



Firefighters on the frontline

Professor Jonathan Crego talks to Dr Sabrina Cohen-Hatton about her pioneering work in the fire service



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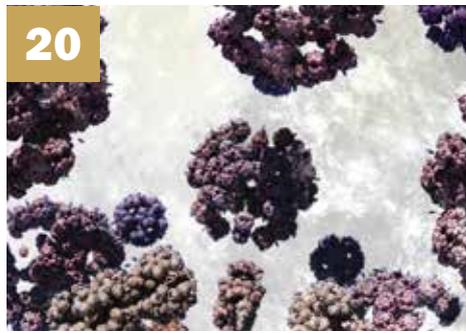


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Welcome to Challenge Cardiff

Over the summer I attended the Cardiff University Innovation Awards, where I presented Dr Sabrina Cohen-Hatton and Professor Rob Honey with the People's Choice award.

In their ground-breaking project Dr Cohen-Hatton and Professor Honey used helmet-mounted video cameras to show how commanders in the fire service handled emergencies, which led to the implementation of a new decision control process.

This work has gone on to change policy and practice not only in the fire service but across all emergency services in the UK. It is an excellent example of how research and innovation influence policy, which translates into improved practice on the frontline. In this issue Dr Sabrina Cohen-Hatton speaks to Professor Jonathan Crego of the Hydra Foundation about her inspirational research.

There has been a 10% increase in cancer cases in Wales over the last ten years. As part of our role as the leading cancer research centre in Wales, we are developing the Cardiff University Integrated Cancer Research Programme. This aims to bring together our cancer research community aided by strong involvement from patient and public representatives. The programme could provide major, widespread benefits for patients in Wales and beyond. Leading on this is Professor John Chester, who combines his research with clinical practice. For this issue he speaks to patient and public representative Jim Fitzgibbon from the Wales Cancer Research Centre about his work.

Managing water is a worldwide challenge. Our Water Research Institute, headed by Dr Isabelle Durance, brings together academics from across the University. You can read how their interdisciplinary research is finding solutions to one of the world's most pressing problems.

In our What Made Me Curious feature, Professor Kim Graham talks to Heather Stevens CBE about her career in cognitive neuroscience, how her research into memory and cognitive decline in ageing is improving our understanding of the causes of dementia, as well as her experiences as a woman in science.

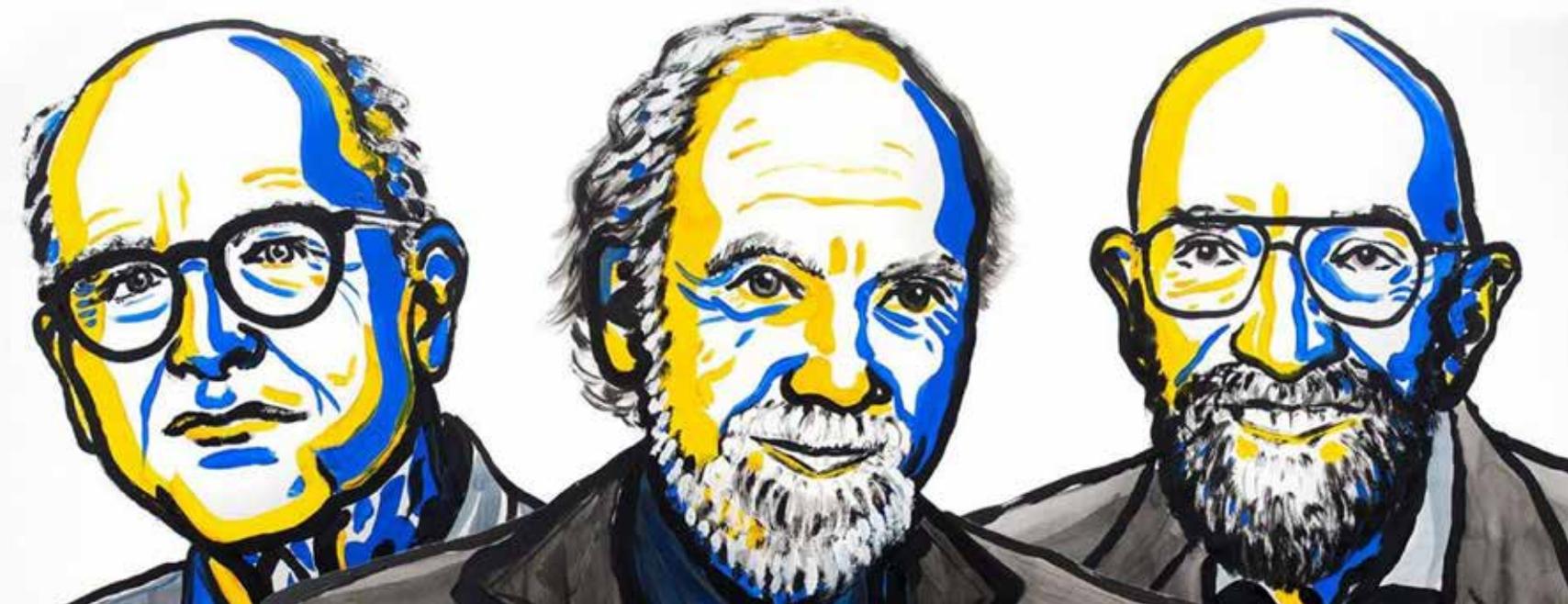
To find out more about the work featured in this issue, please go to our website www.cardiff.ac.uk. Please contact challengecardiff@cardiff.ac.uk if you would like to challenge our academics on an issue that matters to you.

PROFESSOR COLIN RIORDAN
VICE-CHANCELLOR



The Royal Swedish Academy of Sciences has decided to award the

2017 NOBEL PRIZE IN PHYSICS



LIGO scientists celebrate Nobel Prize

Cardiff University's Gravitational Physics Group is celebrating the awarding of this year's Nobel Prize in Physics to Rainer Weiss, Barry C. Barish and Kip S. Thorne.

The Nobel Prize in Physics 2017 was divided, one half awarded to Rainer Weiss, the other half jointly to Barry C. Barish and Kip S. Thorne "for decisive contributions to the LIGO detector and the observation of gravitational waves".

Gravitational waves are tiny ripples in space-time that are emitted as a result of violent cosmic events, such as exploding stars and merging black holes. These waves were first predicted by Albert Einstein in 1916 as a consequence of his general theory of relativity, and were first detected by the LIGO (Laser Interferometer Gravitational-Wave Observatory) team 100 years after Einstein made his predictions.

A network of three highly sensitive detectors in Louisiana, Washington (as part of LIGO) and Pisa (as part of Virgo) have detected four gravitational wave signals between them to date, and continue to scan the sky for the elusive signals.

For the past decade, the Gravitational Physics Group at Cardiff University, which is a key part of the LIGO team, has laid the foundations for how we go about detecting gravitational waves and has developed novel algorithms and software that have now become standard search tools for detecting the elusive signals.

The Group also includes world-leading experts in the collision of black holes, who have produced large-scale computer simulations to imitate these violent cosmic events and predict how gravitational waves are emitted as a consequence. These calculations were instrumental in decoding all four of the observed gravitational-wave signals to date and to measure the properties of the black holes that were detected.

Professor Mark Hannam, from the School of Physics and Astronomy, said: "LIGO has already given us a string of discoveries – the first direct detection of gravitational waves, the

first observation of a binary black hole system, the first observation of black holes several tens of times more massive than the sun, and arguably the first direct observation of a black hole. But the truly incredible achievement was to make the LIGO detectors. We already knew gravitational waves existed. We already knew black holes existed. What Weiss, Barish and Thorne did was to build the first machine sensitive enough to be able to directly measure gravitational waves.

"It took them over 40 years, and the result was the most sensitive measuring device ever made. It is an incredible new tool that has only begun to transform our understanding of the universe."

Illustration: Niklas Elmehed.
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Two new genes linked to Alzheimer's risk

A team of researchers led by Cardiff University has identified two genes that influence a person's risk of developing Alzheimer's disease.

The new finding builds on the team's previous work of identifying 24 susceptibility genes. It enables a better understanding of the mechanisms underlying the disease and offers further hope in developing new treatments.

Dr Rebecca Sims from Cardiff University's School of Medicine said: "In addition to identifying two genes that affect the risk of developing Alzheimer's disease, our new research reveals a number of other genes and proteins that form a network likely to be important in its development."

"These particular genes, which suggest that immune cells in the brain play a causal role in the disease, are also very good targets for potential drug treatment."

The two novel genes, which were not previously considered candidates for Alzheimer's risk, were identified during a study which compared the DNA of tens of thousands of individuals with Alzheimer's with age-matched people who are free from the disease.

There are currently around 850,000 people in the UK with Alzheimer's. During the course of the disease, proteins build up in the brain to form structures called plaques and tangles. The connections between nerve cells are lost, and eventually the nerve cells die and brain tissue volume is reduced. People with Alzheimer's also have a shortage of some important chemicals in their brain. These chemical messengers help to transmit signals around the brain. When there is a shortage of them, the signals are not transmitted as effectively.

