

THE DNA OF INNOVATION: VOLUME VI

PIONEERING RESEARCH, GLOBAL IMPACT

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VICE-CHANCELLOR'S FOREWORD



Professor Patrick G Johnston

The researchers profiled in this publication represent not only individual talent and outstanding leadership but also a step change in how we will deliver our ambition to be a world-leading research university.

This latest publication in our *DNA of Innovation* series marks a significant milestone on the Queen's journey – the establishment of our new interdisciplinary Global Research Institutes and Pioneer Research Programmes.

They build on a solid foundation of core excellence and bring together researchers working across disciplines to address some of the greatest global challenges of our time. As one of the featured academics says – 'We can answer the big questions and we can do it here in Belfast.'

To date, two of our Global Research Institutes have been launched officially – the Institute of Electronics, Communications and Information Technology (ECIT), opened by His Royal Highness the Prince of Wales, and The Senator George J Mitchell Institute for Global Peace, Security and Justice, opened by our former Chancellor, the celebrated diplomat whose name it bears.

The Global Research Institutes and Pioneer Research Programmes are evidence of an increased level of ambition by our University and our staff.

They show how we are working differently to achieve our aspirations and operating at an expanded scale. They are engine rooms for growth for Queen's, for Northern Ireland and for the careers of the exceptional individuals whose achievements, commitment and leadership shine out from these pages.

They are working to ensure a healthy global population, an inclusive, secure and enriched

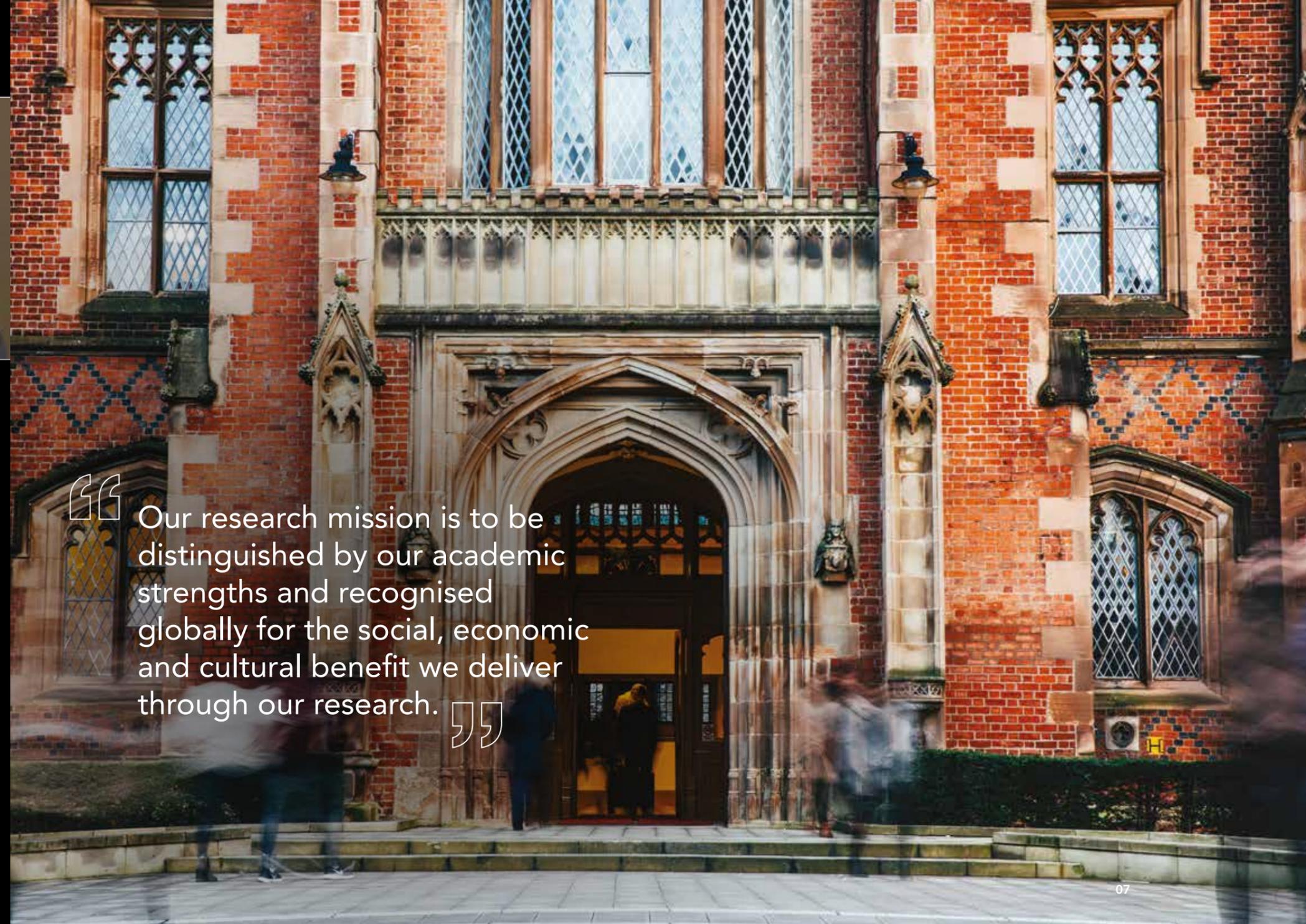
society. They are tackling the familiar problems of disease, the new horizons of the fourth industrial revolution – and more.

Our research mission is to be distinguished by our academic strengths and recognised globally for the social, economic and cultural benefit we deliver through our research.

Through their work we will accomplish that mission.

Professor Patrick G Johnston
President and Vice-Chancellor
Queen's University Belfast

“ Our research mission is to be distinguished by our academic strengths and recognised globally for the social, economic and cultural benefit we deliver through our research. ”



PIONEERING RESEARCH, GLOBAL IMPACT

This is an exciting time at Queen's. The establishment of our Global Research Institutes and Pioneer Research Programmes opens up new horizons and possibilities, creating opportunities for inspiring researchers to set and achieve ambitious goals for interdisciplinary research.

We are a leading research university, joint 8th in the UK for research intensity, ranked in the top 20 for research quality and impact, with over 75 per cent of our research rated as world class or internationally leading. Now it is time to go further.

It is our purpose and responsibility to take on major global challenges, to find answers that will help to build a better society and in a time frame that can make a difference.

How should we be tackling problems such as cancer, respiratory conditions, eye disease? How can we manage risk in order to protect the most vulnerable? How do we help societies which are recovering from conflict? How do our lives stay secure in the midst of the expanding information explosion?

These are some of the themes that are being explored in this latest edition of *The DNA of Innovation*. They are being tackled by research leaders both established and emerging, backed by our University's academic leadership and by professional support and expertise in such crucial areas as funding, partnerships and commercialisation.

These initiatives are also representative of a wider research excellence at Queen's. We provide an environment which encourages and accelerates the translational journey from original ideas to outcomes that work. But global challenges cannot be met successfully by individual researchers working in isolation. Success requires collaboration at all levels and so we are establishing teams that are international and interdisciplinary, working across the Queen's campus and with other institutions, in our search for solutions.

Our work is international in scope and scale, with partnerships and projects in China, Brazil, the Middle East, the USA, France, Germany and Switzerland highlighted in the present edition. These are extending our University's reputation as distinctive and collaborative, focused on grand challenges.

Our Global Research Institutes are bringing together a critical mass of research

excellence that is playing to proven core strengths but making them stronger by an expansion in scale and capacity. Our Pioneer Research Programmes provide the scope for novel collaborations, creating space for the rapid development of new ideas which will address emerging societal challenges.

Through all of this inspiring work we are enhancing the reputation of our University for ambition and innovation and furthering Northern Ireland's recognition as a place that encourages the growth of Pioneering Research, Global Impact.

Professor James McElnay
Pro-Vice Chancellor, Research, Enterprise and Postgraduate Affairs

Mr Scott Rutherford
Director, Research and Enterprise



Professor James McElnay



Mr Scott Rutherford

“ It is our purpose and responsibility to find answers that will help to build a better society. ”



“ We’re pressing the restart button. We want to be pioneers, pushing barriers, continually driving forward. ”

NEW HORIZONS IN INFORMATION TECHNOLOGY – WITH ROYAL APPROVAL

When Professor Sir John McCanny went to Buckingham Palace in February 2016 to receive a Queen’s Anniversary Prize from the Prince of Wales, it was a red letter day in more ways than one.

The prize was for the Centre for Secure Information Technologies (CSIT) and its work in protecting the online activity of billions of internet users around the world. On the day, John, Director of the Institute of Electronics, Communications and Information Technology (ECIT), of which CSIT is a part, was accompanied by the Queen’s Chancellor, Tom Moran, and the Vice-Chancellor, Professor Patrick Johnston – and with them, at the request of the Palace, they brought three members of CSIT staff and five PhD students.

John says, ‘The award recognised quality research which has a broader societal impact but it also recognised teamwork. Ideally, I would have liked to have brought all 92 people involved but this wasn’t possible. However, later we received a request from Clarence House asking if Prince Charles could visit us during a planned trip to Northern Ireland.

‘This meant everyone in the Institute could share in the CSIT celebration and we also used the occasion to formally launch ECIT as one of the four Global Research Institutes at Queen’s.’

These events were the beginning of a year of landmarks, including an additional Royal seal of approval – the granting of a Regius Professorship to mark the Queen’s 90th birthday – celebrating research that is not only internationally excellent but which has had major impact on wider society and the economy.

John describes this as ‘one of the most significant things that’s ever happened to this University. There have been Regius Professorships since 1497 but they are rare and prestigious awards with only 14 since the reign of Queen Victoria. There’s never been one in Northern Ireland before.’ John also received a Knighthood in the 2017 New Year’s Honours for services to higher education and economic development.

Based at the Northern Ireland Science Park – now branded as Catalyst Inc – ECIT became the anchor tenant in 2004. Since then, the Science Park has grown to over 160 companies employing over 2,500 people.

The Institute has now established two new Centres to sit alongside CSIT, lifting its numbers from 180 to 250, with the ambition to grow to 320 by 2020. The Centre for Wireless Innovation is integrating the areas of wireless communication and high frequency electronics while the Centre for Data Science and Scalable Analytics Systems will be at the heart of what is known as the information explosion – being able to process and gain meaningful information from increasingly large amounts of data.

‘With CSIT, in the last three years we’ve helped to create around 1,100 new jobs in cyber security in Belfast alone. Not too many universities outside the USA can claim that.

‘My philosophy is – if you’re not going forward, you’re going back. We want to be pioneers pushing the barriers, rather than simply being responsive to pre-defined agendas. We have to be leading, continually driving forward.’

He describes a trip to the USA with representatives of ten UK universities to visit Berkeley, Stanford, Harvard and MIT. ‘Part of the sessions related to their research but the other part was about their innovation structures and

processes. What struck me was how similar we are at Queen’s and how we’re aligned with their way of thinking, albeit as yet on a smaller scale.

‘They’re leaders, spotting the big problems before they’re all that visible, producing solutions, bringing in people from different backgrounds and I’m proud that we can be seen as having comparable levels of activity and ambition.’

As ECIT begins this new phase, John reflects on how it all began. ‘When we started, that was a pretty radical thing to do – taking academics away from the main University campus to stick them on a derelict shipyard site and saying – don’t worry guys, it’ll be all right. So far it has been very successful but now we’re pressing the restart button with much bigger and more ambitious plans to increase the depth and breadth of our research and to promote even wider economic and social impact.’

Professor Sir John McCanny, Director The Institute of Electronics, Communications and Information Technology (ECIT)

WIRELESS INNOVATOR AT THE HEART OF THE DATA EXPLOSION

Dr Trung Duong has been on a remarkable journey. It has taken him from Vietnam to Belfast, from playing with walkie-talkies as a child to being awarded an outstanding professional accolade, a Research Fellowship of the Royal Academy of Engineering (RAE).

He says, 'I was always interested in electronic devices so when I finished high school I decided to pursue a career in the field of telecommunication.' That career path has led to a key research role at the Centre for Wireless Information, one of the pillars of ECIT, the Institute of Electronics, Communications and Information Technology at Queen's.

Trung studied for a Masters in South Korea, then travelled across the globe to the Blekinge Institute of Technology in Sweden to pursue a PhD.

'I wanted to get a broader world view so I decided to go to Europe. I finished my PhD in 2012, then a year later I applied to Queen's for a job as a lecturer and was very lucky to get it. Normally you need to have several years as a postdoc but when I came for interview I think they saw some kind of potential in me.'

He joined Queen's in 2013. Two years later, the RAE was describing him as one of the UK's top early career engineering researchers.

The RAE Fellowship recognises his work in bringing together advances in signal processing to help develop a two-tier network system for wireless traffic. This is in order to increase the capacity of the available wireless spectrum as the number of wireless devices increases rapidly.

