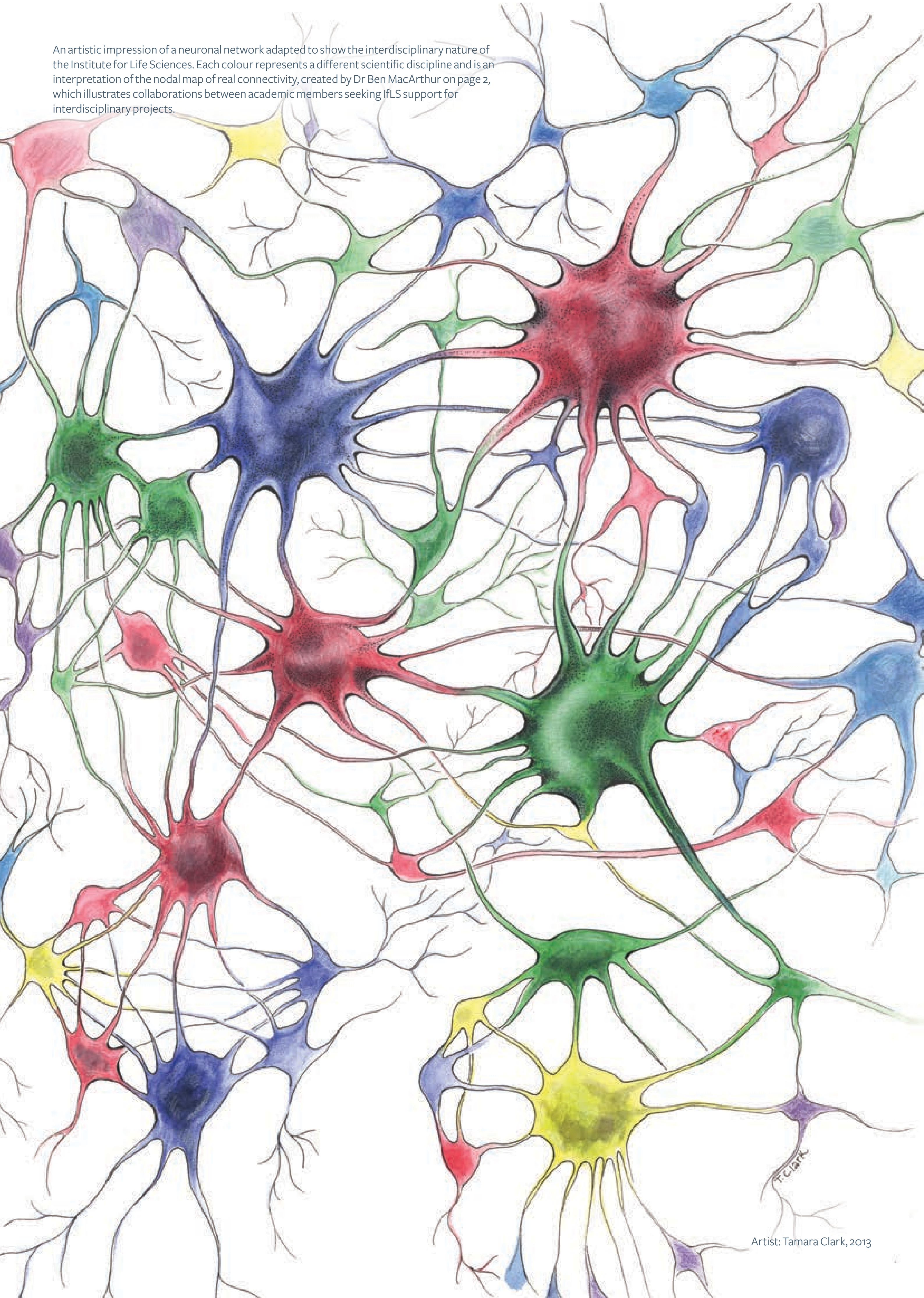
Nutrient enrichment can increase the susceptibility of reef corals to bleaching.
Nature Climate Change 3:160-164.

An artistic impression of a neuronal network adapted to show the interdisciplinary nature of the Institute for Life Sciences. Each colour represents a different scientific discipline and is an interpretation of the nodal map of real connectivity, created by Dr Ben MacArthur on page 2, which illustrates collaborations between academic members seeking IfLS support for interdisciplinary projects.



Artist: Tamara Clark, 2013

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