Dr Doug Brown, Director of Research and Development at Alzheimer's Society said: "The discovery of two new risk genes for Alzheimer's is an exciting advance that could help to deepen our understanding of what happens in the brains of people with the disease. These genes reinforce a critical role for special cells in the brain – called microglia – that are responsible for clearing up debris including damaged cells and proteins. Insights like this

are vital to help unravel the complexities of Alzheimer's disease and show researchers where to focus their efforts in the search for new, effective treatments."

Cardiff University's involvement in the research was funded by Alzheimer's Society, the Medical Research Council (MRC), Welsh Government and Alzheimer's Research UK.





Major funding for materials analysis centre

A partnership led by academics at Cardiff University and University College London (UCL) has been awarded over £3m to host a state-of-the-art analysis centre providing unprecedented insights into the surface properties of materials.

The funding for this national facility has been awarded by the Engineering and Physical Sciences Research Council (EPSRC) and will allow UK academics and industry to access the latest x-ray photoelectron spectroscopy (XPS) facilities.

XPS is one of the standard tools for characterising the surface properties of any given material, and can play a crucial role in the development of new high-performance materials by helping to understand how they react with their environment.

The new facility, which will be co-led by Professor Philip Davies from the School of Chemistry, will provide a central analysis centre at the Research Complex at Harwell, just outside of Oxford, as well as offering specialist analysis at Cardiff University, UCL and The University of Manchester.

The aim of the EPSRC's national facilities is to provide resources that are of otherwise limited availability to UK researchers, be it a cost issue or a lack of access to the relevant expertise.

Helping dementia carers make sense of their experiences

A powerful animation produced by Cardiff University and narrated by Sir Tony Robinson lays bare the communication difficulties facing people with dementia, in a bid to help carers better understand and support people with the condition.

Based on a decade of research by Professor Alison Wray of the School of English, Communication and Philosophy, the animation will help families and professional carers understand why communicating with a person with dementia can be so challenging.

One of the University's Honorary Fellows, Sir Tony Robinson – who is also an ambassador for Alzheimer's Society and has experience of family dementia – narrates the animation, telling the story of the disorientation and confusion associated with memory loss.

The animation not only shows how people with dementia have difficulty finding words and struggle to make sense of the world, but also how they develop coping mechanisms, and the onward impact these can have on the messages they express.

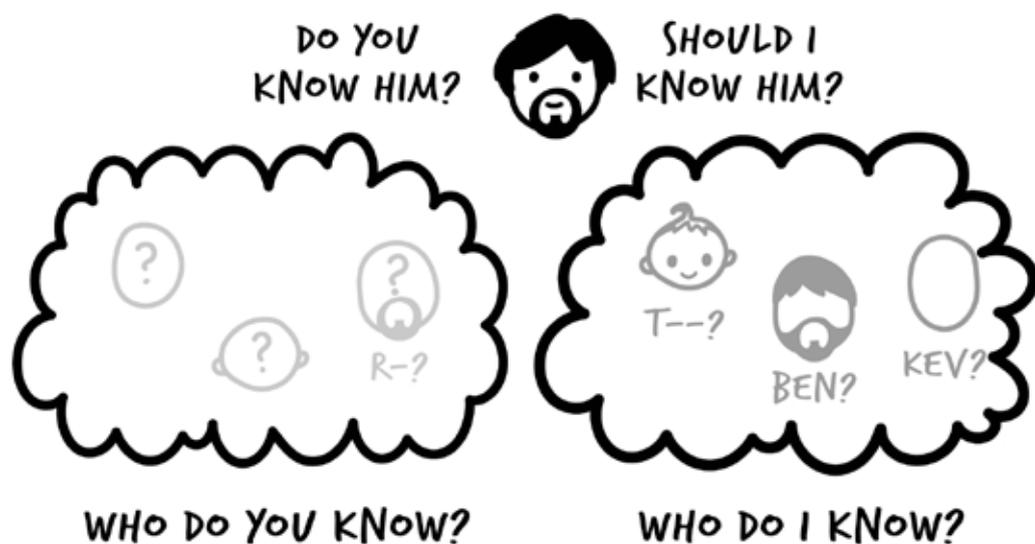
It also looks at how their messages are likely to be received and responded to by others, helping carers realise that neither they, nor

the person with dementia, are to blame for the many misunderstandings and frustrations that can arise.

The tips for carers featured in the animation include being patient, changing their tone of voice and looking for the reasons behind the words or behaviours of a person with dementia. The animation also shows how carers can empathise with reactions, and help people with dementia find the missing information.

The animation is available online and is free. It has also been distributed to collaborating care and care-training providers including Wesley Mission Queensland, Six Degrees Salford and Sunrise Senior Living.

The animation, based on Professor Wray's research project – The Dynamics of Dementia Communication – was drawn by David Hallangen, and funded by an impact grant from the Economic and Social Research Council.



Digital intelligence in the police service

Innovative study in collaboration with the police reveals fragmented approach to social media and big data.



The Open Source Communications Analytics Research Centre (OSCAR) led by Cardiff University was funded via the Police Knowledge Fund by the College of Policing and the Higher Education Funding Council for England, to look at how the police service is using social media and 'big data technologies'.

The work examined how social media and other forms of publicly available 'big data' are changing: how police investigate crimes and respond to critical incidents; the ways they develop intelligence; and methods for engaging with communities. Importantly, and unlike previous research in this area, it adopted a holistic and comprehensive approach, investigating these impacts across the full range of policing disciplines including: counter-terrorism; serious organised crime; public order; and neighbourhood policing. It was jointly conducted by academic researchers in direct collaboration with police officers, to develop unique insights into this aspect of policing.

Key findings

Too much attention nationally has focused upon purchasing increasingly sophisticated 'big data' technologies and not enough on developing the skills of analysts and users within police organisations. Nationally, the approach is fragmented with different

agencies and police forces adopting very different approaches. There does not seem to be a consensus about how much of this work is 'generalist' and how much should be 'specialist'. Communications policing is the new community policing, and should be treated as such, to reflect how more and more of social life has a digital component.

Only a relatively small proportion of police officers and staff have the digital skills and tools needed to exploit the opportunities for digital intelligence and evidence to inform their investigations and enquiries.

Police organisations should seek to recruit data scientists within their workforce, to enable new ways of working for the information age.

Nationally, there is an 'R&D gap' in terms of police developing the tools and techniques needed to keep up with the rapid advances in social media technologies.

An important element of the OSCAR approach was that the academic research was conducted on live policing operations, in the process triggering a new counter-terrorism investigation.

Work from the programme has been influential internationally, with presentations on its work provided to the US Department of Homeland Security, NATO and Europol.

Signing seals world's first compound semiconductor cluster

The Cardiff Capital Region City Deal, Welsh and UK Governments have ratified the development of a compound semiconductor (CSC) cluster in South East Wales.

The ceremony at the Cardiff headquarters of IQE plc paves the way for the Newport foundry development, backed by Cardiff University.

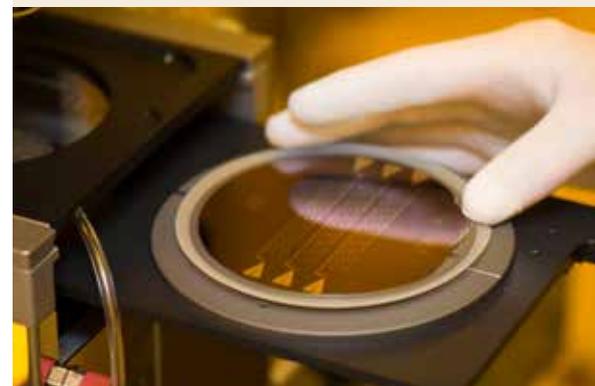
Secretary of State for Wales, The Right Hon. Alun Cairns MP, Welsh Economy and Infrastructure Secretary Ken Skates AM, CSC Foundry Directors Councillors Bob Greenland (Monmouthshire) and Andrew Barry (Merthyr), and IQE Chief Executive Dr Drew Nelson formally signed the Foundry deal.

The ceremony followed an agreement in May by the Cardiff Capital Region (CCR) Regional Cabinet to contribute £37.9m from the CCR City Deal's Wider Investment Fund to establish a CSC Foundry, with the potential to lever £375m of private sector investment and create up to 2,000 high-skilled jobs.

CSC Foundry is the first major investment since the £1.2bn CCR City Deal programme was signed by the 10 local authority leaders in March.

The facility at Newport will be owned by all 10 councils in the Regional Cabinet under the special purpose vehicle 'CSC Foundry Limited' / 'LDC Ffowndri' and the space will be leased to IQE plc for CS manufacturing and applications development.

In 2016, Innovate UK – the UK Government's innovation agency – announced a £50m investment to establish a new Compound Semiconductor Applications Catapult in South East Wales. This new catapult will build on existing investment by Cardiff University, IQE, and Welsh Government.





Uniting the fight against cancer

With around 19,000 new cases of cancer registered in 2015, Wales has seen a 10% increase in just ten years. By 2020 there will be around 150,000 people in Wales who are living with a diagnosis of cancer; an enormous health challenge for our nation. While an increasing number of successful treatments and declining cancer mortality rates represent good news, increased cancer incidence, and an increased awareness of the numerous sub-types of tumours, means there is still much to be done.