Trung says, 'It's an increasingly smart world. It's changing very quickly. At Queen's we're tackling major issues in digital innovation, especially in cyber security, in wireless communication and in scalable analytics. We focus on the hottest research topics in the world.'

'Every ten years the standard for wireless mobiles changes – 3G, 4G and soon 5G which will be a whole new revolution. We're going to have more than 11 billion mobile phones connected to the internet. That's 1.5 phones per capita.'

'Ten years ago, we just talked on the phone or sent a message. Now we have everything. Imagine your bus is coming in 15 minutes. You have your cellphone so you decide to watch a live video. Just think how much data that is. And now imagine that everyone's doing this at the same time.'

'We have to satisfy a huge growing demand and my research is about how we tackle this.'

Along with the explosion in data comes the need for better wireless security. Trung is collaborating with a number of technology companies, like Keysight. 'With the increase in information you need to encrypt the data. The broadcasting nature of the wireless channel makes it very vulnerable to cyber attacks so now we need additional levels of security as well as the traditional cryptography.'

'We can exploit the random characteristics of wireless channels, and physical layer security is a new research direction in wireless security. My research is tackling those challenges – high capacity and high security.'

Through his RAE Fellowship he is also collaborating with the two world-leading researchers in his field – Professor Vincent Poor, Professor of Electrical Engineering at Princeton University, and Professor Lajos Hanzo, Head of the Southampton University Wireless Group.

He says, 'I was very lucky to get this Fellowship but the reputation of ECIT and Queen's is very strong and that led to my success. It's also another success for the University and it's more evidence that ECIT is the best telecommunications research centre in the whole of the UK.'

Trung also received an accolade from Queen's recently when he was awarded the Vice-Chancellor's Early Career Researcher Prize.

“ We're tackling major issues in digital innovation. We focus on the hottest research topics in the world. ”

Dr Trung Duong
The Institute of Electronics, Communications and Information Technology, and
School of Electronics, Electrical Engineering and Computer Science



“ We have the opportunity to solve problems of scale, magnitude and complexity that we have not been able to solve before. ”

SYSTEMS THAT TELL THE STORY OF EVERYDAY HUMANITY

Professor Dimitrios Nikolopoulos is Head of the School of Electronics, Electrical Engineering and Computer Science at Queen's. He is an internationally-acclaimed expert in system software and hardware-software co-design of large-scale systems – and he is a man who is not afraid of a challenge.

He explains, 'Back in my graduate days, you had data used by scientists and engineers only but now it's data used by everyone – for your financial transactions, your traffic navigation system – pretty much anything. We generate vast amounts of data and to process this we need advanced computing technology that we don't have on our desktops, our workstations or even in our research labs.'

'The pace at which we're generating data is much faster than the pace at which we're improving our systems and their capacity. And because we don't have the capacity, we throw 80-90 per cent of the data away. Imagine – humanity is generating all this data on a daily

basis by travelling, by working, by interacting with others and with the environment and we throw most of it away. So that's where I come in – to build new software and hardware systems that allow you to host more data and process more data per second.'

Over the past number of years, Dimitrios has been a lead investigator in competitively-funded projects with an overall budget in excess of £40m. Holder of the Royal Society Wolfson Research Merit Award, he is Acting Director of the Centre for Data Science and Scalable Analytics Systems, one of the new Centres at the Queen's Institute of Electronics, Communications and Information Technology (ECIT), where his expertise is leading ground-breaking research.

He says, 'Before, there were bits and pieces of knowledge engineering, data engineering, high performance computing – but there was no integration of these research themes into one coherent team to address the global challenge of the information explosion. Now there is.'

'We have a good spectrum of expertise, starting from extracting knowledge from the data, understanding the data, right through to

building the hardware and the software and the networks to move the data. All of this gives us the opportunity to solve problems of scale, magnitude and complexity that we have not been able to solve just through our individual research efforts.'

He gives an example of such a problem. 'Say there's a virus somewhere. It starts spreading and you want to understand how this is happening. In order fully to do so, you need to somehow model the travel patterns and the movement and social interaction of every single person in the world.'

'Take a global event like the Olympics where you had millions of people travelling. They came from so many different countries to Brazil and then they went back and resumed their daily lives. This is extremely difficult to model computationally because people don't behave the same way everywhere in the world.'

'You have to understand roughly how different people of different social backgrounds, from different countries and different continents behave on a very large scale and then try to simulate that on a computer. It's an enormously challenging problem.'

Dimitrios sees his research having huge benefits for Queen's and its global impact. 'Our scientists here – in any discipline – rely on our ability to analyse data in order to understand trends, to understand societies, communities, and how our natural environment evolves.'

'And we need to understand what our scientists need – the doctors who are researching cancer, the food security experts, the astrophysicists. Out of all this data, what exactly is the information we have to extract, how soon do they need it and what's the most economical method to provide it for them?'

And there are important connections with the industrial world. 'In this School, every one of my colleagues has not only strong links with industry but measurable impact, whether through technology transfer under licence or spin-outs.'

'They always think of what industry needs and by extension what the customer needs and what society needs. They don't solve research problems just out of curiosity. It's because someone out there is waiting for a solution.'

Professor Dimitrios Nikolopoulos
The Institute of Electronics, Communications and Information Technology, and
School of Electronics, Electrical Engineering and Computer Science

QUANTUM COMPUTING AND THE THREAT TO SECURITY

At CSIT, Queen's Centre for Secure Information Technologies, Dr Elizabeth O'Sullivan is taking part in a global campaign to tackle one of the most pressing problems of the modern technological age – post-quantum security.

She explains, 'Quantum technology, or quantum computing, is being actively pursued in the world of physics. While it offers great potential for technology in general, it poses a huge threat to most of the communication infrastructures we have today.'

She points to the quantum factoring algorithm which was formulated by the mathematician Peter Shor in 1994. 'It has the potential to break all of our commonly-used public key cryptography. So while the progress towards quantum computing is still in its infancy, the consequences of a scalable quantum system that could render all our communications systems and infrastructures insecure, are too great to ignore.'

'Currently we rely heavily on public key cryptosystems built upon two hard problems that have an underlying theoretical connection. This is not a healthy position to be in and it's why there is a huge effort internationally to design and develop systems that are secure today but will also be secure against quantum computing.'

Elizabeth, a Queen's graduate with a PhD in theoretical and computational physics, joined CSIT as an engineer in 2011 and became a lecturer in 2014 in the area of secure digital systems, specialising in software security architectures. She had previously worked in industry, in particular with Latens, the large satellite company, which became Pace UK and is now Arris.

She says, 'That was my introduction to the area of security. I was attracted by the idea of building systems at a large scale, understanding how the infrastructure, the software, the computational aspects interact and how security is built in.'

At CSIT, which is one of the key components of ECIT, the Institute of Electronics, Communications and Information Technology, Elizabeth's focus is on lattice-based cryptography, in which there is substantial interest because of its apparent

resistance to attack by both classical and quantum computers.

She is deeply involved in a Horizon 2020 EU-funded project with leading experts in the field. 'Our partners on the theoretical side are ENS in France and we also have Bochum University in Germany and USI in Switzerland. We're looking at satellite communications with Thales Research UK, secure data analytics with EMC/RSA and public safety communication with HW Communications.'

There are many international connections. Along with CSIT's Director of Research, Professor Maire O'Neill, Elizabeth works closely with the Electronics and Telecommunications Research Institute in South Korea. They have designed embedded security architectures for EV charging systems using Physical Unclonable Functions (PUF), the next generation of anti-counterfeiting technology, for LG-CNS.

Participation in international standards activities in emerging technologies is another important role. The Data Security Systems group at CSIT are members of the Industry Specification Group for Quantum Safe Cryptography (ISG-QSC) within the European

Telecommunications Standards Institute (ETSI). Elizabeth and Professor O'Neill have also taken part in a post-quantum security workshop organised by NIST, the US National Institute of Standards and Technology, which involved several other universities and international institutions.

'They're preparing for transition towards quantum-resilient technology and it was terrific for us to be involved and contribute our evaluation of suitable technology.'

'We really need to start acting now; infrastructures can take many years to fully transition from one type of technology to another. Furthermore, there are already widespread concerns that encrypted information such as government classified data is being harvested in anticipation of a quantum factoring machine, and all our past secrets can be decrypted.'

'We're involved at the start of something that in five to ten years' time every company will have to think about. Through our experience we hope to be a point of reference, not only for the UK but internationally, so that we can help people make the transition.'

“ We're involved at the start of something that in five to ten years' time every company will have to think about. ”

Dr Elizabeth O'Sullivan
The Institute of Electronics, Communications and Information Technology, and
School of Electronics, Electrical Engineering and Computer Science



“ We’re furthering our global reputation for leadership in interdisciplinary research, education and enterprise. ”



Professor Nigel Scollan, Director
The Institute for Global Food Security (IGFS)

DRIVING FORWARD GLOBAL FOOD SECURITY

Professor Nigel Scollan’s career journey has taken him from his home county of Fermanagh to Edinburgh, Canada, Wales and now back to Northern Ireland where he joined Queen’s in 2016 as the new Director of the Institute for Global Food Security.

A world-leading expert in animal agriculture and associated supply chains, for the previous eight years he was a leading figure at IBERS – the Institute of Biological, Environmental and Rural Sciences, Aberystwyth University.

During that time, he says, ‘I became very focused on the enterprise agenda and how we can nurture closer relationships between academia and business in the agrifood sector. I firmly believe we should be conducting excellence in research but research which is relevant to address major challenges in society. And to do that you need connections.’

One of those connections was with Waitrose. Through it, he became Waitrose Professor in

Sustainable Agriculture at IBERS. ‘The Chair was positioned around Waitrose and their supply chains. That was a fantastic opportunity to learn about the key challenges that industry has. It’s an extremely good model of how you can nurture the development of novel working relationships between academia and business.’

From growing up in rural Fermanagh, Nigel’s passion for farming and animal production has been lifelong. He studied animal science at what was then the Edinburgh School of Agriculture and in 1987 was offered a postgraduate studentship from the former Northern Ireland Department of Agriculture, focused on key issues such as how to improve production systems and environmental sustainability.

In 1990 he undertook a two-year postdoctoral at the University of Guelph in Canada, sponsored by the Natural Sciences and Engineering Research Council. That was followed by a research scientist post at the Institute of Grassland and Environmental Research Aberystwyth which would later merge into the university to become IBERS and where he would hold a number of senior management positions.

‘Aberystwyth had a long history in plant genetics and plant breeding but it didn’t have a strong component in animal science. So linking scientists together was the mission back in 1993. That fuelled and excited me about the importance of interdisciplinary research.’

Of his new role, he says, ‘This Institute is in a very exciting position – globally recognised, addressing major issues in food security, and we’re in a recruitment phase now, building on that platform.’

‘We have three key themes – the development of future farming systems; then food safety, food authenticity and traceability; and finally human nutrition. These are the core areas we need to be driving forward with new staff appointments but we’ll also be seeking to grow areas of academia already in Queen’s which may not consider themselves to be in the space of food security.’

To explain, he points to another experience at Aberystwyth. ‘I also had a role as Professor in Public Engagement with Science and I had a parallel colleague, Richard Marggraf Turley, a specialist on Keats, who was Professor of Engagement with the Public Imagination.’

‘We found a common interest – food. I was interested in the science of food and production of food that’s safe and of high quality. Richard was interested in studying food in literature from two or three hundred years ago, including the poems of Keats, and how the challenges then were not dissimilar to those today.’

‘All of this can help to inform and guide us. Making connections between the natural sciences and the social sciences is exciting and I want to explore opportunities to build on that.’

Nigel sees the immediate future as ‘furthering our global reputation for leadership in interdisciplinary research, education and enterprise. And it’s about how we engage with wider society. I’m passionate about public engagement. The end users of our work need to be part of our whole scientific journey.’

‘We must be sure that our work is acceptable to society. If there’s an understanding of what science is trying to do then we can make better connections and deliver more effective solutions together.’

THE PSYCHOLOGIST WHO'S MAPPING THE UK FOOD CHAIN

When Moira Dean came to Queen's as a lecturer in 2007 she found herself taking up a unique role – as a psychologist working in the School of Biological Sciences.

'And I'm still the only one,' she says. 'At the time the School had an undergraduate course on food quality safety and nutrition and in the third year there was a module on the psychology of consumer behaviour. That was where I fitted in.'

But this was not her original academic interest. She has a degree in Physics from Imperial College London. Psychology came later – first with a degree from the Open University and then a Masters and a PhD in Social Psychology at the University of Surrey where she worked for seven years as a postdoc before joining Queen's.