Jim Fitzgibbon from the Wales Cancer Research Centre talked to Cardiff University's Cancer Research Theme Lead, Professor John Chester, about the importance of collaboration in the fight against cancer.

JF: Can you tell me how you got to where you are today?

JC: I started my career as a biochemist but halfway through my PhD at the Beatson Institute for Cancer Research, in Glasgow, I became interested in practising medicine. After undertaking some voluntary work to discover if medicine was the right path for me, I applied for medical school and trained at St Mary's Hospital, in London.

Whilst working as a junior doctor and still undertaking research, I became interested in oncology which led to six years oncology training in Leeds where I became an academic clinician, both in the laboratory and then increasingly in clinical trials. The opportunity to spend more time in research drew me to my current professorial role in Cardiff University.

JF: Not all clinicians are researchers and not all researchers are clinicians. Why struggle to combine the both?

JC: The fantastic privilege of being an academic clinician is that you have two sets of patients: you have the short-term patients whom you see in the clinic and you have the long-term patients who will benefit from research that hasn't yet borne fruit. All of my research is clinically orientated and I hope is research which benefits patients in the long term.

JF: A lot of your work seems to be about bringing people together in the Wales Cancer Research Centre and the Experimental Cancer Medicine Centre. And then there's the proposed Cardiff University Integrated Cancer Research Strategy. What are the key things that you have to do to create a successful partnership here in Wales?

JC: That's the hardest question I've been asked in a long time. The most difficult thing is persuading people of the benefits of working together. Most people, including researchers, are naturally interested in their own things. We

have to get beyond people's self-interest and get them to believe that the whole is greater than the sum of its parts – which I'm a massive believer in. I genuinely and fundamentally believe that we achieve more together than we do separately.

JF: As an outside observer, I perceive there are some cancers that get all the attention and all the money. An example would be leukaemia. Is there something in what I'm saying and if so how do we do something about that?

JC: I think we definitely need to improve and continue with public education. We've already come a long way in the last 100 years – we've gone from cancer being stigmatised in large parts of society to most people now understanding it and talking about it. But I've just done what everybody does: talked about cancer in the singular when cancer is actually a massive variety of diseases. As well as multiple hundreds of acknowledged cancer types, we are now sub-dividing cancer into extra cancer sub-types, almost literally each day. My personal view, and it's a patient-orientated one, is that everyone's cancer is different. There are as many cancers as cancer sufferers. Therefore we need to adopt what's often referred to as personalised or precision medicine.

JF: What do we mean by personalised medicine and is it something that's actually going to happen?

JC: Personalised medicine is often described as 'the right treatment, for the right patient at the right time' and it's already here. For example, there is a subset of lung cancers which have a genetic test at diagnosis that can help the patient decide, with their clinician, what the right treatment is. The test can help them decide whether to take a tablet on a daily basis rather than traditional chemotherapy into the veins, on a once-every-few-weeks basis.

So that can make a big difference to the patient in how they are treated, and a big difference in the chances of success because if you make the right treatment choices, the patient's chances of benefiting from it, and avoiding unnecessary side effects, are greater.

We have to get beyond people's self-interest and get them to believe that the whole is greater than the sum of its parts – which I'm a massive believer in. I genuinely and fundamentally believe that we achieve more together than we do separately.



JF: One of the things that people said to me when I got involved in the governance of cancer research is that you need to look at who is funding the research. If it's a charity it's probably okay, but if it's a pharmaceutical company be suspicious of their motives. How suspicious do we, as members of the public, need to be?

JC: My views have changed a lot over time. Having come from a vaguely socialist upbringing, I used to be very suspicious of the profit motive of the pharmaceutical industry. However, it's back to that partnership thing. I do think the pharmaceutical industry shares the goal of improving patient outcomes, but with a profit motive added on. Also, there's an increasing acceptance that it's not just necessarily the health of a community that is important but the greater wealth of the community as well. If you can make the economics of it work appropriately, a successful drugs business can feed back into successful public health services. So, without getting too far into that semi-political domain, I do think the pharmaceutical companies share quite a lot of the goals of clinicians – and that's handy because the kind of research we do in laboratories in Cardiff University will get a certain distance towards patient benefit, but can only go so far. To actually get new drugs marketed often requires the massive finances of the pharmaceutical industry.

JF: You are a great champion of public involvement and I have appreciated your support over the last four years. Why do you champion this cause?

JC: Part of it is that understanding thing. There has been stigma about cancer as a disease and fear of cancer treatments. Even today, where treatments are much less toxic and much more effective than they used to be, the diagnosis of cancer still holds fear. So we need to increase the public understanding of cancer, its causes and the research we are doing to address those. This requires a working partnership with people who can communicate with the public on their own level. And there's the fact that the public, patients and people who support cancer research should be guiding what we do and helping us decide what the priorities are.

JF: Some of the most inspiring people that I've met are clinicians who have also been researchers, because they have that contact with reality. But clinician researchers are still in the minority, aren't they?

JC: Yes and no. People like me who have that duality and are employed by universities are



in the minority, but there are a lot of research-interested clinicians within the NHS. Velindre Cancer Centre, for example, has some fantastic researchers who wouldn't necessarily call themselves researchers because they are delivering clinical trials research to patients but doing it in a different context. They are doing it as part of their working life and mixing in the research with everyday clinical practice.

JF: What are you working on at the moment?

JC: There are two major things occupying me at the moment, from the research point of view. One is the Wales Cancer Research Centre which very deliberately brings together a very broad collection of researchers, not just within the University and the NHS in Cardiff, but across Wales. We are developing something called the Wales Cancer Partnership which will also draw in the pharmaceutical industry and charities, and I hope primary care, too, because there's a lot of important prevention and earlier diagnosis work to be done in hospitals, GP surgeries and community clinics.

The other thing that takes up a lot of my time is the Cardiff University Integrated Cancer Research Programme which is about identifying the strengths that we have in Cardiff University, bringing them even closer together than we have before, and focusing on the things that will bring the maximum benefit for patients in Wales and beyond. We need to be very aware of our social responsibility as a prominent cancer research establishment in Wales, but we also need to think beyond and do research that is genuinely excellent, by international standards, and applicable to people beyond Wales.

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The age of the cyber attacks

The WannaCry cyber-attack that plunged the NHS into crisis in May 2017 was seen by some as a watershed moment, prompting a sea change in attitudes towards cyber-security. The attack itself, which affected an estimated 200,000 computers across 150 countries, had serious consequences in the UK – NHS England cancelled over 6,900 appointments, with computers, MRI scanners, blood-storage refrigerators and theatre equipment being hit.

The WannaCry incident was an example of how susceptible our everyday items are to being hacked, and was just one of a growing number of high-profile cyber-attacks to hit big businesses and government. In 2015, UK telecommunications company TalkTalk admitted that nearly 157,000 of its customers' personal details were accessed in a cyber-attack, a situation in which technology giant Uber found itself this year when hackers stole its customers' personal data, including names, email addresses and phone numbers.

According to the latest statistics, nearly half of all UK businesses have identified at least one cyber-security breach in the last 12 months.

For these businesses, cyber-attacks can have serious financial consequences; however, the risks posed to critical national infrastructure could be potentially life-threatening, as demonstrated by the WannaCry attack. In June last year, a series of powerful cyber-attacks swamped websites of Ukrainian organisations, including hospitals, banks, ministries, newspapers and electricity firms. During the attack, the radiation monitoring system at Ukraine's Chernobyl Nuclear Power Plant went offline.

The emerging threats posed to civil society, business and government lie at the heart of Dr Pete Burnap's research. Based in the School of Computer Science and Informatics, Dr Burnap

is an expert in the field of cyber-security and recently became Director of the new Airbus Centre of Excellence in Cyber Security Analytics at the University.

Dr Burnap (PB) spoke to Phill Everson (PE), who leads the Cyber Risk Services practice for Deloitte in the UK, about the current cyber-security landscape, the scientific research that is helping to shape our defence against cyber-attacks, as well as the skills gap that currently exists in the field.

PE: For a lot of the general public, terms such as cyber-security can seem very vague and quite cryptic. How would you go about defining this area?

PB: Cyber-security is really about awareness. Are you aware of the choices you make when configuring your technical equipment such as laptops, smart phones and wireless devices? Do you know how data are collected through these and how they can be manipulated to extract information or be used to launch attacks? A key issue here is that while access to this equipment is now easy and you can connect them to the Internet in a few simple steps, the security settings of the devices are rarely well configured.

I would define good cyber-awareness as crucial for cyber-security. We all know we need to lock our front door at night – and it's easy to do so. Security on technical equipment should be as intuitive as that.

PE: At Deloitte we frame it in terms of being secure, vigilant and resilient. An organisation can never be completely secure, but it's essential to try, for example, through the application of controls to an organisation's most critical assets. Vigilance is needed to monitor constantly emerging and evolving threats, and resilience is essential to bounce back after a data breach or crisis situation. A cyber-strategy sits above all of this, ensuring that an organisation's cyber-risk programme is in line with their business objectives and risk appetite. In your opinion, how big an issue is cyber-security in our society today?

PB: It's probably one of the biggest and most underestimated issues. As with all things catastrophic, they never seem real until you are facing them. Our entire social and economic being is now based around technology and it is becoming more pervasive every day. We are very quickly moving towards a world where cars will be driven by machines, for example. I am sure there is a lot of work going on to secure the communications to and from these vehicles, but I would put money on the fact that the vehicles will also connect to your mobile phone to play music. What happens if your mobile phone has malware on it that spreads to the decision-making module in the vehicle? The onus will be on the vehicle manufacturers to test this but, as per my previous point, technologies change so quickly.

What is secure today may not be tomorrow, so people need to be aware of how to secure their own devices and equipment so that when it interacts with other systems it doesn't lead to increased cyber-risks.



Phill Everson, Cyber Risk Services, Deloitte in the UK

According to the latest statistics, nearly half of all UK businesses have identified at least one cyber-security breach in the last 12 months.

PE: The development of vehicles – of growing levels of autonomy – is hugely interesting and presents all kinds of economic and social implications. At Deloitte we're conducting research on these implications along with the related cyber-security challenges. This reflects a broader issue of securing cyber-physical systems, such as connected systems that can cause physical damage. As these systems proliferate, cyber-security will take on a whole new level of societal importance. It will be essential to incentivise security by design and to harmonise safety and security standards. Do you think we are becoming more susceptible to cyber-attacks? And why do you think these attacks are becoming more frequent?

PB: Susceptibility is increased by exposure. We are all becoming more exposed to devices, such as phones, watches and personal assistants. The frequency of attack is likely to be increased in line with exposure.

PE: Cyber-attacks are certainly getting more public attention, though it's not clear if attacks are becoming more frequent or just

more transparently criminal. The barriers to entry are certainly lower. Even petty criminals are increasingly cunning. The sharing of tradecraft and 'off the shelf' hacking products within the dark-web means a low-level hacker can deploy tools and tactics that challenge the capabilities of major security firms. What role do scientists like yourself play in tackling cyber-crime?

PB: Our main objective at Cardiff University is to use data and artificial intelligence methods to better provide insights into threats to cyber-security and increase awareness of risks. Emerging technologies are a big theme, as is protecting the nation's commercial IT infrastructure and our industrial manufacturing plants. We are constantly trying to detect and predict cyber-attacks so that we can better defend and block attacks that would disrupt the normal running of society and the economy.

PE: What kind of projects are you engaged with?

PB: Most of our projects are based on better detecting the indicators of a compromise at varying levels, from the Internet of Things, online social networks, organisational IT networks and individual devices. We look at these in a wide variety of contexts from personal use through to the massive industrial manufacturing systems and critical national infrastructure.

PE: On our side, we've focussed recently on helping financial services to navigate regulation such as the EU General Data Protection Regulation, developing security operation centres for critical infrastructure, and orchestrating large-scale crisis response to wiper malware. Demand is also growing for supporting corporate boards with understanding and developing cyber-risk strategies for complex multi-national operating environments. How do you ensure that your academic work aligns to current and future business, government and third-sector problems that need to be solved?

PB: We work very closely with these sectors to ensure alignment. For instance, we host the Airbus Centre of Excellence in Cyber Security Analytics, where we work very closely on site with Airbus to take on board their requirements and translate our research expertise into commercial-ready solutions. We also have a close relationship with the National Cyber Security Centre, who are the national lead for cyber-security awareness raising. We participate in events and feed our research into them via public talks and workshops.

PE: A tangential problem we face as a society is that we're not getting enough young people into the field of computer science – a recent report showed that more than half of England's secondary schools did not offer GCSE computer science – so the prospect of tackling cyber-crime in the future looks pretty uncertain. What more should we be doing to plug this skills gap, and what is Cardiff University doing to encourage more people to study this area?

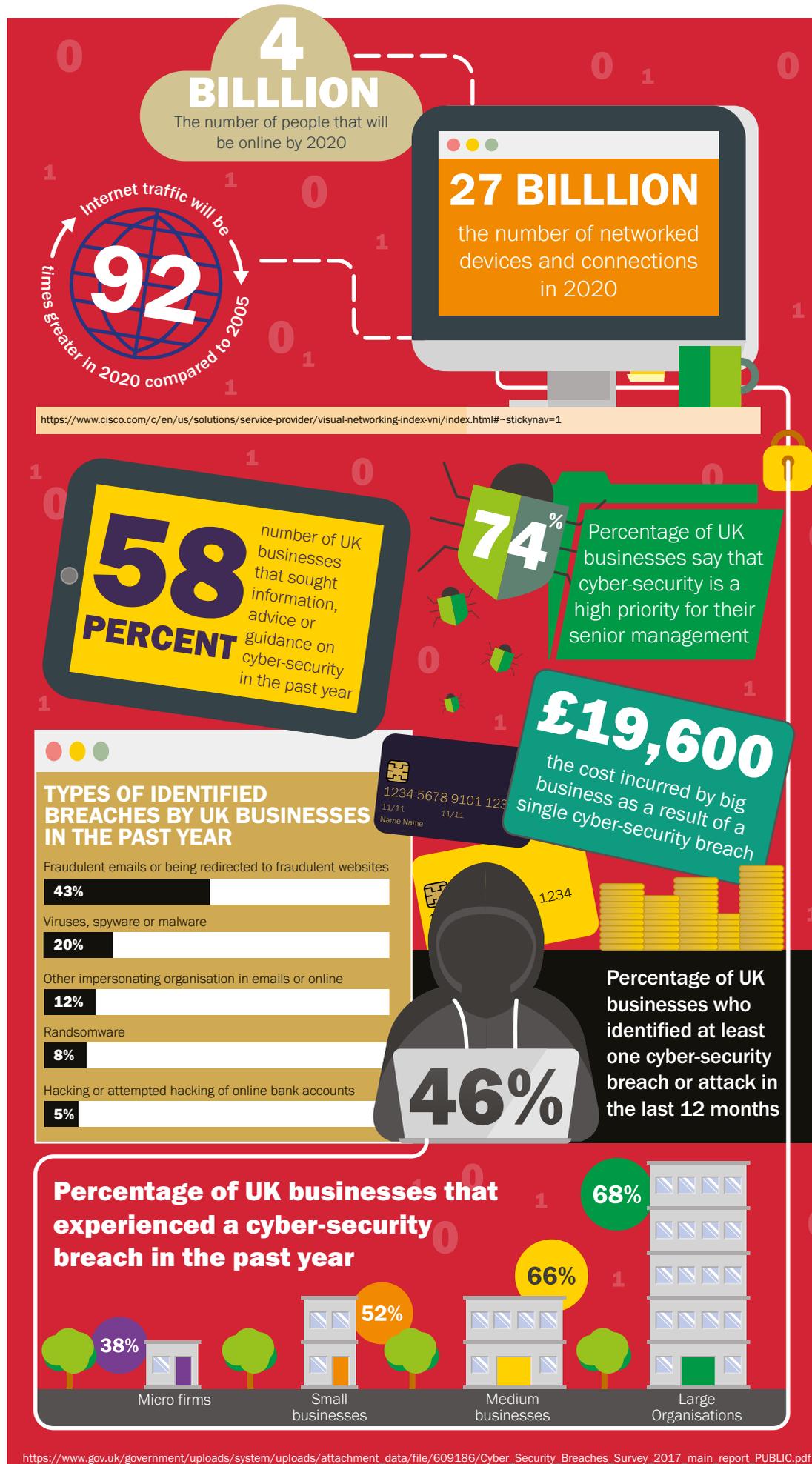
PB: We need to better define the roles available to cyber-security graduates. The current image most people think of is a hacker in their bedroom, and ending up in prison. We need to change this, as why would anyone want to follow that path? Cyber-security has a wide range of roles, some of which are not even technical, so we need to reach into other disciplines such as psychology, sociology, criminology and politics. Cyber-security is a socio-technical problem – people are often the target of cyber-attacks so we need people who can raise awareness and explain behaviours just as much as we need people who can develop security software, hardware and visualisations.

At Cardiff University we are developing a broad range of support, outreach events, and taught programmes to encourage more people to study in this area. For example we host an annual event where we invite around 60 girls from across Wales into the University to tackle a range of coding problems and to meet women in IT positions in government and business, who talk to the girls about the wide range of career opportunities.

PE: I agree that cyber-security is a socio-technical challenge. Yes, we need data scientists and mathematicians, but we also need lawyers, social scientists, economists, and intelligence analysts to address the many facets of cyber-security. In some cases the skilled people are available, but companies are looking for people that 'look like them', and missing the opportunity to find scarce talent by diversifying their workforce.

Similarly, Deloitte runs a Women in Cyber initiative to encourage more women to join and stay in the industry. We also cover tuition fees for a few hundred students including independent learners, helping them to gain an apprenticeship or prepare for a degree in a related subject.