'My PhD was in genetically modified food which was coming on the market for the first time. The project was funded by MAFF [Ministry of Agriculture, Fisheries and Food] because they wanted to look at the perceptions of the

public and their willingness or otherwise to buy GM food. Monsanto were trying to sell it to us. There was a big backlash about so-called Frankenstein food so it was all very topical and useful for my PhD.'

After that, she worked on several EU-funded projects – on whole grain consumption, organic foods, and who buys them. 'My work was on risk perceptions, risk communication, but when I came to Queen's there wasn't anyone doing that kind of research. There was research on the measurement and the assessment of risk but not on risk perception.'

Now Professor, Moira's focus is on Food Safety and Nutrition and her work is feeding an increasingly important strand for the Institute for Global Food Security – research around diet.

She has been involved in several major projects led by Safefood, the all-Ireland body. She was Principal Investigator in *Good Days, Bad Days*, which looked at the way people shopped, the choices they made, and what practices could be encouraged to help them shop more healthily. There were also projects looking at portion size and the effect of food marketing on the pre-school child.

Moira says, 'You can give up smoking but you can't give up food. Eating is something we have to do but we have to modify what we do. That's quite hard for people. Again, food isn't just something from which you get nutrient value. There's so much tied into it, culturally and socially, and that's partly why it's so difficult for us to change eating habits.'

Within the Institute, she is working closely on food integrity with her colleague Professor Chris Elliott who led the UK Government review into the 2013 horsemeat scandal. 'That changed a lot of things for us. During the review Chris had to interview everybody to find out the information, which was a very different kind of methodology. So now, while he looks at the food chain, in terms of traceability and authenticity, we're also plotting the human chain – from the farmer to the retailer. We have a PhD student funded by a government scholarship who has interviewed everyone involved in the beef chain.'

'In the case of beef, public perception is that there's one farmer. But it's not as simple as that. Calves are born on one farm, then they may go to another while they grow and to another to be fattened. So there you have three farms. And in processing there are also several different stages with animals coming in and going out.'

'We've plotted the whole of the UK beef chain, something which hasn't been done before, but you need that kind of mapping to understand the vulnerability, where things can go wrong. Next will come the fish chain and the wheat chain. All these chains are different. There are different laws and regulations, different methods of transport, different countries involved.'

Moira is also working with Dr Niamh O'Connell whose focus is on farm animal health and welfare. 'We're finding out why farmers or companies practise the way they do and how we can change that.'

As she sums it up – 'It's about people. If you want to find out about human beings, their attitudes, their behaviour – that's where my research comes in.'

“

If you want to find out about food and human beings, their attitudes, their behaviour – that's where my research comes in.

”

Professor Moira Dean
The Institute for Global Food Security (IGFS), and
School of Biological Sciences

ARSENIC IN RICE: HOW BELFAST IS SOLVING A GLOBAL PROBLEM



“ Our work has led to new regulations from the EU and the WHO, setting guidance standards, and it’s changing US laws. ”

Professor Andrew Meharg
The Institute for Global Food Security (IGFS), and
School of Biological Sciences

Professor Andrew Meharg has gained a worldwide reputation for his research into a global food problem – the high levels of toxic arsenic in rice, the staple diet of half the world’s population. But he would be the first to admit there is a certain irony in this.

He points out, ‘No, we don’t grow a lot of rice in Belfast!’ But what is certainly being grown is the reputation of the Institute for Global Food Security and the School of Biological Sciences where he is Professor of Plant and Soil Sciences.

Andy says, ‘We’re interested in research that makes a difference throughout the world. The work I’ve been doing was characterisation of arsenic in rice. Our work has led to new regulations from the EU and the World Health Organisation (WHO), setting guidance standards, and it’s changing US laws. People are recognising the problem, the dangers of disease

such as lung and bladder cancer. Now we want them to act and come up with solutions.’

He and his team have come up with one answer – developing a rice cooker that works like a coffee percolator. ‘It is a real breakthrough,’ he says.

Andy has been Acting Director of the Institute in the period between the promotion of its first Director, Professor Chris Elliott, to the role of Pro-Vice-Chancellor of the Faculty of Medicine, Health and Life Sciences and the arrival of the new Director, Professor Nigel Scollan, a world expert in animal agriculture and associated supply chains.

A Queen’s graduate, Andy began his academic career in chemistry, focusing on plants and soils. ‘I was really interested in thinking about more fundamental environmental issues, and I’ve been able to use chemistry in this direction too.

‘We’re looking at how pollutants move through agronomic food chains, how they get into

soils, how they’re transferred into plants, and the human exposure to that. We base all our analysis on high end analytical chemistry.’

Queen’s is investing £6m towards the work of the Institute, supporting three main research themes: the integrity of food supply, disease and nutrition, and the farms of the future – how to change agricultural practices to enhance profitability and sustainability without compromising biodiversity and ecological stability.

The Institute will also be a hugely important component of the new £39m building for the School of Biological Sciences, due to open in 2018.

Andy spent 13 years at the University of Aberdeen before coming back to Queen’s five years ago. ‘I could see what was happening here. This Institute is a whole new way of thinking, a new and novel approach to agriculture. It’s about the whole process, from the soil right the way to human health outcomes, how food is central to that and

how the choices we make about food affect our livelihood and the health of the planet.

‘We have a considerable flow of people from around the globe working in our labs as visitors, as PhD students, as postdoctoral fellows and as staff. We have people from China, Bangladesh, Brazil, Thailand and elsewhere – all working on the problems with rice but doing it here in Belfast. The influence we have and the impact we make are remarkable.’

And there are the graduates. ‘Our key industry in Northern Ireland is agriculture and we are creating the future leaders of that industry. They leave with skills and they leave with responsibility.

‘The students we train are virtually 100% employed straight off. They have what the market needs and wants but they also have that wider knowledge and experience of the global issues that are important to us all.’

RESEARCH THAT'S A RECIPE FOR A HEALTHIER POPULATION

Professor Jayne Woodside's research is focused on how diet and lifestyle factors may affect chronic disease risk, including cardiovascular disease and cancer. And she doesn't mince her words about the importance of making an impact.

'We can sit in our offices and our labs and do all sorts of interesting experiments and write them up for publication, but if the health and the diet of the nation don't actually change, then what's the point?'

Jayne is Professor of Human Nutrition within the Centre for Public Health at Queen's and she is also Deputy Director of the Institute for Global Food Security, one of the University's four global research institutes. She specialises in the use of biomarkers to assess dietary intake, conducting controlled dietary interventions and, finally, interventions to promote long-term dietary change.

She says, 'It's very difficult to measure diet accurately. We have a number of different types of questionnaire-based methods. There's a food

frequency questionnaire which is a list of around 100 foods and we ask people to remember how often they ate them over the past year. They really struggle with that.

'Then there's a food diary where we ask people to write down everything they eat over seven days. Eating behaviour can change when people are involved in that. For example, they don't want to tell the researchers about a chocolate bar so they'll not eat it – or they'll eat it and not write it down.

'So what we're trying to do is to use biomarkers to capture a picture of overall diet. This means we're measuring what's in the blood or the urine, rather than asking people to remember.

'Of course, there are challenges. Nutrients turn over in the body at different rates, so you're only going to measure recent intake, but if we can measure diet better it will help to assess the link between diet and disease more accurately. If you're getting the measure of diet a bit wrong, then you're not going to get the true answer.'

On the subject of dietary interventions, Jayne says, 'We take a group of people and change their diet for up to four months. We may deliver

food to them or bring them in to be observed eating. We've shown that with more fruit and veg, you improve heart health and immune function, for example. We're strengthening what we know about diet and health through changing diet in a controlled way and observing the relevant outcomes.'

But these particular interventions usually involve people who are interested, who volunteer and who want to know what is good for them. What about people who are harder to reach, who are resistant to change?

Jayne recalls a time 20 years ago when researchers at Queen's were seeking funding for a study, based on one in France which had shown that people who had had a heart attack were less likely to have another one if they adopted a Mediterranean-style diet.

'The researchers at Queen's were told by the funders – you'll never get people in Northern Ireland to change their diet. But we have now done two studies – one getting people who've had a heart attack to change to a Mediterranean-style diet and the other with people who're at high risk of heart disease, getting them into groups, educating them by

discussion, even showing them how to cook certain foods, and we've shown that we can get them to make real changes.

'And these are people in more deprived communities, people with very poor diet. So if you look at a Mediterranean-style diet on a scale of 0–15, they are on a scale of three or lower and we're trying to boost them to the midrange.

'We're seeing impact on the participants immediately. People report back that they feel much better. Some even say it's almost as if they've taken back control of their lives. They may feel better in other aspects of their health. We try to capture that and measure psychological health in our studies, too.

'We're improving the evidence between diet and health but ultimately, to see real impact, we want to see shifts in the dietary intake of the local population as a whole and that's much harder to achieve, much longer term. We're at the start of that journey.'



If we can measure diet better it will help to assess the link between diet and disease more accurately.



Professor Jayne Woodside
The Institute for Global Food Security (IGFS), and
School of Medicine, Dentistry and Biomedical Sciences

MAKING CONNECTIONS: A NEW VISION FOR HEALTH

“Our team’s ultimate goal is to translate our basic science and move these therapeutic cells into the clinic as soon as possible.”

Professor Alan Stitt
Institute for Health Sciences, and
Dean of Innovation and Impact, Faculty
of Medicine, Health and Life Sciences

A pillar of Queen’s University’s Global Institute for Health Sciences is the Centre for Experimental Medicine (CEM). Opened in 2015 in the brand new and award-winning Wellcome Wolfson building, it involved an investment of £32m – and the effort and dedication of a lot of people.

One of them is Professor Alan Stitt. ‘Over three years, I devoted a large part of my life to this project by driving the research strategy and working with University colleagues on the fundraising and operational planning; but it has been absolutely worth it.’

Alan, McCauley Chair of Experimental Ophthalmology and Dean of Innovation and Impact in the Faculty of Medicine, Health and Life Sciences, sees the building as ‘an Institute of Health Sciences in micro. Its floor plan has been designed so that researchers working in different disciplines can interconnect and collaborate. It creates an exciting environment in which impactful discoveries can be made.’

Alan’s own research is focused on one of the world’s major sight-threatening diseases, diabetic retinopathy. His team is seeking to understand the precise molecular basis of the condition and advance new treatments. One approach they have developed is to harness the regenerative capacity of vascular stem cells. ‘My team’s ultimate goal is to translate our basic science discoveries into the clinic arena as soon as possible and make these therapeutic cells available for patients.’

He points to other developments in which he collaborates closely with clinical and basic scientists within international consortia in diabetic retinopathy. One example is a €2.25m international project shared with CEM colleagues, Drs Tim Curtis and Reinhold Medina, in which they lead a collaboration with Ireland and the USA on a gene therapy approach to reverse diabetes-linked blood vessel damage to the retina.

The team is also making exciting new discoveries with the potential to improve the treatment of diabetic macular oedema (DMO), one of the major sight-threatening end points of diabetic eye disease.

The team has identified how blockade of an enzyme which metabolises fats in the blood can prevent blood vessel leakage and progression

to DMO. This discovery by Queen’s scientists demonstrates that a tablet can be taken which has the potential to reduce the need for monthly injections and protect against vision loss in a much wider group of patients with diabetes.

‘We could soon see an alternative, pain-free and cost-effective treatment for diabetic-related blindness.’

Eye health is one of the priority themes of the Institute for Health Sciences, alongside cancer, respiratory disease, diabetes-related vascular disease and antibiotic resistance.

‘Our medical School has key strengths in these internationally competitive areas. We are concentrating our efforts to achieve high quality research that has global impact.’

‘Multi-disciplinary research is key – clinicians and basic scientists, including biologists, physicists, chemists and pharmacists all working towards one goal. Getting all these people to work together creates an endeavour that’s greater than the sum of its parts.’

‘One of my roles as Dean of Innovation and Impact in the Faculty of Medicine, Health and Life Sciences is to encourage connections between researchers and a range of

stakeholders who can help translate what we do into something that helps people. Queen’s is already making a major contribution to global health, whether it’s improving access to good nutrition, maintenance of a healthy lifestyle, developing and delivering new drugs for important life-limiting diseases.

‘The Institute will promote better connections between our researchers through activities such as “sandpits”, thereby enhancing lateral thinking and radical approaches to global health issues. These will bring researchers from distinct areas together around a common theme, with encouragement for free thinking and uncovering inventive solutions to major problems.’

‘And it’s fun. Researchers like nothing better than to talk about research and this is their opportunity. But at the heart of everything we do is finding really meaningful treatment for patients. Making it work. Having local and global impact.’

LEADING THE WAY IN THE MICROBE-BODY ARMS RACE

In September 2016, more than 100 international delegates, along with senior officials from funding agencies of 11 European countries and the European Commission, gathered at Queen's for a unique conference. Its subject: the world's most deadly infectious diseases and the latest findings to shape future treatments.