These are early but necessary steps to address the skills gap and make cyber-security an industry that welcomes men and women from a broad range of backgrounds and specialisations.





In-work poverty – a growing problem

A record 60% of people living in poverty in the UK live in a household where someone is in work, according to a Cardiff project funded by the Nuffield Foundation.

Margaret Greenwood (MG), Shadow Minister (Work and Pensions) and MP for Wirral West, talks to lead researcher on the project, Dr Rod Hick, School of Social Sciences, about the project findings and the contribution which policy can make to alleviating poverty among working households.



MG: How are you defining in-work poverty? What are the criteria for inclusion in this category?

RH: A household is defined as being in in-work poverty when at least one adult is in paid employment, but they remain in poverty. There are thus two parts to the definition – being in a working household, on the one hand, and being in poverty, on the other. Most analyses in the UK define a household as being a working household when one of the members works at least one hour a week, though more demanding criteria can also be used. The primary measure of poverty we analysed is the relative income poverty measure, which captures where a household's income falls below 60% of the national median income. This is intended to reflect a circumstance where a family's income falls significantly short of widespread or typical incomes in society.

MG: Your research found a rise in in-work poverty among households in the private rented sector and among social housing tenants. How important are housing costs as a factor determining in-work poverty?

RH: They are an increasingly important factor in explaining in-work poverty trends. Having observed that in-work poverty had risen by a quarter between 2004/5 and 2014/15, we wanted to see who had borne the brunt of this increase. We looked at quite a few characteristics, and, initially, we found that the rise in in-work poverty was observed for all groups. It was only when we looked at the trend over time by those in different housing tenures that we noticed a major difference: all of the increase was experienced by families living in the private rented sector and in social housing, without any increase occurring for owner-occupiers.

So, housing tenure and housing costs are becoming much more important in determining poverty rates. I expect this to continue in the coming years, and I think we're going to hear

much more about the link between housing costs and poverty going forward.

MG: How effective have tax credits been in reducing in-work poverty? What effect are we likely to see from subsuming tax credits into Universal Credit?

RH: Our analysis demonstrates that tax credits were highly effective at reducing poverty – for families who received them. But, through a combination of design and take-up, receipt by families without children who experience in-work poverty was very low, despite such families making up almost one-half of those in in-work poverty.

While Universal Credit is often labelled a 'simplification', it not only amalgamates six social security benefits into one, but also introduces significant changes, too – for example, there's been a lot of discussion recently about how claimants will have to wait up to six weeks for an initial payment, and it also introduces work-focused conditionality for people who are in employment, which didn't apply under the tax credit system. One big problem is that Universal Credit now has significant cuts built into it – including the fact that there will be no additional payments for third or subsequent children. These cuts are likely to drive up poverty, and especially child poverty, which is forecast to rise sharply in the coming years.

MG: People living in one-earner households face an increased risk of in-work poverty. What are the advantages and disadvantages of moving from thinking about individual workers to thinking about whole households when tackling in-work poverty?

RH: The advantage is perhaps that it brings us back to thinking about poverty, which is always considered on a household basis. It also makes explicit the fact that one can reduce poverty in working households through various mechanisms that seek to ensure

income adequacy for working households. These can include increasing the minimum wage, or promoting progression in the labour market, but they can also include increasing supports for children, such as Child Benefit, or tackling high housing costs, or even increasing payments for out-of-work family members. This is because in-work poverty is about the balance between total income and the needs of working families.

Perhaps the disadvantage is that in-work poverty raises a new challenge in terms of identifying those households who experience it. The 'whole household' nature of the problem means one can't simply assume that workers who are low paid experience in-work poverty – one needs to know something about their wider household circumstances, both in terms of other income sources, and the number of family members who are dependent on the family income. There is a possibility that the greater difficulty in identifying those in in-work poverty may frustrate attempts to tackle it.

MG: Public discussions often equate in-work poverty with low pay. Why is it then that the introduction of the National Living Wage has not led to a decrease in levels of in-work poverty in the UK?

RH: The National Living Wage, which is not, in fact, a living wage, but is a more generous minimum wage, is due to increase in generosity between this point and 2020. While there has been something of a sleight of hand in attempting to portray it as a living wage, it has to be recognised that it does represent a significant increase in the minimum wage – at least for people aged 25 and over. So, in that sense it's a welcome development. But analysis by the Resolution Foundation shows that the gains that will accrue from this increase in the minimum wage for those on low incomes will not offset the cuts imposed under Universal Credit and the ongoing freeze of most working-age payments. The latter is quite a substantial

cut, when we consider the cumulative impact of this freeze over a number of years.

MG: Your findings indicate that low pay and in-work poverty are not synonymous, and that there are a number of other factors that contribute to the rise in levels of working poverty. What are some of these factors and how can we tackle them?

RH: Well, one factor, which we've mentioned already, is changes in tenure patterns, and rising housing costs, and this is an area where I think there will be a lot of attention in the coming years. Another is the number of people working in households experiencing working poverty. Another would be the amount of work performed by members who do work – for example, whether they work part-time or full-time. And then, as we've discussed, there are non-labour market factors, such as the performance of the social security system.

MG: Without changes in social policy to counter these factors, is the risk of in-work poverty likely to continue rising?

RH: In my view the most pressing factor is trends in housing tenure and in housing costs. There has been a shift away from owner-occupation and a significant growth in the private rented sector in the last decade. It's not clear to me that this shift is going to abate any time soon. This is problematic from a poverty



perspective because the private rented sector is associated with high housing costs, and elevated poverty rates, and a continued shift towards the private rented sector is likely to generate upward pressures on poverty rates in the UK.

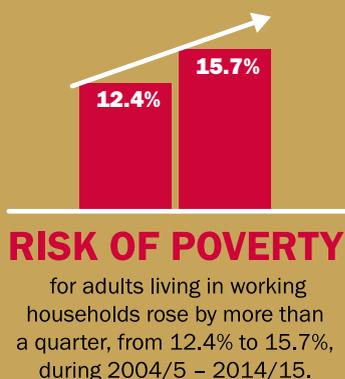
MG: One of your most troubling findings is that among people living in workless households who find work, 25% will only go so far as to enter working poverty. You found that lone parents and families with three or more children are over-represented in this group – what does this tell us about the nature of work and family life in relation to in-work poverty?

RH: Yes, these are the groups who can and do struggle to make the transition into work and, while at it, to exit poverty. It's interesting you've identified this as one of the most

troubling findings - my sense is also that many people find this transition hard to understand, perhaps even hard to accept. I think it points to the difficulty of reconciling work and family life for families with children, and the need for policy to be supportive of those making these transitions into the labour market wherever possible. One way one might do this is by providing more publicly-provided childcare, which might make it easier for parents to work additional hours where they wish to do this.

MG: What influence do you hope your work will have on social policy?

RH: In the first instance, my hope is that it raises awareness that in-work poverty is a growing problem. Previous studies have often focused on it in passing, or as part of a wider study, but given that as many as six in ten of all those who experience poverty in the UK live in families where someone is in work, I think there's a need to think about this problem in greater depth. More specifically, I hope they can contribute to understanding that the tax credit system, while expensive, did make a significant difference in terms of raising the incomes of low income working households, and that reforms to this system need to be made with great care – indeed, with greater care than is being taken at present.



TENANTS IN SOCIAL AND PRIVATE RENTED SECTOR



SIX IN TEN PEOPLE IN IN-WORK POVERTY

THREE IN TEN PEOPLE OF WORKING AGE

SUB-GROUPS WHO EXPERIENCE A VERY HIGH RISK OF IN-WORK POVERTY

(While also accounting for a large share of its composition):



People living in one-earner households have a significantly higher risk of in-work poverty, and account for almost six in ten people experiencing working poverty, more than double their population share.



**Critical decisions:
Firefighters on
the frontline**

Dr Sabrina Cohen-Hatton completed her PhD while working full time in the fire service. Her ground breaking research has gone on to influence national policy across all emergency services. She spoke to Professor Jonathan Crego of the Hydra Foundation, an expert in critical incident decision making, about her pioneering work.

JC: You're a very special person in the fire service. Your history is long, I think the readers need to understand where you come from. Tell me about your journey to date.

SCH: I joined the fire service when I was 18 as a firefighter. Most officers in the UK start the same way. We do our time riding out on the fire engines, putting out fires and performing the rescues that are so synonymous with the idea of what a firefighter is. I worked my way through every single rank and now I'm Deputy Assistant Commissioner of the London Fire Brigade. It's a job that I adore, a profession that I'm passionate about.

We are the ones that are trusted to help when people are potentially having the worst day of their lives. Our daily business represents really painful traumatic life-changing events for the people that trust us to help. That's a responsibility I take incredibly seriously.

Equally, as I've gone through the ranks and become a commander, I'm now asking firefighters to go into inherently dangerous situations. I'm asking them to trust me to know what to do to keep them safe in those situations, so that they can carry on keeping people safe.

JC: There's so much depth to what you've said. You got an interest in research, I want to unpick that very moment you recognised 'I want to research', to find out more about this.