The conference marked the closing of the four-year INBIONET – Infection Biology Training Network – funded by the Marie Curie Initial Training Network Scheme and coordinated by Queen's, but it also signalled the beginning of the new EU agenda on infectious diseases for the next five years.

The conference was hosted by Professor Jose Bengoechea, Director of the Centre for Experimental Medicine (CEM) at Queen's, one of the three leading research centres which

make up the University's Global Research Institute for Health Sciences. His research into combatting the multidrug resistant microbe *Klebsiella pneumoniae* – one of the hospital superbugs – is recognised worldwide.

Jose says, 'We're focusing on one group of microbes that cause respiratory infections that affect one per cent of the population every year. We've seen headlines that tell us that by 2050 one person will die every three seconds in the world because of antimicrobial resistance. We call this the microbe-body arms race.'

His laboratory has uncovered the foundation for new therapy with the potential to save thousands of lives in the UK. Jose says, 'The approach we established was – instead of trying to identify new drugs or new antibiotics, let's try to help our body and our defences do their job. We started by asking basic questions – why our lungs are not capable of clearing infection, what the microbe is doing to prevent that.'

'We now have a much clearer picture of how the microbe is counteracting our defences. Our idea for the next five years is to keep going with

the fundamental questions but at the same time we're moving forward with this basic science knowledge to a clinical phase and we hope to run the first trials.'

Jose's commitment to this field began when he was a student at the University of Navarra in Spain. 'I was interested in microbiology. I wanted to find out why the microbes were infecting us.'

After finishing his PhD, he moved as a postdoc to Turku in Finland to be trained in molecular microbiology. His first independent position was at the University Hospital in Palma Majorca and when the Spanish Research Council set up a new centre there on respiratory diseases he became director of one of the Infection and Immunity research programmes.

He came to Queen's in 2013 and became Director of CEM three years later. 'What attracted me was the environment, the quality of the research, the ambition of the University.'

That ambition continues in the new Centre, the £32m Wellcome-Wolfson building which

opened in 2015. It houses 50 research groups committed to translational impact on respiratory disease, eye disease and infectious diseases and addressing global issues such as diabetes, asthma, acute respiratory distress syndrome, cystic fibrosis and antimicrobial resistance.

Jose says, 'We're not going to cure everything, we're not going to investigate everything. We have world-class expertise in these particular world health problems so it makes sense to focus on that.'

'The new building is magnificent but what is more important is what happens within it. It's about the people and how they take on the ambition and the ideas. It's a challenging role for me as Director but my attitude is – we are a community. We do things together.'

'This is a multidisciplinary centre. With so much expertise from so many different areas we can answer the big questions about these diseases and we can do it here in Belfast. We can really develop our global ambition and I think the Queen's Global Research Institutes are the perfect framework for that.'

“ This is a multidisciplinary centre. With so much expertise in different areas we can answer the big questions and we can do it here in Belfast. ”

Professor Jose Bengoechea
The Institute for Health Sciences, and
Centre for Experimental Medicine (CEM)



MAKING DIRECT IMPACT THROUGH STEM CELL RESEARCH

“Not only can we develop new treatments but we can help with earlier diagnosis.”

Dr Andriana Margariti
The Institute for Health Sciences, and
School of Medicine, Dentistry and Biomedical Sciences

Dr Andriana Margariti had a choice of which lab to go to during the final semester of her Masters in biomedical science (haematology) at Kingston University. 'But as soon as I saw that one of the projects was stem cells, that was it.'

She says, 'I have always been passionate about stem cell research. I realised from a very young age how important it was in clinical trials, helping people with diseases like cancer, diabetes, cardiovascular complications.'

'The group I joined was based on stem cells and cardiovascular disease. I was with them for three months and it was really exciting. At the end they offered me a PhD position and I told them I would think about it before giving them an answer.'

'But within a few days I knew that this path was for me. I had a strong determination to build up my career on stem cells and vascular biology – so I said yes.'

She went on to do her PhD in the Department of Cardiology at King's College, London, and

she remained there for postdoctoral training in the cardiovascular division of the British Heart Foundation Centre of Excellence, developing the research that has brought her international recognition since then.

Its focus is on direct reprogramming, where one fully differentiated cell type changes directly into another, a process that can lead to the development of new cell therapies for major diseases. Its impact has been recognised by several prestigious awards, including the Papanikolaou Prize from the Hellenic Medical Society for significant contribution to medical research and the prize for outstanding performance and scientific research awarded by King's College.

Andriana says, 'After my postdoc, I decided it was time to start my own lab. I saw that Queen's had a big recruitment campaign at that time. I came for a visit and talked to people and I could see how the University was planning for the future. There was a lot of ambition, a real desire to invest time in young researchers, to help them get established, and I decided this was an ideal place to start my own group.'

She joined Queen's in 2013 as a lecturer at the Centre for Experimental Medicine, part of the

Institute for Health Sciences, and has continued to drive her research forward, building major international links.

She says, 'When I moved, I thought it would be important to establish collaborations with the leaders in the field. I wanted to learn from the best' – and so she decided to spend time in the United States.

The outcome: collaborations with two of the top cell reprogramming laboratories in the world. One is led by Professor Deepak Srivastava at the University of California, San Francisco (UCSF) and the other by Professor George Daley at Harvard Medical School.

Andriana is pleased with what has been achieved in the three years since she arrived at Queen's. 'We've established valuable networks and unique expertise. We're screening and developing new drugs and not only can we develop new treatments but we can develop very simple prognostic tools that will help with much earlier diagnosis.'

The work is also being recognised through new grants, including funding from BBSRC New Investigator Award and the British Heart Foundation Northern Ireland for an

investigation into how skin cells can be transformed into blood vessels to help in the global fight against heart disease.

The research will lead to a better understanding of the process involved when a stem cell taken from a certain type of skin cell is transformed into one that lines blood vessels.

Cell therapy strategies that aim to recover vascular function are being explored increasingly as viable therapeutic avenues. Andriana says, 'When someone has a heart attack, there is a temporary loss of blood supply to the heart muscle. By developing these cells, we hope to help the heart repair and re-establish blood flow after a heart attack.'

Away from the lab, she is being invited to talk at workshops and conferences in London, Scotland, Sweden, Switzerland, Greece, Italy and across the USA. Direct reprogramming is the theme. And her message: The road ahead will be challenging and hard but the journey has begun.

THE CELLS THAT MAY ANSWER QUESTIONS ON LUNG DISEASE

Dr Cecilia O'Kane is a respiratory physician and researcher whose work is inspired by the voices of her patients. 'They were coming to the clinic,' she explains, 'some of them with incurable conditions, and asking – Doctor, is there anything we can get involved in? We want to be part of the answer to this. That has been a real spur to me.'

A Queen's graduate, Cecilia undertook specialist training in respiratory medicine, followed by a PhD in tuberculosis at Imperial College London. Now a Clinical Senior Lecturer based within the Centre for Experimental Medicine, she says, 'I wouldn't have foreseen myself in academia at all until that time but I really enjoyed the process of research, asking questions and trying to answer them with a view to developing new treatments.'

She returned to Belfast to finish her clinical training but she says, 'I really wanted to

continue asking those questions. For people who live with chronic ill health, there are patients' groups who build up a sense of community, who are really very focused on understanding their condition better. They're volunteering to take part in studies and so it made me wonder – is there anything else they could take part in?'

'That felt like a big deficit for me but it was also really inspiring and a real motivation. Here was something our patients wanted to do, here was a way to really help them but we needed to focus on delivering that.'

She applied for a Clinician Scientist Fellowship from the Department of Health, looking at structural lung remodeling in patients with chronic inflammation, particularly cystic fibrosis.

'That allowed me a five-year period of protected research time so I was able to focus on developing a programme. Around the same time, a colleague was building a group in intensive care research and together we began looking at different mechanisms of lung inflammation and lung damage. That led to a

wider group around critical care and respiratory research, working right through from the lab to clinical trials.'

Cecilia has now developed research in collaboration with Orbsen Therapeutics, a biomedical company in Galway, into a new treatment for patients with acute respiratory distress syndrome (ARDS), a condition that affects over 20,000 people in the UK each year. It is looking at the use of mesenchymal stromal cells (MSCs) which can reduce inflammation, fight infection and improve repair of injured tissue.

But what is novel about this research is that it will be using cells taken from the umbilical cord. 'It has lots of MSCs and because they come from baby tissue they are young and healthy. They are also very powerful and so we are planning a clinical trial with intensive care patients.'

'These cells can teach your own immune cells to take up bacteria better, they can teach tissue to heal and they have direct anti-inflammatory effects. That's a unique set of properties. No tablet or medication we might give can do all of those things at the one time.'

'A treatment that reduced death and long-term disability from ARDS would have major healthcare impact. The MSC story in intensive care is very exciting and it may give us important information about how MSCs work and open up the potential for further use.'

She says, 'For Queen's, respiratory medicine is a key area, one of the pillars of the Institute for Health Sciences, and the environment at the Centre for Experimental Medicine allows you to really work as a team.'

'You can't do these things on your own. You need lots of people with different backgrounds and skillsets but all with a common interest. The synergy you can achieve by working together is a very powerful strength.'

“ People who live with chronic ill health are really focused on understanding their condition better. ”

Dr Cecilia O'Kane
The Institute for Health Sciences, and
Centre for Experimental Medicine



“ There’s a real need for insights rooted in quality research by people who’ve demonstrated global political and cultural understanding. ”



Professor Hastings Donnan, Director
The Senator George J. Mitchell Institute
for Global Peace, Security and Justice

BUILDING A PEACEFUL, SECURE AND INCLUSIVE WORLD

Professor Hastings Donnan has just received an email. It’s from a Kurdish television company. They’re coming to Belfast to make a programme and they want someone to give them a briefing. So they have turned to Queen’s and the Senator George J. Mitchell Institute for Global Peace, Security and Justice.

‘It’s another example of the unpredictable nature of our activities,’ says Hastings, the Director of the Institute. But he is keen to stress that the Institute’s Northern Ireland knowledge is not the sole basis for its reputation.

His own research expertise is on the difficult border areas of Pakistan and Afghanistan. He has colleagues working on the Middle East, Sri Lanka, Latin America and many other parts of the world.

He says, ‘All of this activity provides a comparative focus. That dimension is really critical. We learn much by studying peace-building in other regions and similarly we draw some negatives and some positives for Northern Ireland when we go elsewhere.’

The Institute was originally established as the Institute for the Study of Conflict Transformation and Social Justice. It was renamed in 2016 and became one of the University’s four new Global Research Institutes when it was launched by the man it honours, Senator George Mitchell, former Queen’s University Chancellor and international diplomat, the man who did so much to bring peace to Northern Ireland.

Hastings says, ‘I want the new Institute to be more expansive as well as more inclusive and to extend what we look at. For example, when you talk about security, people think of X-ray machines at the airport. But security isn’t just surveillance. It’s about the things that underpin security, like social justice.’

‘Again, the word justice in the title means more than the legal notions. It means gender justice, environmental justice. And then there’s peace. The struggle for peace isn’t only about ending violence, critical though that is. It’s about building that peace on an everyday basis after the political settlement. And that focus is one of our unique selling points as an Institute.’

There is also an emphasis on multidisciplinary and interdisciplinarity. ‘There are questions that aren’t immediately answerable from any single perspective. So bringing together colleagues

from right across the University, from biological sciences, from medicine, from electronic engineering, as well as from social science and humanities, helps us answer big world questions in a way that’s impossible otherwise.’

He singles out a large grant shared with the Centre for Secure Information Technologies, supplying 30 PhD students with scholarships. ‘With cyber security there are social and cultural consequences around issues of trust, privacy, ethics, what it’s permissible to know about people. We’re working together, looking at the issues that might be presented by future new technologies.’

There is also a project on drones over borders, examining the issue of sharing data among several jurisdictions. And there are collaborations on global food security. ‘If you think of humanitarian interventions, large population displacements, the problems of food supply chains – there are a lot of questions there.’

Another of the Institute’s core activities is engaging with civic society. ‘We want everyone to have a voice,’ Hastings says. ‘We’re engaged with government institutions here and elsewhere. We bring in actors from across civic society and ask them what they think

is important, what questions they think we should be asking.’

‘We have high profile events with speakers like George Mitchell, Arlene Foster, Bertie Ahern, Jonathan Powell – all being challenged by an audience of people who aren’t professional politicians. We had sixth formers taking part in a lively and engaging debate on dealing with the past, with Martin McGuinness.’

And there are callers like the Kurdish television company. ‘We’re contacted by the Northern Ireland Office or the British Council about visitors from Bahrain, say, or South Korea. We could spend every day of every week briefing visiting delegations.’