SCH: I was called to respond to a fire where a firefighter had been incredibly badly burnt. My now husband (we were engaged at the time) was on that crew. There was a one-in-four chance it was him. It was the longest four minutes and 37 seconds of my life, it was agony driving to that fire not knowing if it was him. When we got there I was so fortunate that it wasn't my loved one who was injured, but it was a friend of ours, someone whom we both worked with. I felt an incredible sense of guilt for a long time, for feeling relief that it wasn't my loved one that was burnt.

JC: I am grateful for that honesty. There is a whole dimension of emotion in decision making and something that is often written out of procedures and policies. Was that your entry into psychology?

SCH: In a way, yes. It was at that very moment I wanted to research how people make risk-critical decisions in particular on the incident

ground, because we're the ones that are trusted to know what to do, right?

We need to know how people are thinking, how they respond and how they behave. Eighty per cent of industrial accidents are caused by human error, that's not a failure on a piece of equipment, of a policy or procedure, that's something to do with how someone's interpreted a situation or a cognitive bias they might have, a previous association or a previous conditioned response. That is the basis of how we make decisions and that's something you can't write down in a new policy or capture in a new piece of equipment. That's human nature.

So, the only way to reduce human error, make firefighters and the public safer, is to understand how people think and behave.

You can't, in my view, criticise the commander for making a decision in a certain way, when it reflects the way their brain is wired as a human being.

JC: You started your studying at the Open University while serving as a firefighter. What did you achieve and where did you go next?

SCH: I did my bachelor degree and master's degree while I was serving. I decided I wanted to know more and direct my own studies, for all my looking through the literature, there were no answers. I came to Cardiff and approached Professor Rob Honey about doing a PhD. He agreed to take me on and has been the most wonderful supervisor. He gave me seven years to complete my PhD, but I did it in just three years. I was absolutely smitten with the work and couldn't find enough hours in the day.

The day I was due to start my PhD, was the day my daughter was born. I took some time out on the advice of Professor Honey. I started doing my PhD while working full-time and with a new-born baby at home. I would go into the lab at 5am, run experiments, leave for work at 8.30am, get straight to work, come home, spend time with my daughter, go back into the lab for the nightshift to run the second set of

experiments and be there till 1 or 2am quite regularly. I would be fixing bits of equipment, as at that time of the night there were no engineers around to fix the bits you inevitably break. I'm not quite sure if I completed a PhD in engineering or psychology!

I'd go back home, have a couple of hours sleep and be back again in the morning. But when I was spending that time with my daughter, I was so focused on her that the sky could've fallen in and I wouldn't have noticed. I slept less and worked more. It was for a finite amount of time. I made it work and I finished in double time.

JC: You have an incredibly pragmatic view of psychology. Can you help me understand how you've applied some of that pragmatic research?

SCH: I'm acutely interested in the theoretical, but I owe it to my profession to do something practical with the research and to apply it.

We've been fitting helmet cameras to incident commanders as they go out, it was always with the intention of what we can learn, what's new and what can we do with it. It was about developing techniques we could put into policy.

JC: I'm delighted we're going to be working together to take that to its next level and using virtual reality and putting the firefighter into virtual scenarios. I'm also aware you've done phenomenal research triangulating a number of theories.

SCH: The first piece of work we did looked at tactical command styles. The most practical evolution was to then look at strategic decision-making. Those commanders making decisions that affect the city you're living in when that incident is happening. You may have heard the terms gold or strategic commander? They are the most senior officers coming together from different agencies, making decisions to set the strategic direction for the incident and how the city will recover.

We did some work looking at Hydra simulations. Hydra is a system where incident commanders can come together, experience a scenario, and make decisions on the situation that's in front of them and provide their rationale for it. It allows those decisions to be compared and discussed in a forum where commanders can go on and develop it.

We looked at the way in which decisions were made in Hydra scenarios and compared it to a more realistic strategic command scenario.

London Fire Brigade set up exercise Unified Response. We buried eight train carriages under tons of rubble in a disused power station. We replicated a collapse in Waterloo station, we had 2,000 live casualties and players as far up as Government that were involved. We activated the civil protection mechanism where we would bring in resources from other countries. It was a huge exercise run in real time over four days. We ran the strategic command as it would run in real life. What we were able to do then, by simulating the same methodology, was to collect data on the way commanders were making decisions, that we could sequence using Hydra. We were able to replicate that in a more realistic scenario and compare the two. We found that decision-making patterns were really similar, so it lends a lot of support to the way we're training strategic commanders.

JC: Were you able to extrapolate that to live incidents and how fire officers were behaving on the ground in real incidents?

SCH: That's something we've done previously using a similar method. Our first piece of research looked at how incident commanders make decisions. We had a very established national policy with a very established national decision model that we were using throughout the UK for our incident commanders.

What I was really interested in was: does this model reflect the way people are making decisions, or is it something that we put in policy, so fire and rescue services can say 'we have this, everyone should be following it'? It's also the same model we're using to scrutinise a decision after an incident, so if a decision you make has consequences that you have to defend and you can't demonstrate your process was in line with that model, where does that leave you as an individual commander, and where does that leave you as an organisation?

When we fitted helmet cameras to incident commanders as they were going out to live operational incidents, it was the first time it had been done anywhere in the world. We found the decision-making process was nothing like the decision-making guidance. The decision-making policy we were using nationally only represented 20% of their decisions. However, if you were using that model to scrutinise the decisions, you'd use it to look at 100% of the decisions. So, you can see where, as an individual commander, there's a bit of a dilemma.



We did some work developing a new technique called the decision control process that helped those commanders to link their decisions to the rationale. We recognised two pathways. The very analytical, standard pathway and policy which only applied to 20% of decisions and the intuitive pathway, those kind of split-second, gut-instinct decisions which represented the other 80%.

Psychology will tell you that those two different types of decisions take part in two different parts of the brain. That's something the policy doesn't take into account. You can't, in my view, criticise the commander for making a decision in a certain way, when it reflects the way their brain is wired as a human being. This new technique was aimed at supporting those commanders.

Not being one to shy away from a challenge, as much as we had the academic evidence, I wanted practical evidence that would support its application. I got another 84 incident

commanders and I tested them, half using the new model and half using the old model. The ones using the new decision control process, their situational awareness was much higher, up to five times more than the old decision model.

We also found there was more goal-directed decision-making. People were linking up their plans with decisions. This supports a concept we call operational discretion. This is where you recognise the incident you have doesn't have a standard policy as it's not a standard incident, we deal with the unexpected every day. It allows those commanders flexibility to identify what the right operational decision is even if there is not a policy that prescribes what that decision should be. We went on to change the national incident command policy and that is now embedded in the joint emergency services interoperability programme, which is a national doctrine we have for all emergency services as to how they deal with major and complex incidents.

JC: If I could summarise: you are an operational firefighter, a committed researcher trying to find out what's behind and what matters in decision-making to operational commanders in order to save lives. What next?

SCH: We are going to continue to build on the work we've done on strategic decision-making so we can help those commanders who are operating under intense pressure and have huge responsibilities, especially when there are lives at stake.

We're also interested in looking at virtual reality and how that can help decision makers. Joining up psychology, technology and its practical application is the next stage.



Putting Great West research on the map

The GW4 Alliance launches major new facility and holds high-profile networking event

Cutting-edge microscopy facility unveiled

The new GW4 Facility for High Resolution Cryo-Microscopy, based in the University of Bristol's Life Sciences Building, was unveiled at an opening ceremony on Friday 1 September 2017 in front of an audience of over 120 researchers. The cutting-edge facility was supported by awards from Wellcome and the Biotechnology and Biological Sciences Research Council (BBSRC) alongside co-investment from GW4 universities.

It will provide researchers across the region with a suite of state-of-the-art microscopy and analysis tools, enabling them to better understand the molecular processes responsible for cell function or malfunction. Professor Jim Smith, Director of Science at Wellcome, delivered a keynote speech at the opening ceremony, in which he described this kind of shared access to technology as the "future of scientific discovery".



Dr Sarah Perkins , GW4 Director and David Sweeney , Executive Chair Designate Research England

Great West research and innovation in the spotlight

GW4 held a successful networking event, the Great West Research and Innovation Day, on 1 November 2017 in Bath. The high-profile event brought together senior academics from across GW4 and featured keynote speeches from Dr Ruth McKernan OBE, Chief Executive, Innovate UK, and David Sweeney, Executive Chair Designate, Research England. Throughout the day, attendees also heard lightning talks from successful GW4 projects exemplifying research collaboration, doctoral training and industry-led innovation.

Following the event, it is hoped that new strategic research initiatives will be established to address industrial strategy and global challenges, in areas as diverse as microbiology, the creative industries, micro-electronics and water security.

Award nod for supercomputing collaboration

The GW4 Alliance was shortlisted in the Technological Innovation of the Year category at this year's Times Higher Education Awards for its world-first supercomputer, Isambard. The Times Higher Education Awards are often called the Oscars of the higher education sector and attract hundreds of entries from UK universities.

The Engineering and Physical Sciences Research Council (EPSRC) awarded the GW4 Alliance, together with Cray Inc. and the Met Office, £3m to deliver a new Tier 2 high performance computing (HPC) service to benefit scientists across the UK.