In summary, Hastings says, ‘There’s a real need today for insights that are grounded and evidence-based and are rooted in quality research by people who have already demonstrated their research credentials and their cultural and political understanding of different parts of the globe.’

‘I’m always saying to my colleagues – we’re not just in this for ourselves and to promote our careers. When you do your research it has to make some kind of difference to people’s lives.’

TRANSFORMING CONFLICT THROUGH SOUND AND MUSIC

An £800,000 award from the Arts and Humanities Research Council to the Senator George J Mitchell Institute for Global Peace, Security and Justice is funding a unique project – the role of sound, narrative, music-making and digital media in conflict transformation.

The research, led by Professor Fiona Magowan, School of History, Anthropology, Philosophy and Politics, is being conducted in the Middle East, Brazil and Northern Ireland but the seeds for the project were sown in a very different region – the Northern Territory of Australia.

Fiona was educated at the universities of Nottingham and Oxford in Music and Social Anthropology. She was awarded a D.Phil at Oxford in 1995 where her Australian research began.

She says, 'As a musician and an anthropologist, I'm passionate about the significance of music in social life. I carried out research in

North East Arnhem Land, in a small island community called Galiwin'ku, with Yolngu people who express their connections to land in ritual performance. I wanted to understand women's songs and their relationship to men's song performance, since beliefs, emotions and cultural rights are vested in their ritual language of the environment.'

More recent research has looked at the domestic moral economy, the implementation of policy on Aboriginal livelihoods and its impact on labour and cultural production, sustainable economy and senses of wellbeing.

She asks, 'In the midst of customary, market and neoliberal economies in which Yolngu now work, how do you reconcile concepts and practices of productivity over processes that support and sustain people's relationships with one another? This is where you can get value conflicts coming in.

'Ritual is central to life events and Aboriginal performance of the Law. Indeed, for many societies performance is a means of peace-making and peace-keeping. We want to explore how sound, music and narrative mediate

and transform relationships in situations of protracted conflict or societies emerging from conflict.'

The new AHRC project involves four co-investigators: Professor Pedro Rebelo (Director, Sonic Arts Research Centre), is a composer, sound artist and performer, whose research focuses on Brazil; Professor Beverley Milton-Edwards (School of History, Anthropology, Philosophy and Politics) will research counter-narratives to ISIS through popular music; Dr Julie Norman (Queen's Research Fellow, Mitchell Institute) will be working with music and media among Syrian and Palestinian refugees; and Dr Stefanie Lehner (School of Arts, English and Languages) is analysing the dramatisation in Northern Ireland theatres of issues relating to the conflict and the way different voices come into play.

Fiona says, 'The art of peace-building is the art of compassion and performance enables that compassion to be manifest. I will be looking at Musicians Without Borders, an international organisation with training programmes based in Derry, who are using music to bring together those affected by conflict. We'll be exploring

how the use of music can impact upon and potentially transform lives, as well as open up new spaces of engagement to alleviate trauma.'

Material collected throughout the project will contribute to a final sound-art installation and exhibition to be showcased in Derry and Rio de Janeiro.

Fiona says, 'We will analyse the complexities of how music makes transformations possible and what is realised and experienced in these engagements. What kinds of processes are involved? To what extent are societies being transformed and how?'

In her teaching, she says, 'I try to expand students' cross-cultural awareness of how senses and emotions in performance influence identity and relationships in various ways to show that conflict transformation and peace-building are ongoing processes. It's about learning how we can live better together through nuanced understandings of others around the globe.'

“ The art of peace-building is the art of compassion and performance enables that compassion to be manifest. ”

Professor Fiona Magowan
The Senator George J. Mitchell Institute for Global Peace, Security and Justice, and School of History, Anthropology, Philosophy and Politics

“ People don't see the role of mid-level organisations in building peace. Yet without them the whole thing falls to pieces. ”

THE PEACEMAKERS WHO ARE TOO OFTEN FORGOTTEN

Dr Joanne Murphy will never forget the day she and her colleagues went to Brussels to make a presentation on conflict transformation. The date was November 21, 2015 – which turned out to be the day the city's great security lockdown began.

Joanne says, 'It was quite an experience. People from Northern Ireland are used to security alerts but this was exceptional – a huge city completely shut down. And there we were, ready for our showcase about mapping commemorative communities, and we couldn't do it.' The presentation did go ahead at a later date but the irony of that day has stayed with her.

Joanne is a lecturer at Queen's Management School with research interests centred around the management of public sector change during and post conflict. And as a Senior Research Fellow for 2015-16 at the Senator George J. Mitchell Institute for Global Peace, Security and Justice, she has also secured a much

sought-after British Academy grant on the often-overlooked role of management in peace-building. The project focuses on the experiences of city managers in Belfast, Bilbao and the Kosovan city of Mitrovica and it explores the hidden dynamics of how public servants impact on conflict and the transition to stability.

A Queen's graduate with a BA in Political Science, Joanne's first job was with the Community Relations Council in Belfast. While there she also studied for a Masters on cultural management, 'but I wanted to move to another job and after the Masters I decided to do a PhD, specifically looking at organisational development and change.'

She describes herself as being 'extraordinarily fortunate' to get a place within the PhD programme at Trinity College Dublin and to be supervised by Professor John Murray, one of the most influential figures within Irish management at that time.

'But my PhD was in something very unusual within a management school. It was about organisational change in policing.' It would result in a book – *Policing For Peace* – 'which

looked at the process of change through an organisational lens rather than a political or criminological lens.'

After her PhD, she became a research assistant at Trinity on a cross-border European-funded project looking at decision-making in public sector organisations. 'That took me away from policing, outside my comfort zone, and that was very good for me.'

The core of what interests her now is how organisations impact on peace-building and conflict processes. 'Anyone who's worked in the public sector understands how significant mid-level bureaucrats are in terms of decision-making. Yet what do we think about? – politicians, the community – and a lot of the time they aren't the ones making the decisions.'

As part of one AHRC grant, former senior civil servants from the Housing Executive, the Northern Ireland Office, the NI Executive, the Arts Council, local councils and other bodies were brought together.

'Some of the stories they told were utterly compelling. Suddenly you realised that here

were people who were professional civil servants, plunged into extraordinarily extreme environments and expected to cope.

'One of the really fascinating areas was housing – how housing managers really deftly managed intensely political and dangerous situations, putting themselves in physical danger to try to manage difficult circumstances on housing estates.

'What these organisations were doing was actively peace-building, trying to build social processes to move society closer to lower levels of conflict. People tend to see societies emerging from conflict through a financial lens – how do you stabilise the economy – or through a security lens – how do you stabilise the security situation. They don't see the role of mid-level organisations in building and sustaining peace. Yet without them the whole thing falls to pieces.

'Political skills are hugely valuable. Leadership and support of staff are critical. If you have staff with these skills, who know what they're doing, then look after them because they're worth their weight in gold.'

Dr Joanne Murphy
The Senator George J. Mitchell Institute
for Global Peace, Security and Justice, and
Queen's Management School

LISTENING TO THE VOICES MARGINALISED BY CONFLICT

When Dr Julie Norman came to Belfast in 2015 as a Queen's University Research Fellow, she brought an extra dimension to the role – her teaching.

'I pushed for that,' she says, 'It's really important for me to keep a foot in education and teaching and working with young people. My research is stronger when I'm teaching – and vice versa.'

Julie is one of 14 outstanding postdoctoral researchers from all over the world who are now at Queen's, extending their impact and accelerating their careers. At the Senator George J Mitchell Institute for Global Peace, Security and Justice her research is focused on human rights and security in conflict situations, 'looking especially at political prisoners and detainees and how the state and prisoners end up negotiating policy, through prisoners' resistance on the one hand and states' attempts to control on the other.'

And she is teaching. 'In fact, I ended up stepping into the role of Director of Education, convening our brand new Masters programme in Conflict Transformation and

Social Justice. That became a whole new aspect of my work which was very exciting.'

With a PhD from American University in Washington DC, before coming to Queen's Julie had been at Concordia University and McGill University in Montreal, teaching courses on Middle East politics, Israel-Palestine, human rights and international development.

'I was familiar with Queen's, and with working on protracted conflict I was familiar with Northern Ireland as well. The new Institute appealed to my interdisciplinary interests and background and it was bringing together a lot of what I hoped to do – so I applied.'

She has become immersed in her role, including involvement in a number of important knowledge exchange projects. 'People want to learn from the context here in Northern Ireland. For example, we've had former fighters from Lebanon meeting former combatants here. We had hunger strikers and lawyers from Israel-Palestine coming to meet former hunger strikers here and we've had a cross-community group from Israel-Palestine meeting a cross-community group from Corrymeela.'

And there is her own growing experience of Northern Ireland. 'There are so many layers and nuances. You come to appreciate the complexity. Living here, going to events where the audience member next to you asks a question and makes a comment that refers specifically to suffering or loss they experienced during the conflict – that's very humbling.'

Her research projects include awards from the British Academy for work on community engagement in divided societies and the implication of detention policies on security and human rights in protracted conflict. She is also turning her attention to the plight of refugees in the Syrian conflict.

She says, 'The work on prisoners is ongoing. I find it a very under-studied and under-analysed aspect of conflict. And the refugee situation is obviously one that demands attention.'

There is also the need to be able to respond to events. 'When you're teaching about the Middle East, in particular, it's constantly changing. I might prep a lecture and between the time I leave home and get here I know I have to change it.'

'It's the same with research. Working on contemporary issues, you need to have openness and flexibility. We're not content just to sit in our offices. We're engaged with what's going on in the real world.'

Over the past decade, Julie has spent weeks or months each year in Israel-Palestine and the West Bank. 'A lot of the focus of my work is to try to amplify marginalised voices, to get stories heard that wouldn't be heard otherwise and to let those stories speak for themselves. And I want policymakers to hear these voices.'

'In the classroom, I strive to be as objective as possible, to encourage students to draw their own conclusions. And as a researcher, I see myself as a practitioner. I want to have some impact on policy.'

'There are certain issues of justice where to stay completely objective would be morally questionable. There are times when you feel you have to take some kind of stand. But I think being able to do that through writing, through research, through teaching is a real privilege.'

“

People want to learn from the context here in Northern Ireland. For example, we've had former fighters from Lebanon meeting former combatants here.

”

Dr Julie Norman
The Senator George J. Mitchell Institute
for Global Peace, Security and Justice

“ Deeper understanding of radiation lets us optimise its use. ”

A NEW FRONT IN THE FIGHT AGAINST CANCER

Professor Matt Zepf talks enthusiastically about the upgrade of his laser facility at Queen's Centre for Plasma Physics. The original was called TARANIS – and with a dash of humour the new version has been named TARANIS-X.

But this is no dinosaur. It is funded by a £1m grant from the Engineering and Physical Sciences Research Council (EPSRC) and Matt says, 'This upgrade will take our laser to a standard that is internationally unique.'

Matt and Professor Fred Currell, along with colleagues Dr Helen McCarthy and Professor Jorge Kohanoff, are at the forefront of the Centre for Advanced and Interdisciplinary Radiation Research (CAIRR), a Pioneer Research Programme (PRP) that brings together life scientists, physicists, physical chemists and computational physicists, all focused on optimising treatment of cancer patients using radiation.

Matt's field is ultrafast and ultrahigh power radiation sources – such as the ultrashort pulses of extreme ultraviolet light which will be delivered by TARANIS-X – while Fred's research is into robotic radiation sources, cancer modeling and radiation nanomedicine.

Matt says, 'We realised we had an opportunity to bring our expertise together, along with the work of our other colleagues, to build something special and that has become the CAIRR PRP.' It is a multidisciplinary team but he emphasises, 'First you have to have people who are excellent in their individual disciplines.'

That is certainly the case with CAIRR. The researchers have the tools and capabilities to deepen understanding of fundamental radiation/matter interactions and apply it through several layers of increasing complexity – from the atom to the patient.

Their work is being funded by £1.4m from Queen's over three years and there are already almost 50 staff involved across two faculties, including postdocs and students.

Fred says, 'I think of CAIRR as an impact accelerator – that something done at a very basic level can be accelerated into the domain of the patient.'

'Matt's planning an experiment which will teach us about the basic behaviour of radiation. There are also other experiments by colleagues which will tell us more about radiation and how it interacts with water, then how it interacts with living systems, right from the most basic up to what happens in a person.'

'This understanding of radiation can inform a lot more about how we optimise its use. It leads to a quicker pipeline.'

Matt says, 'There is really fundamental research that's valid in its own right. We already have data which shows that if you take something simple, like a lump of glass, and make small changes to its nanostructure, you get a completely different outcome in the way radiation interacts. These are things that couldn't be seen before but now we can watch a movie of the processes being triggered by radiation evolving.'