This collaboration has produced the world's first ARM-based production supercomputer, named 'Isambard' after the renowned Victorian engineer Isambard Kingdom Brunel.

The supercomputer is able to provide system comparison at high speed, as it includes over 10,000, high-performance 64-bit ARM cores, making it one of the largest machines of its kind in the world.

Opinion series shines spotlight on regional strengths

Leading experts across South West England and South East Wales have provided their perspectives on the strengths, challenges and aspirations of the region for GW4 Opinion. Contributors to the series so far include senior representatives from organisations including Oracle, Renewable UK Cymru, Arts Council England, Creative Cardiff and Life Sciences Hub Wales.

The series has provoked debate and interest from researchers, decision makers and businesses. Will Godfrey, Chief Executive of Newport City Council, said: "GW4 Opinion is an excellent contribution to the debate about how South West England and South East Wales can work together to exert more influence over both UK and Welsh Governments and in turn develop a more coherent approach to policy making and delivery."

Find out more and read the latest articles at gw4.ac.uk/opinion. If you are interested in writing for the series, please contact info@gw4.ac.uk.

New board member joins GW4 Alliance from Cardiff University

GW4 appointed a new Board Member, Professor Karen Holford, as she took up the role of Deputy Vice-Chancellor at Cardiff University. Professor Holford said: "I am delighted to join the GW4 Alliance at an exciting time in its development. I hope to build on the fantastic work of the Board, to contribute to the collaborative mission of GW4 and support ambitious research across our four universities."



"GW4 continues to go from strength to strength and it is encouraging to see flagship collaborative projects, such as Isambard, gaining national and international recognition. We celebrated our success and catalysed new strategic research initiatives at the Great West Research and Innovation Day."

Dr Sarah Perkins, GW4 Director

Port Talbot steels itself for globalization

The photo essay 'Welsh town Port Talbot steels itself for Globalization' by Aleydis Nissen, a PhD researcher and graduate tutor at Cardiff University, has been published in Yale Journal of International Affairs.

Her pictures document life in Welsh steel town Port Talbot post Brexit. She picks her favourite photographs for Challenge Cardiff.



“I prefer the last picture of the statue titled ‘the Mortal Coil’. This statue from sculptor Sebastien Boyesen depicts in an exquisite manner how the steel workers carry on despite the bustle and turmoil which is happening above their heads in Wales, the UK and the wider world.”



WHAT MADE ME CURIOUS

Professor Kim Graham is a leading cognitive neuroscientist and Dean of Research in the College of Biomedical and Life Sciences. Professor Heather Stevens CBE, founder of the Waterloo Foundation, took Kim on a trip down memory lane to find out what made her curious, her current work and her experience of being a woman in science.



HS: I know you've been working on memory for a long time, but what first got you interested in dementia?

During my undergraduate degree, we were taught about neuropsychology, which is the study of how cognition is altered in patients after brain damage. I thought this was fascinating, but wasn't quite sure how you became a research neuropsychologist in real life.

I then worked on a summer placement with Professor Ian Deary at The University of Edinburgh (a world-leader in cognitive epidemiology). I was responsible for running neuropsychological tasks in individuals with Type 1 diabetes, and it gave me the confidence to apply for a neuropsychological research assistant job advertised in Cambridge. They contacted me and told me to apply for a PhD place instead! Which I did, and (after a slightly stormy interview) got offered a place. This was a real stroke of luck – the Medical Research Council (MRC) Cognition and Brain Sciences Unit, where I did my PhD, turned out to be one of the leading centres for cognitive neuropsychology and neuroscience.

My PhD involved studying a rare form of early-onset dementia, called semantic dementia. I

was interested in how knowledge of the world progressively declined in this disease, and what that could tell us about how it is organised in the brain. This experience laid the foundation for my long-term interest in memory and dementia, and I remained in Cambridge until 2007 when I moved to Cardiff.

HS: What's your current work focusing on?

I have two parallel streams of research. The first focuses on identifying different brain networks supporting memory. The framework for this research stems from my recently published Oxford University Press book, *The Evolution of Memory Systems: Ancestors, Anatomy and Adaptations*. In the book, we took a contemporary view of brain evolution, rarely applied to study memory. This led us to a radical new proposal: that there are seven different memory systems which emerged over evolution, with each new system adding to those inherited from our earlier ancestors. Using neuropsychology and brain imaging, my group tests for evidence of this complex evolutionary history in humans by looking for differences in how distinct brain networks contribute to memory, perception, knowledge and emotion.

My second strand of research involves asking how our genes and lifetime experiences may influence later life risk of cognitive decline in aging. This is an important question because if we can identify risk factors for poor cognitive health prior to the onset of brain damage, we might be able to develop effective preventative or public health interventions to optimise healthy aging. Brain imaging is a very valuable tool here as it allows us to obtain sensitive markers of network activity in healthy participants, and ask how these are influenced by different dementia risk factors (e.g., genes, lifestyle, cognitive ability, immune health and so on). Our current work is funded by the MRC and is in collaboration with the University of Bristol; we are scanning a large cohort of healthy individuals who have been followed from birth.

HS: We have all this wonderful technical stuff in the Cardiff University Brain Research Imaging Centre (CUBRIC). Is that able to help you in your research?

Although it seems common practice now, it is worth remembering that the first functional magnetic resonance imaging (MRI) only happened in 1991 (just when I started my PhD). Since then, we have seen remarkable developments in

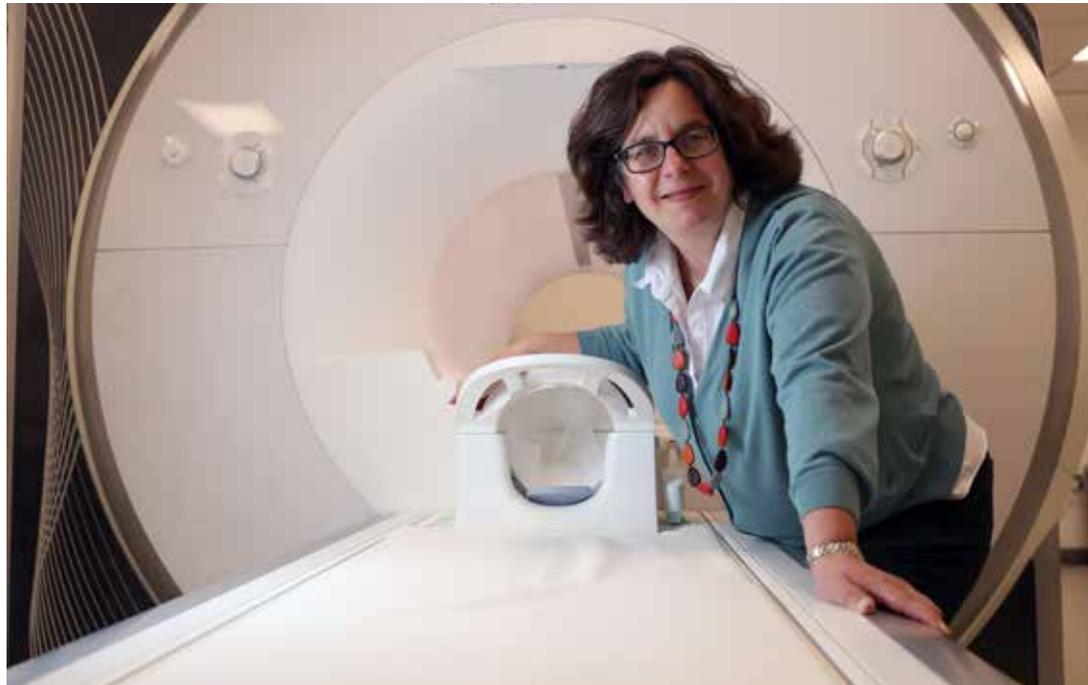
imaging, both in terms of the resolution and detail at which we can study the brain, the analysis and modelling tools we can apply to interrogate data and the cross-collaborative working across disciplines required to advance knowledge.

CUBRIC is an excellent example of this interdisciplinary approach, bringing together physicists, engineers, psychologists, clinicians, geneticists and computational modellers to understand the complexities of brain and mind. How do we learn to ride a bike, play the piano, remember where we went, who we saw, know when events happened, and in what order, write novels and stories, feel emotions and respond to emotions in others?

In my own research, CUBRIC's new 7T MRI scanner is allowing me to study brain activity in brain structures which were previously invisible to us. With CUBRIC's new Connectom MRI scanner, my group can answer new questions about the anatomy of memory. Magnetoencephalography (MEG) imaging allows us to get a handle on the sequence of brain activity across the brain, in a way not possible with MRI. When we bring all that information together and combine it with sophisticated cognitive psychology and frameworks, we are in a world-leading position to rapidly advance our understanding of human memory. Both the parts that we inherited from our ancestors, and those which we developed more recently and which make us uniquely human.

HS: I am fascinated by the idea that there are seven different memory systems. Can you give me a snapshot of each of them? And are they the same for men and women?