Fred says, 'CAIRR is an attractor. What we are doing is exciting and people want to come and be part of it.'

'One of the special things that we're going to end up with is the fact that having a hub that works like this is a tremendous invisible asset and I also think that one of the big things for me over the next few years will be to internationalise CAIRR.'

He is keen to emphasise the way they all work as a team of equals. 'Within CAIRR there's no one expert, no one superman or superwoman leader. It's important that if we look back in five years time we can see that we have continued to nurture and grow this kind of collective. We need to keep our eyes on that.'

Professor Fred Currell, Lead (left), and Professor Matt Zepf
Centre for Advanced and Interdisciplinary Radiation
Research (CAIRR), and Centre for Plasma Physics

UNDERSTANDING RADIATION: FROM THE ATOM TO THE PATIENT

Jorge Kohanoff has a vivid memory of his first day as a lecturer at Queen's. 'It was 1999. I'd never done any teaching before, except with postgraduates, but the first thing I was given was a level one course with 150 students. And on top of that the overhead projector didn't work.'

The second lecture went a lot better and so did the ensuing years. He is now Professor of Computational Chemical Physics, he leads the Atomistic Simulation Centre (ASC), and he is playing a major role in one of the new Pioneer Research Programmes (PRP), the Centre for Advanced and Interdisciplinary Radiation Research, focused on optimising cancer treatment using radiation.

His journey to Queen's was a long one: first from Buenos Aires as an undergraduate student to Trieste in Italy as a Master of Philosophy, then a PhD from ETH, the Swiss Federal Institute of Technology, while working at IBM in Zürich, which boasts several Nobel prizewinners.

Later came a postdoctorate at the École Normale Supérieure of Lyon, back to Trieste as a visiting scientist at the International Centre for Theoretical Physics, and then to Belfast. 'A new research direction had opened up here in 1995 with the establishment of the Atomistic Simulation Group by two leading figures in my field, Professor Mike Finnis and Professor Ruth Lynden-Bell. So when a temporary position became available I applied.'

Jorge became Director of Research at the ASC in 2012, taking on a number of new staff and creating diversity. 'We designed and built a research team where members have complementary expertise and interests and yet there is sufficient overlap to promote collaboration.'

Atomistic simulation focuses on the theoretical and computational modeling of what happens in the atomic scale in solids, liquids, molecules and plasmas. 'We simulate the motion and properties of such systems at the level of the atoms and, even deeper, of nuclei and electrons.'

'We then use this to interpret existing experimental data and predict new phenomena, to reach computationally where pen and paper theory alone can't, and to investigate

hypothetical situations where experiments aren't yet possible – eg under extreme conditions or at size and timescales that can't yet be accessed directly.'

One of his specific interests is the interaction of radiation with biological systems. 'I had developed a collaboration with Professor Gary McVeigh, a Queen's academic who was my consultant at Belfast City Hospital. He was investigating early detection of cardiovascular disease and analysing blood flow in a way similar to work I had done for my PhD. This sparked my interest in interdisciplinary research at the interface of medicine, biology and physics.'

In 2008 Jorge went to Cambridge for a sabbatical year to focus on this area of research. When he came back he passed his interest and his knowledge on to a student, Maeve Smyth, who was looking for an appropriate PhD subject.

'We talked about research avenues and she chose the area of modeling radiation damage to DNA in its natural environment, an important aspect which was not being thoroughly addressed in the community.'

He explains, 'What we do lies at the microscopic end. We try to understand model systems made

of small DNA fragments, instead of simulating a whole DNA that's metres long. Our goal is to find out how irradiating the DNA produces the damage that will then trigger the apoptotic response – cell death.'

'Within the PRP the knowledge acquired at the nanoscale through simulations will be used within an approach known as multi-scale modeling to access larger scales. Here is where we connect with the modeling and experimental work that Professor Currell's team is doing.'

'We're trying to bring all the questions together and get answers for the benefit of the patient, to find out if what we've learned can be used to develop new therapies or improve existing ones.'

And there is a footnote. The PhD student of 2009, Dr Maeve Smyth, has continued her training at the Velindre Cancer Centre in Cardiff and has recently been hired by the NHS as Stereotactic Radiotherapy Development Physicist.

Jorge says, 'From those early beginnings, she will now be in hospitals using the greater knowledge of radiotherapy that she has developed. That is a very successful journey.'

“ We're trying to bring all the questions together and get answers for the benefit of the patient, to find out if what we've learned can be used to develop new therapies or improve existing ones. ”

Professor Jorge Kohanoff
Centre for Advanced and Interdisciplinary Radiation Research (CAIRR), and
School of Mathematics and Physics

“ Through partnerships, we can make a difference in local communities whilst also pioneering new ways of thinking and working nationally and internationally. ”

SOCIAL INNOVATION AND THE EVIDENCE OF WHAT WORKS

Professor Paul Connolly, Lead of one of the new Pioneer Research Programmes at Queen's, gives an enthusiastic explanation of its title – the Centre for Evidence and Social Innovation (CESI).

'In a nutshell, social innovation is about finding novel solutions to entrenched social problems – but solutions that actually work. We're in partnership with key agencies, government departments and the voluntary sector, looking at big problems like drug and alcohol misuse, educational underachievement, public health issues, and asking – how can we break the cycle?'

'The evidence part is what makes us unique and sets us apart from other centres. Too often social innovation happens in the dark, in a vacuum, so people just go on re-inventing the wheel. We're using robust evidence, rather than conjecture or political opinion, to understand the nature of problems.'

The words – what works – are embedded in CESI's three research themes – what works for families; what works for schools; and what works for communities. Among major initiatives, the Centre is working to establish long-term relationships with two communities in Belfast – the Greater Shankill Children and Young People Zone and the Colin Neighbourhood Partnership.

Paul, former Head of the School of Education and now Dean of Research for the Faculty of Arts, Humanities and Social Sciences, describes these as 'innovation zones, sites on our doorstep where we should have partnerships as a University, where we can try out new things which meet the needs of local communities but which also help us as a research organisation to pilot new ways of thinking. They are incubators of innovation.'

'We want to blur the boundaries between researchers and the community. We want to change mindsets so that people aren't surprised to see people from Queen's on their doorstep. We need to be recognisable and known locally so that people develop confidence and are happy to work with us.'

Other projects include a major collaboration with the Department of Education looking at children's social and emotional learning. 'One of their signature programmes is about Nurture Groups, designed for children at the start of primary school who are demonstrating clear behavioural problems and are already struggling in mainstream education. The idea is to refit a classroom to look like a home environment. The children spend part of a day there for two terms, helping them develop attachments that perhaps they've never had.'

'But does it work? The Department engaged us to do a robust evaluation and we've shown that it does. Within two terms, a significant proportion of children were able to come off the behavioural register and go back full time into the main stream. We also found that the programme pays for itself after two years, in terms of other services which are saved, and it has recouped its cost many times over by the end of primary school.'

Further evidence-based research has involved work with Fostering Network around the Letterbox Club, a scheme that gifts books to

children in foster care, a group who have low educational outcomes and performance.

'It has funding, it's well liked, but we found ultimately that it didn't work. Now we have developed a partnership with Oxford University's Rees Centre for Fostering and Education and through our ongoing work with a range of organisations across the UK, we've identified a need to supplement the scheme.'

'What's missing is the involvement of foster carers themselves. We're proposing a large scale UK-wide study to develop a training manual and sessions for foster carers to see if that active ingredient helps to improve literacy. So here we have something that began with a small local pilot study and could change a national programme.'

Paul's overall view of CESI is that 'if we're at all successful, we'll have measurable change regionally but there's a real sense that we can change ways of thinking nationally and internationally. We're the largest centre in Europe doing this type of work and playing a leading role in demonstrating what works.'

Professor Paul Connolly, Lead Centre for Evidence and Social Innovation (CESI), and Dean of Research, Faculty of Arts, Humanities and Social Sciences

THE CHALLENGE OF YOUNG LIVES AFFECTED BY DRUGS AND ALCOHOL

Start talking to Dr Kathryn Higgins about the success and influence of her research and the first thing she will say is – ‘It’s the work of a team. I can’t stress that enough.’

For 16 years, that team has been engaged in the Belfast Youth Development Study, one of the most ambitious projects in the UK to focus on the experiences of young people growing up, and involving around 5,000 who entered post primary education in the year 2000.

Kathy says, ‘We’ve followed them since they were 11 and we continue to follow them into adulthood, looking at the trajectory of their lives – their schooling, mental health outcomes, very detailed drug and alcohol data, and the whole dynamics of family and community. In fact, some of them are now parents themselves.

‘The study has shown that while for most young people drug use is a phase from which they mature with minimal harm, for those who become addicted, the problems are immense.

Overall, this is a great resource for much of our further work because no matter what you’re doing, if it’s not predicated on a robust research base you’re on a hiding to nothing.’

Kathy is Director of Graduate Studies at the new School of Social Sciences, Education and Social Work at Queen’s and she is also playing a key role in CESI, the Centre for Evidence and Social Innovation, a Pioneer Research Programme where she leads one of the main strands – titled ‘What Works for Communities’ – with a focus on drugs and alcohol misuse and other issues.

A Queen’s graduate with a degree in Psychology, she also studied at Cardiff University for a Masters in Occupational Psychology. It was later, when she had taken up a post which she soon discovered ‘wasn’t for me,’ that an advertisement for a very different job caught her attention.

‘It was in Dundee and it was part of a World Health Organisation study looking at HIV prevalence among drug users. The methodology appealed to me because it was very outreach-driven. I got the job, which ran for

two years, and it led to me becoming absorbed in this very problematic area.’

Later she found a new opportunity – a post within the new Institute of Child Care Research at Queen’s. ‘There was new legislation, the Children (Northern Ireland) Order 1995, which was trying to address a very Cinderella area, research about children and young people, and with my experience in Scotland I had become very interested in the pathways that young people take.’

That interest has led to a series of major research initiatives, such as the Belfast Youth Development Study, which has also helped her and her colleagues to secure important new funding from the National Institute for Health Research for a project looking at new psychoactive drugs – so-called legal highs.

Kathy explains, ‘We had the presence of mind in the last sweep of the Belfast study to include the then legal highs, like methadone, so we had data which we were able to use for a further proposal. There hasn’t been much research internationally so it’s cutting edge and we’re at the forefront.’

She sees this approach as an important ingredient of CESI. ‘We’re paying attention to future trends but it’s also about the way we conduct our research. We’re in the digital era so we’re finding creative ways of collecting information, such as an app we tested within the drug and alcohol field and which has provided some excellent data.’

‘I’m a networker,’ Kathy says – and that fact is demonstrated by DARN, the Drug and Alcohol Research Network, an initiative she co-founded and co-directs. ‘We’re collaborating across the University – with Public Health, Psychiatry, Chemistry, Nursing – and also with policy-makers and practitioners.

‘We’ve created an informed research agenda on alcohol and drugs use, a vital, one-stop resource for all those who aspire to make a difference. We’re constantly trying to push the boundaries. At the end of the day, this is about people’s lives.’

“ We’ve created an informed research agenda, a vital one-stop shop for those who aspire to make a difference. ”



Dr Kathryn Higgins
Centre for Evidence and Social Innovation (CESI), and
School of Social Sciences, Education and Social Work

THE ETHICS OF RISK AND INEQUALITY

“ We want to see that when people devise policies to manage risk, they take much more account of the effect on inequality. ”

Dr Tom Walker, Lead
Centre for the Study of Risk and Inequality, and
School of History, Anthropology, Philosophy and Politics

Dr Tom Walker wasn't always a philosopher. Originally he was an engineer.

'I worked for ten years providing power lines across the north of Scotland. I was put in charge of a plan for dealing with oil spills, things like that, which got me thinking about questions of ethics, what was appropriate, what was fair, and how we should treat the local community.'

So he took what he thought would be a career break and did a degree in philosophy at the University of Sheffield. 'But it turned out I enjoyed it more than I was expecting, so I stayed on and did a PhD.'

When he finished he joined the Centre for Professional Ethics at Keele University, where most of his teaching was for medical professionals, dealing with questions of applied ethics. Now he is at Queen's, leading a cross-disciplinary Pioneer Research Programme on Risk and Inequality.

The programme takes as its starting point the position that risks of many kinds – financial, environmental, health-related – pose the greatest threat levels to low income and socially disadvantaged groups.

There are three themes in the programme – finance, environment and health. On finance, Tom says, 'This came out of the 2007-08 crisis. All the big institutions have risk managers – even the ones that collapsed. We're looking at how they missed the risks that were there and what the impact of that is on different parts of the economy.'

'On the environment, we're focused on climate change and renewable energy, two big global themes. With climate change we have problems like rising sea levels which tend to affect poorer countries and we want to know who the risks fall on. With renewable energy, we're looking at availability and affordability, what it means in places like Africa and how that creates inequality as well.'

'With health, the issues are to do with the disproportionate effects of certain risk behaviours, such as smoking. Also, health inequalities are mapped very closely onto social and financial inequalities. We're not treating them as separate things.'

'One of the biggest risks to health if you're poor is the fact that you're poor. So increasing financial inequality increases health inequality. On this we're bringing together practitioners on the ground, such as from the Centre for Public Health, from the Schools of Law, Sociology and Politics.'

And then there is Brexit. Tom says, 'Sometimes I think that if we hadn't already come up with this research programme, we would have had to create it just for Brexit.'

'This is going to open up a whole new strand of research. There are going to be questions about how responding to the risks coming out of Brexit are managed in a way that doesn't exacerbate

inequality. I think we'll be looking at a lot of things that weren't part of the original plan.'

'When something like Brexit happens, it alters our focus and as new risks develop, then we'll try to be flexible and move into them. But we have a network in place so that we can look at Brexit from the perspective of Westminster, Dublin and Brussels, as well as Belfast.'

'With a lot of our research, our concern is with getting to the policymakers so Government is going to be the main target. We want to see policy change which tackles inequality. We want to see that when people devise policies to manage risk they take much more account of the effect on inequality and how the two are connected.'

'There are several well-established centres looking at risk and there are several well-established centres looking at inequality. But there's nobody looking at how the two are connected. We're the first that we know of anywhere in the world. That's what makes this programme pioneering.'

THE STORY OF JACK AND A £1.7M GRANT

Remember BT's 1990s advertising campaign, *It's Good to Talk?* Featuring the late Bob Hoskins, it was about families and friendships and how to change the attitudes of men to the domestic telephone.

What's not widely known is that the research behind it was carried out by a young PhD student in sociology at Trinity College Dublin, Maria Lohan. Fifteen years later she is Professor Maria Lohan, Director of Research for the School of Nursing and Midwifery at Queen's, and one of the key contributors to two Pioneer Research Programmes – Risk and Inequality and the Centre for Evidence and Social Innovation.

She says, 'British Telecom sponsored my PhD. Practically all the quotes used were taken from the conversations we had with men. Back then, they couldn't get men to use the home telephone. It was seen as a tool for women, who were the lynchpins of families and did all the communicating.'

The campaign was a big success for BT but also for Maria. 'Through that study I gained a great insight into men's lives, their friendships and their ways of understanding their families.'

This would develop into questions about how men's lives are changing in the contemporary world and lead to a £1.7m grant from the National Institute for Health Research for a UK-wide trial to study a new way of addressing teenage pregnancy, targeting the roles and responsibilities of young men.

After her PhD, Maria joined the School of Nursing and Midwifery at Trinity, then came to Queen's in 2005. She says, 'Part of my role here is helping nurses and midwives to use research to develop patient-centred care, which is at the heart of how we deliver health services.'

Her own focus is on aspects of men's health. How do they understand their fertility? What are their approaches to avoiding or becoming a parent?

'I started a programme on teenage pregnancy and discovered that there's a pile of research on the socio-economic predictors and the consequences in people's lives. But one big piece was missing – men. So that whetted my appetite to try to understand much more about what a teenage pregnancy would be like in a young man's life.'

This led to *If I Were Jack* – an educational intervention about teenage men and unintended pregnancy, with an interactive film which stops at crucial points where the viewer has to put himself in Jack's place and take difficult decisions. It was developed through a grant from the Economic and Social Research Council and its success has led to the UK trial which began at the start of 2017.

Maria says, 'This is now being delivered throughout Ireland, in Australia and being trialled in the UK. And we have big ideas about applying it to sub-Saharan Africa, calling it *If I Were Maganga* – a name that bridges Muslim and Christian cultures.'

Working with Barnardo's, they are also developing a bespoke version for Hydebank in South Belfast, the first young offenders' institution in the UK to become what is known as a secure college.

'We're dealing with men who are already fathers and men who are not fathers yet. The fathers open up about the losses they've experienced. Sometimes a child is born and they've lost the relationship already. That's important peer learning for young men to stop and think about potential fatherhood in their lives.'

She says, 'We don't usually look to men in relation to gender inequality but gender works in men's lives too. If we understand this we can also understand the way men's lives are changing and put into effect new approaches to involving them in pregnancy, reproduction and parenting.'

“ We can put into effect new approaches to involving men in pregnancy, reproduction and parenting. ”

Professor Maria Lohan
Centre for the Study of Risk and Inequality, and
School of Nursing and Midwifery

“ We saw the opportunity to come together to be at the leading edge of this new wave of innovation. ”

INTELLIGENT SYSTEMS CREATING THE FACTORIES OF THE FUTURE

They call it Industry 4.0 – the fourth industrial revolution – the unique coming-together of several technology innovations that integrate the physical and virtual worlds and will change the global manufacturing sector. And Professor Seán McLoone will be at the heart of it.

He is leading a Queen’s Pioneer Research Programme (PRP) – Intelligent Autonomous Manufacturing Systems – to address the challenge of designing smart manufacturing systems for tomorrow’s world. He says, ‘I want to grow this into an internationally recognised Centre of Excellence for Queen’s, and make it the go-to place in the field.’

A Queen’s graduate with a PhD in control engineering, Seán spent 10 years on the staff of the National University of Ireland Maynooth, becoming Head of the Department of Electronic Engineering, before returning to Queen’s where he is now Director of EPIC, the Energy, Power and Intelligent Control research cluster in the School of Electronics, Electrical Engineering and Computer Science.

He says, ‘There was a national initiative in the Republic around advanced manufacturing and manufacturing competitiveness. The Irish Centre for Manufacturing Research was established and I was involved in it with my research team from its inception. It operated on an all-Ireland basis with industrial collaborators including Bombardier and Seagate as well as Intel, Pfizer, Johnson & Johnson – all large multinational players.

‘The essential model was industry coming together to define a research agenda of common interest with academics involved. I became one of the academic leads with research on the theme of virtual metrology and predictive maintenance, a forerunner to the idea of using data in manufacturing – Industry 4.0.’

The programme he leads at Queen’s has three themes – virtual sensing, prognostics and virtual factory simulations; flexible automation; and autonomous and intelligent decision-making – and it brings together academics from the EPIC cluster and colleagues from the School of Mechanical and Aerospace Engineering, as well as the Schools of Psychology and Maths and Physics.

‘It’s very much a multidisciplinary endeavour. The origin of the PRP was the realisation

that there was good synergy between Mechanical and Aerospace Engineering, with their expertise in digital manufacturing and factory modelling, and the data analytics and intelligent systems expertise in my group. We saw the opportunity to come together to be at the leading edge of this new wave of innovation.’

There has been a huge growth and convergence of technologies in terms of sensing, cyber physical systems and what is known as the Internet of Things – a world where everyday objects have network connectivity.

Seán says, ‘This has led to a huge amount of data being generated by manufacturing processes and indeed the complete manufacturing supply chain. The challenge is – how do you combine the available data into valuable information on which you can make decisions and how do you develop automation systems that can act on that information?’

‘We want to turn that data into actionable information, determining what we should do on the factory floor, what changes should be made to improve process performance and product quality, reduce energy consumption and waste, and ultimately minimise the cost of manufacturing.’

At the heart of this is robotics. ‘Currently, robots are fixed structures customised to a particular task and there’s a lot of work involved if you want to change them to do something else. Our ambition is a robot that would basically have the adaptability of a person – able to take on different tasks during the course of the day. We’re trying to develop flexibility, adding more intelligence to the robots, so that they can adapt quickly to new situations and interact safely with human operators.’

In August 2016, Seán and his colleagues organised a week-long international conference at Queen’s on ‘Control’ with strong industrial participation. It included workshops on ‘Shaping a Low Carbon Energy Future’ and ‘Industry 4.0: Putting Theory into Practice’. Among the companies represented were Kuka, one of the world’s leading robot manufacturers, and Seagate, a global leader in data storage.

Seán says, ‘This is the kind of industrial engagement we want to build on. It’s about getting the visibility that will give us external recognition and, more importantly, the external awareness that if companies have problems, they can come to us. I want Queen’s to be a recognised centre of competence in Industry 4.0, nationally and internationally.’



Professor Seán McLoone, Lead Intelligent Autonomous Manufacturing Systems (I-AMS), and School of Electronics, Electrical Engineering and Computer Science

VIRTUAL REALITY: HELPING US SHAPE OUR 'SMART' FUTURE

You are walking across the floor of a huge factory. In front of you there is an array of robots working on a production line. You look around, studying the rest of the space – and then you take the headset off.

Now you are in a white room on the top floor of the Ashby at Queen's University. This is the home of virtual reality (VR) and robotics research within the Energy, Power and Intelligent Control Cluster (EPIC) at the School of Electronics, Electrical Engineering and Computer Science. And just to reinforce it, there are even a couple of large Iron Man lookalikes standing to attention against the wall.

Robotics, intelligent control and virtual reality make up one of the highest strategic priority areas of the UK and are a focus for Industry 4.0 – what's being called the fourth industrial revolution. This is the design of the 'smart factories' of the future where cyber physical systems monitor processes and make decisions based on a magical array of sensors.

It is also the target area for one of the new Pioneer Research Programmes (PRP) at Queen's – Intelligent Autonomous Manufacturing Systems – led by Professor Seán McLoone and in which Dr Karen Rafferty, Deputy Head of School, is playing a key role.

She says, 'You can use VR to create optimised factory designs, working out whether everything's positioned properly, maximising efficiency, planning for expansion and rehearsing the response to every conceivable problem. But VR and its applications can help us make all sorts of great advances in the way we live and work.'

A Queen's graduate, Karen came to the world of virtual and augmented reality over time. Her PhD research project, sponsored by the Civil Aviation Authority, was in the simulation and performance assessment of airport landing lighting, using what's known as environmental sensing – extracting useful information from the environment.

When she became a Queen's lecturer, her interest moved towards VR – 'but that's also

about environmental sensing. With VR you're immersed in a virtual environment. The visuals are very impressive – like a computer game – but we also want to be able to replicate touch, and even taste and smell are on the menu. That's when I got into haptics – being able to feel and interact, which adds to the sense of realism.'

As well as working towards the objectives of the PRP, Karen sees many other exciting applications. In the medical world, she and her colleagues are developing simulators for training doctors to carry out keyhole surgery and maximise the benefits of novel hi-tech treatments. They are working with surgeons at the Royal Belfast Hospital for Sick Children and with ophthalmologists on techniques for eye surgery.

And there are opportunities to link in robotics. 'A surgeon might have a very slight hand tremor, which might cause a problem with a certain task, but robots are very precise and you could pass the task to them – although I'm not sure we'll ever get to the stage where robots will take over completely. And of course there is a body of research that wonders – if we train surgeons using VR and robotics, is there a

danger that they may become detached from the responsibility of making mistakes?'

Within the PRP, Karen is researching autonomous intelligent decision-making. 'What can we use a robot for that would be better than using a human being? We're trying to figure out – can robots learn and observe and, essentially, think?'

In VR, she says, there are new opportunities all the time. She and her team are developing assisted living devices, aids that will help older people and others to remain in their homes for longer, rather than going into specialist care.

'There are a lot of gains to be had. People can be trained in it, learn in it and have fun in it. There is also the huge potential for using it to create empathy and understanding, where you can step into someone else's shoes.'

'And just imagine walking through the park with a small wireless head-mounted display that tells you all about the plant or the tree that you're looking at. It just gets better and better.'

Dr Karen Rafferty
Intelligent Autonomous Manufacturing Systems (I-AMS), and
School of Electronics, Electrical Engineering and Computer Science

“ VR and its applications can help us make all sorts of advances in the way we live and work. ”

“ We want to have a major impact in the care of patients, from the very young to the very old, to improve their lives and health outcomes. ”

LEADING THE WAY TO NEW HORIZONS IN HEALTHCARE

In the world of healthcare innovation, Professor Ryan Donnelly's name is synonymous with tiny objects that make a huge impact – microneedles.

These minute projections in a patch take the sting out of injections. They penetrate the skin painlessly to administer medication or monitor drug levels in a patient's body without drawing blood.

He has now secured a contract manufacturer who is willing and able to manufacture his microneedles for the market and he is currently working with a number of leading international pharmaceutical and biosensors companies on specific product developments.

Ryan, who holds the Chair in Pharmaceutical Technology at the School of Pharmacy at Queen's, is leading a Pioneer Research Programme (PRP) – Materials and Advanced Technologies for Healthcare – which is bringing a range of researchers together in an exciting collaboration.

Ryan says, 'We've been working for years with Schools and Institutes right across Queen's and beyond – with researchers in Engineering and Chemistry, for instance – but if we were going to develop a Pioneer Research Programme

that would grow and address global challenges and perhaps in time lead to a Global Research Institute specifically focused on this area, then we needed to collaborate with people from different disciplines in a more focused way.'