Our short blog for Oxford University Press provides an easy-to-read brief outline of each memory system, and its key functions (see: <https://blog.oup.com/2016/11/evolution-human-memory/>). One important system, which links closely to our ability to remember past events, is the navigational system. This supports map-like representations of the environment, and helps place ourselves in the past, present and future (so called mental time travel). Your question about gender differences is an interesting one. Considering the navigational system, a paper published a few years ago looked at sex differences in spatial way-finding, testing a hypothesis that hunter-gatherer lifestyles placed different selective pressures on the development of spatial skills in men and women and led to different cognitive skills in navigation. In fact, they found no evidence for differences between the sexes that could not be explained by navigation experience and other factors. On balance, there is little clear-cut evidence for substantial cognitive distinctions between men and women. I suspect, instead,



that there are greater distinctions within the sexes than between them.

HS: Talking of men and women, how have you found being a woman in science? Do you have any advice for young women starting out today?

It's not always been easy, and I've experienced situations where my ability has been questioned purely because of my gender. I was once asked by a male colleague, for example, if I had the mathematical skills to do a leadership role I was considering. I've also had my commitment to leadership questioned because I have a family. Noting that bringing up two children, who have inherited their parents' inquisitive natures, is far harder than any leadership job I've done to date in a University.

While these experiences have been frustrating, they have built my resilience and determination not to be held back by such antiquated viewpoints, and to help develop and shape approaches which can positively address issues of equality, diversity and inclusion. As you become more senior, I think you also start to feel more comfortable in being vocal about the need for change. For young female researchers starting out today, my advice is to recognise that it won't always be plain sailing, so you'll need to be resilient. I'm glad those comments didn't stop me pursuing my career opportunities, don't let them stop yours.

HS: You've also mentioned how different factors affect our brains coming into old age. Is this the same for men and women? What advice can you give us for good brain health as we age, particularly us women?

The bad news is that some disorders of old age

are more prevalent in women than in men. For example, by the age of 65 years, women have a one in six chance of developing Alzheimer's disease compared to 1 in 11 in men. We also know that genetic variants that increase risk for Alzheimer's disease seem to do so particularly in women. We don't really know why this is. Heart health may be one reason: we know that men have a greater risk of early loss of life due to heart disease. Those men that survive into their 60s may have healthier hearts, and consequently protective factors that reduce their risk of dementia. Another potential explanation may relate to the associated drop in the hormone oestrogen that occurs after the menopause in women. This may impact on brain metabolism and health, especially in individuals possessing genes that increase risk of dementia. These are just speculations, however. We really don't know a lot about why particular individuals are more vulnerable to dementia, and this gap in our knowledge is why funders and governments world-wide are making substantial investments in dementia research.

In terms of optimising brain health as we age, lifestyle factors are likely to be important, regardless of our gender. Ensuring we exercise, eat healthily, don't smoke, manage our stress and avoid loneliness and social isolation could help reduce our risk of poorer cognitive outcomes in old age. On that note, I'm off for a run.



◀ Professor Heather Stevens CBE



Water Research Institute

“Our mission is to foster interdisciplinary water research to address the 21st century’s water challenges. We do this by providing a creative environment where researchers from different disciplines co-design and co-deliver research with stakeholders and end-users to provide integrated understanding and solutions to tackle global water challenges.” – Dr Isabelle Durance, Director of the Water Research Institute

Managing water to keep pace with competing and evolving needs is a crucial societal and governance challenge with unprecedented urgency. The World Economic Forum identifies water crises as among the world’s greatest threats. Whilst four out of five jobs globally are dependent upon an adequate supply of water and water-related services (UN World Water Development Report, 2016), the uncertainties of global change, diminishing regulatory capacity and growing demand across all sectors threaten water security worldwide. Recognising the urgency of these challenges and building on decades of relevant research and training experience, the University has invested in a flagship Water Research Institute.

Building on a 50-year tradition and global reputation, the Water Research Institute was specifically designed to foster true interdisciplinarity across the natural and social

sciences, that would encourage researchers to address the complex challenges of water in novel and integrated ways. The Research Institute’s mission, to address the challenges of water for people and ecosystems in a changing world, brings together over 60 academics and 30 early-career scholars from eight Schools across the University: Geography and Planning, Psychology, Business, Biosciences, Earth and Ocean Sciences, Engineering, Chemistry, and Mathematics.

The questions the Research Institute researchers and their teams are attempting to address have never been more pressing: How can we manage water catchments to support the conflicting water needs of people and ecosystems? How do we adapt water systems to global change and ensure long-term sustainability of water resources? How can we develop safe, secure and smart water systems?

Global water challenges

Applying Cardiff’s water expertise developed in Wales to the wider global context is an important aim of the Research Institute.

To achieve this, the Institute is targeting the Global Challenges Research Fund (GCRF). This five-year £1.5 billion Research Councils UK (RCUK) fund is a key component in the delivery of the UK Aid Strategy: tackling global challenges in the national interest. The fund aims to ensure that UK research takes a leading role in addressing the problems faced by developing countries.

Cardiff researchers affiliated with the Research Institute have already been successful in winning GCRF funding for an interdisciplinary project on the Resilience in Groundwater Supply Systems in Nigeria. In this area, rapidly rising levels of urbanisation are coupled with inadequate public water supplies. These trends have led increasing numbers of households to choose to access their domestic water supply through sinking their own boreholes. The project brought together a unique collaboration

between academics from the UK and Nigeria working in the fields of economic geography, psychology, hydrogeology and journalism studies. This joint approach helps to build a fuller understanding of the choices made by consumers, drillers and policy actors, and how this influences the adaptive capacity of the communities concerned.

The Water Research Institute strongly believes that this model of working across disciplines and with local partners, communities and stakeholders is the best way to start understanding complex water issues and ensure that Cardiff’s world-leading research has real and lasting impact.

The Research Institute is also exploring collaborative links for work on African water challenges with the University of Namibia. This is through the Phoenix Project, one of the University’s flagship engagement projects, which won the International Collaboration of the Year category in the Times Higher Education Awards 2017.





Making a difference locally

The Research Institute is keen to make a difference in Wales and contribute to the University's civic mission.

For example, one of its first activities was to work with the global multi-disciplinary consultancy firm Arup and with Dŵr Cymru – Welsh Water to assess emerging challenges to resilience in the water sector.

The Research Institute's interdisciplinary expert group identified and reviewed potential drivers of major change across the social, technological, environmental, economic and politico-legal (STEEP) realms. Since drivers of change do not manifest individually but in clusters, scenario approaches for dealing with plausible futures were investigated. Given the importance of resilience strategies that are able to respond to unimagined events, the expert group also identified ten priority research areas based on knowledge gaps and uncertainties. These pave the way for a research agenda that will support the future resilience of Welsh Water's business.

Training the next generation of water professionals

Another mission close to the heart of the Research Institute is fostering a community of young researchers with the interdisciplinary tools and perspectives to make a difference in the public and private water sectors.

As a first step, the Research Institute has established an active Early Careers Group of researchers from across the University. Julia Terlet, doctoral student committee member of this group, has noted that:

“The Research Institute's Early Career Group gives students and postdocs the opportunity to network and get information about career routes outside and inside of academia.”

In an effort to build upon our existing structures, the Research Institute has submitted two separate applications this year for Doctoral Training Centres, one to The Leverhulme Trust, and one to the Natural Environment Research Council (NERC). Critically, these applications have the buy-in of key stakeholders across business, government and regulators.

Designing research with stakeholders

In order to successfully address these challenging, interdisciplinary questions, the Research Institute is designed to engage researchers with a wide range of external stakeholders and end-users from industry, business, regulatory, government bodies and non-governmental organisations.

To enable this, the Research Institute has invested in professional services staff who have the right collective consultancy, academic and administrative experience to boost links between academia and stakeholders. It is setting up working groups, workshops, and generally providing the creative space both virtually and physically to catalyse these interactions, and build an effective interdisciplinary research community.

Recent large interdisciplinary endeavours, like the NERC-Duress project on freshwater biodiversity and ecosystem services (www.nerc-duress.org), prove the value of this model of research. This project brought together nine stakeholders and 32 researchers across the natural and social sciences, demonstrating how this type of engagement can trigger a step-change by delivering relevant evidence and tools for end-users.

Working with our neighbours

The NERC Doctoral Training Centre application focuses on Freshwater Biosciences and is a joint initiative with Cardiff's GW4 partner universities of Bath, Bristol and Exeter.

This application was successful (students start in October 2018) and marks the first major funding achievement of the new GW4 Water Security Alliance, also led by Cardiff's Dr Isabelle Durance.

The Water Security Alliance brings together the multidisciplinary expertise of 180 researchers, the complementary state-of-the-art infrastructure in water science across the partner universities, as well as our combined stakeholder partnership portfolio. As an alliance, it is the largest UK water research consortium and one of the largest worldwide. The Water Research Institute is at the heart of this initiative, which puts the Institute in an exciting position to deliver our goal.

“Our goal is to co-design impactful research with stakeholders that provides the evidence needed to sustainably manage water resources for both people and ecosystems.”

Dr Isabelle Durance, Director of the Water Research Institute



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