There are three Grand Challenge areas in the programme; *Smarter Materials*, led by Professor Steven Bell from the School of Chemistry and Chemical Engineering, Professor Colin McCoy from the School of Pharmacy and Professor Fraser Buchanan from the School of Mechanical and Aerospace Engineering; *Developing Future Therapies*, led by Professors Chris Scott, Brendan Gilmore and Gavin Andrews from the School of Pharmacy and Dr Adrien Kissenpfennig from the School of Medicine, Dentistry and Biomedical Sciences; and *Optimising Treatment and Community Health*, led by Professors Michael Tunney and Carmel Hughes from the School of Pharmacy.

Ryan says, 'In drug delivery, taking the needle out of the equation for vaccination is one of the grand challenges for global health. Also, 60% of newly-discovered drug molecules fail to reach the market because they're too water-insoluble.

'A lot of these compounds are just sitting around on shelves even though they held great promise. So that's a strong theme – to improve delivery through enhanced formulation and manufacture.'

Prevention of infection is also a major strand. 'The big pharma companies have moved their focus away from antibiotic discovery. We haven't had new antibiotics hitting the market since the 80s so resistance develops.

'Not only do we need to discover new antibiotics but we have to prevent the infection of in-dwelling medical devices, which is a major problem, and by working together we think we can make a big impact.'

Ryan sees new developments in materials science playing a significant role – not only biomaterials that will resist infection but materials designed from the nanoscale. And there is the impact of nanomedicine in the treatment of HIV – targeting drugs to the lymphatic system, reducing infectivity 'and also having the potential to achieve a cure for the virus.'

Then there is tissue engineering. 'People are living longer, they may need replacement joints or organs. So here we see Biological Sciences and Engineering coming together to make replacement body parts that are going to function properly and resist infection.

'People within one discipline are less likely to make the step change that will be required to address these challenges. You need to take an interdisciplinary approach.

'We want to publish in the very best journals but we also want to increase our interaction with industry, making university discoveries that will reach the patient sooner, and we want to interact with healthcare providers and government organisations to influence healthcare policy.

'This programme is about developing a holistic 'molecule-to-patient' strategy. It's about having a major impact in the care of all patients, from the very young to the very old, to improve their lives and their health outcomes.

'Ultimately, we want to ensure that our science affects the care of patients and makes a major contribution to the Health Service here and across the world. This PRP is unique as it covers the spectrum from fundamental scientific research to products and interventions which are wanted by healthcare practitioners and policymakers and needed by patients.'

Professor Ryan Donnelly, Lead Materials and Advanced Technologies for Healthcare, and School of Pharmacy

THE NANOMEDICINE INNOVATOR WHO ALWAYS HAS THE PATIENT IN MIND

Dr Helen McCarthy's view is straightforward – 'There's no point in designing the most fantastic medicine in the world if you can't deliver it to patients.'

She has followed that belief for the past 16 years, ever since she obtained her PhD at Ulster University.

She says, 'My journey has been inspired by two outstanding academics, Professor David Hirst and Professor Tracy Robson, who were my mentors when I was a postdoctoral scientist. They ignited my passion for alternative therapeutics, particularly in the cancer field, so when they moved to Queen's in 2004 I moved with them.'

She took up a post at the School of Pharmacy as a Research Fellow on a cancer gene therapy project. 'I really enjoyed the whole philosophy in Pharmacy – trying to make medicines that actually work. It's very translational.'

She has been a Reader since 2013. She leads a research group on experimental therapeutics, focusing on the development of non-viral delivery systems for nanomedicine, and is a key member of the Pharmacy-led Pioneer Research Programme (PRP) directed by Professor Ryan Donnelly.

'My research is about designing delivery systems for difficult-to-treat therapeutics – DNA, RNA, microRNA. What made me go down that route of trying to mimic viruses in a non-viral sense was something called the Promising Researchers Scheme at the School. It was just £5,000 but it enabled me to go off to Washington State University where I was introduced to the whole new world of nanomedicine and then I came back and developed my research group.'

'I believe strongly that you need to work with others who don't have the same skill set as you. For example, I worked closely with Professor Nicholas Dunne when he was in the School of Mechanical and Aerospace Engineering on an injectable treatment for serious bone fractures and bone metastases.'

'Ryan and I have also worked together for years on therapeutic cancer vaccines. Basically he designs microneedle systems that cross the skin and I incorporate my biological therapeutics, my nanoparticles, and then we evaluate the response. Together we've patented this technology.'

'Within the PRP, part of my role is to mentor the younger generation coming on and to research third generation nucleic acid therapeutics. As new polymer delivery systems evolve, I incorporate my nanoparticles and we evaluate the effectiveness of the therapy.'

'The whole purpose is always with the patient in mind. Even if we're doing some basic research, we need to think – how can this translate to the patient? That's the focus of everything.'

With funding from Cancer Research UK, Helen has also designed and patented a peptide delivery sequence. 'Back in the early days I was very much into delivering a gene for nitric oxide – and it's a fantastic anti-cancer molecule – but it's not going to have any effect because we

can't deliver it to patients. So that's why I designed these systems.'

Helen is also lending her expertise to another PRP – the Centre for Advanced and Interdisciplinary Radiation Research. 'I lead the biological evaluation strand. Frequently patients are given drugs and we're not quite sure how they're going to respond to them. We want to be able to model how tumours will respond to a chemotherapy combination or types of radiotherapy so that patients will ultimately receive the type of treatment that's ideal for them.'

'The generation of such translational technologies always has the patient as the end point so I hope there'll be the momentum and investment to go further. Some really exciting results have come through already and we won't stop until we've made an impact with these nanomedicines.'

Dr Helen McCarthy
Materials and Advanced Technologies for Healthcare, and
School of Pharmacy

“ Even if we're doing some fundamental research we need to think – how can this translate to the patient? That's the focus of everything. ”

DESIGNING NEW ADVANCES IN SUSTAINABLE ENERGY TECHNOLOGY

“Energy presents a lot of opportunities for creative thinking, especially internationally. Sustainable energy is a global challenge... There's a lot of room for academics to come up with bright ideas which can have real impact.”

Professor David Rooney, Lead Sustainable Energy Research Centre, and School of Chemistry and Chemical Engineering

In May 2016, the Vice-Chancellor of Queen's, Professor Patrick Johnston, led a University team to China. They took part in a number of events, including launching a conference for early career researchers, organised by Queen's and the Beijing Institute of Technology and funded by the British Council Newton Fund.

Its theme was energy, something of particular interest to one member of the delegation – the Vice-Chancellor's envoy to the country, Professor David Rooney, of the School of Chemistry and Chemical Engineering.

David has had research links with China for more than 14 years. He is also Vice-Dean of the China Queen's College, established at the China Medical University in Shenyang.

Energy has been at the heart of his career – including collaborations with companies like Petronas in Malaysia, involvement in gas processing in Qatar and dealing with the problems of pollution in Saudi Arabia.

He says, 'The event in China considered the future of energy and sustainable transport, particularly in urban settings such as Beijing. How do you provide energy for a city of 20 million people? How do you minimise pollution resulting from generation of this energy?'

These are also the kind of questions he is asking through the Sustainable Energy Research Centre, a new Pioneer Research Programme (PRP) which he is leading at Queen's. How can technological advances be applied to support clean, affordable, dependable energy in the future?

The multidisciplinary centre will combine blue skies and applied approaches and it will build on existing strengths. David explains, 'Within the University there are a number of pockets of energy-related research. In Chemistry and Chemical Engineering, there are activities around biogas upgrading, battery electrolytes and improving energy efficiency in chemical processes. In Mechanical Engineering there is research into energy efficiency in transport and the integration of new types of technology to improve engine design.'

'In Electrical Engineering, we have research on smart grids. In the School of the Natural and

Built Environment there is research on tidal power and climate change. Then there are the psychological aspects – how do you get the public to engage in general with energy issues? The PRP will link these research strengths.'

The three main research themes focus on areas in which Queen's has a proven track record – renewable energy conversion and storage; transportation; and sustainable chemical manufacturing.

David says, 'For some time we have been involved with research in anaerobic digestion, the conversion of agricultural and food-type waste into biogas. This biogas can then be upgraded into biomethane for use as transport fuels. Further upgrading of the biomethane to heavier chemicals, using energy sources such as wind, provides renewable chemical feedstocks, reducing dependence on fossil fuels.'

'Energy presents a lot of opportunities for creative thinking, especially internationally. Sustainable energy is a global challenge. It's important to all our lives. There's a lot of room for academics to come up with bright ideas which can have real impact. We need technology which we can send to developing

countries, technology which meets their needs and ours, that is translatable.

'But once the technology is developed we have to work with people. Governments, NGOs, industry and the public are all involved in implementing new technologies. We have to have a holistic view of how our technology and our approach will impact on society.'

'The challenges are growing and we want our research to grow too. We want this Pioneer Research Programme to be a platform for research. We have a number of unique selling points within the University in a number of different areas. We want to make sure the PRP showcases and aligns them and allows them to progress well beyond the initial three-year period of the programme.'

'The event in Beijing not only highlighted the importance of energy but also the importance of our early career researchers in developing the innovative solutions needed to address this global challenge. We all have a part to play. It's vital for our future.'

TURNING WASTE INTO ENERGY TO FUEL THE FUTURE

Dr Xiaolei Zhang describes her journey to Queen's as 'not that straightforward.' It began in Beijing where she earned her Bachelors degree from the North China Electric Power University. But the next stop was Stockholm.

She says, 'A lot of Chinese students have dreams. They want to see abroad, to experience the world. I'm one of them.'

As a PhD student at KTH Royal Institute of Technology, she says that 'along with my move from Beijing to Stockholm, my research focus moved from fossil fuel-based power generation to sustainable energy because I knew that was the future trend.'

After being awarded her PhD in 2013, she moved again, this time to Canada, working for 18 months as a postdoctoral fellow at the University of Alberta. Next stop – Belfast and Queen's where in 2015 she became a lecturer in the area of clean energy in the School of Mechanical and Aerospace Engineering.

'My work focuses specifically on biomass and bioenergy. It's an important part of sustainable energy. I'm using thermochemical conversion technologies, with advanced skills either theoretically based or experimentally based. The goal is to convert agriculture or forest waste or waste from our daily lives into valuable products, such as gases, liquids, solid renewable fuels or chemicals.'

Through this activity she is making a major contribution to the work of the Sustainable Energy Research Centre, a new Pioneer Research Programme at Queen's. She is also making connections with industry in Northern Ireland and the Republic.

One company with which she has been involved is Premier Green Energy, a conversion company based in Tipperary. They are working on a technology called pyrolysis – decomposition brought about by high temperatures.

There is also a collaboration with Fleming Metal Recycling, a company in Newry. 'During their recycling process a lot of waste heat is generated. There are also waste tyres which they have to pay to get rid of so we're trying to

develop an integrated system to utilise them and produce valuable liquid fuel.'

She is using process modelling techniques in the work with the Newry company. She frequently uses other modelling skills in her research, including mechanism investigation based on quantum mechanics.

'Quantum mechanics modelling skills are used very widely in materials science and in the medical field but not in the field of sustainable energy. One benefit is that you can solve problems that can't be solved by experimental or conventional modelling techniques.'

In the Pioneer Research Programme there are 36 academics from different schools. Xiaolei says, 'The academics from Chemistry and Chemical Engineering, for example, are more interested in the chemistry side while those from Physics are more focused on computational calculations. My colleague Dr Beatrice Smyth and I are working on bioenergy conversion and from our School we also have academics working on internal combustion engines. We're all working on sustainable energy but from different angles.

'This is an important project from every possible aspect – social, economic, environmental. It affects every part of our daily lives.'

Her research knowledge is also helping to make an impact back home in China. With Dr Smyth and Dr Aoife Foley, she worked on designing the sessions at a workshop in 2016, organised by Queen's and the Beijing Institute of Technology, looking at the future of energy and sustainable transport in an urban setting. The project was led by Professor David Rooney, who directs the Sustainable Energy Research Centre.

She says, 'This is a great starter point for future collaboration. Pollution is a very severe problem in Beijing. We're trying to bring academics from the UK. They have the knowledge and the technical skills and in China there are talented students and academics, as well as high quality experimental resources.'

'It's about a combination of strengths coming together to do something really innovative – and that's what will also make our Pioneer Research Programme a success.'

“ The goal is to convert agriculture or forest waste or waste from our daily lives into valuable products, such as gases, liquids, solid renewable fuels or chemicals. ”



Dr Xiaolei Zhang
Sustainable Energy Research Centre, and
School of Mechanical and Aerospace Engineering

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