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Young talent in every direction



PROFESSOR PETER HOLMES

The Royal Society of Edinburgh launched the **Young Academy of Scotland (YAS)** in November 2011, to bring together the country's most dynamic young leaders. It is the only Young Academy in the UK, and is based on a model developed by the national academies in Germany and Holland. Although it has become part of a growing international movement, the YAS is also unique because it is the only institution of its kind which brings together young professionals from across the whole spectrum of business, the humanities and science, as well as representatives from government and civil society.

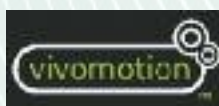
Today, there are about 150 members (each serving five years), selected on the basis of their outstanding achievements both in their chosen discipline and across disciplines. The YAS also fosters interdisciplinary activities and provides a platform for innovative entrepreneurs, professionals and academics to develop a coherent and influential voice, and to address the most challenging issues facing society in Scotland and beyond. It provides a means of reaching beyond the professional environments in which members work, and allows them to contribute to policy and practice in a wide range of areas. Current themes include: the arts, humanities and society; healthy living; public understanding of science; excellence in education; and computing in schools.

In this edition of *Science Scotland*, the strengths of the YAS are illustrated by the wide range of examples of multidisciplinary approaches and collaboration by YAS members – the innovative use of new technologies, and the enterprising approach of researchers, in everything from medicine and psychology to education, history, the media and cultural identity, particle physics and astrobiology.

This special issue also highlights their wide international dimension and how Scotland benefits from the research of these talented people, brought together by the YAS from all around the world, doing work as far afield as Africa and the Pacific – and even outer space.

For more details about the YAS, please go to www.youngacademyofscotland.org.uk

Professor Peter H. Holmes OBE FRSE, Chair, RSE YAS SCIO



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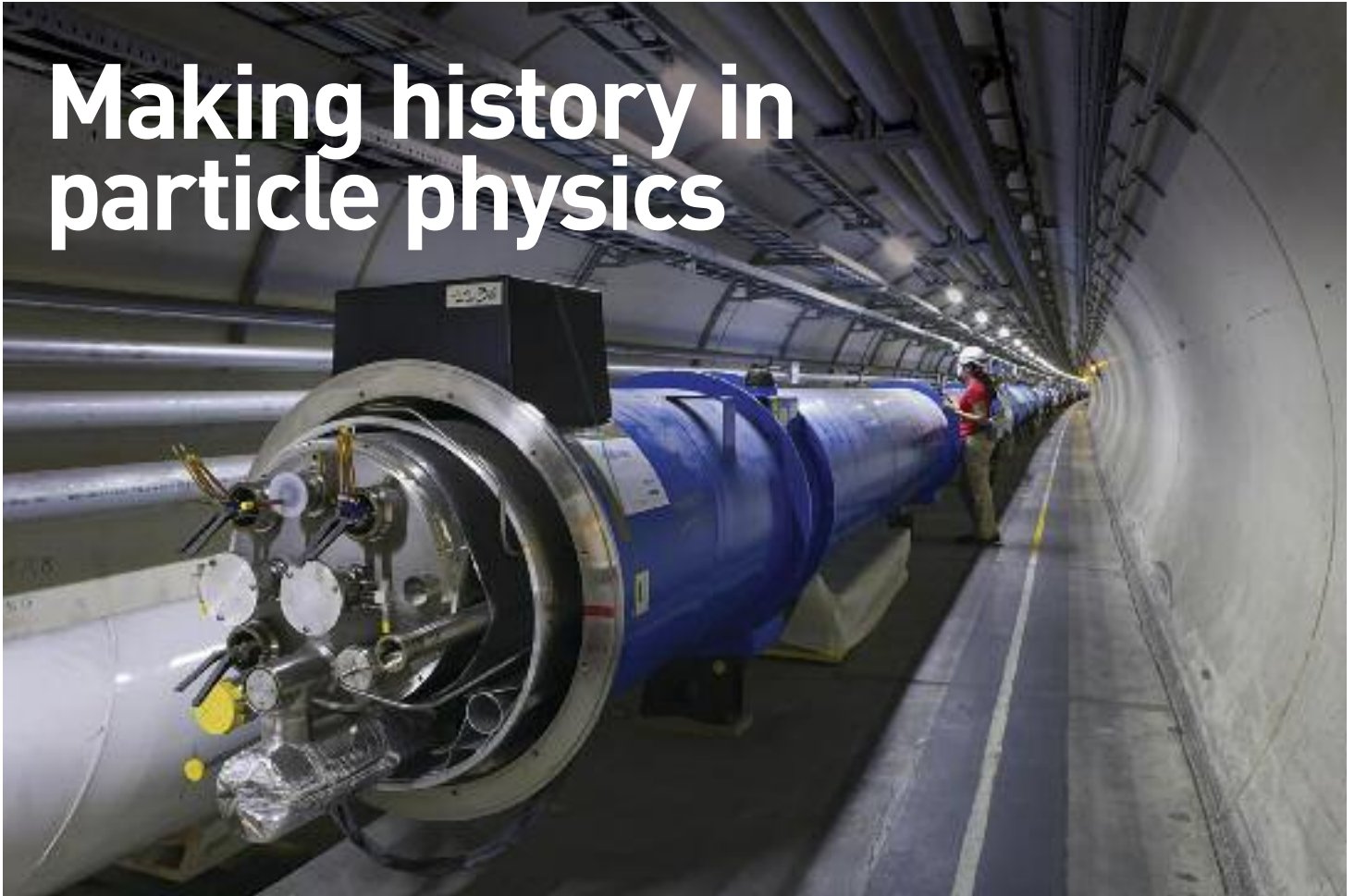
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Making history in particle physics



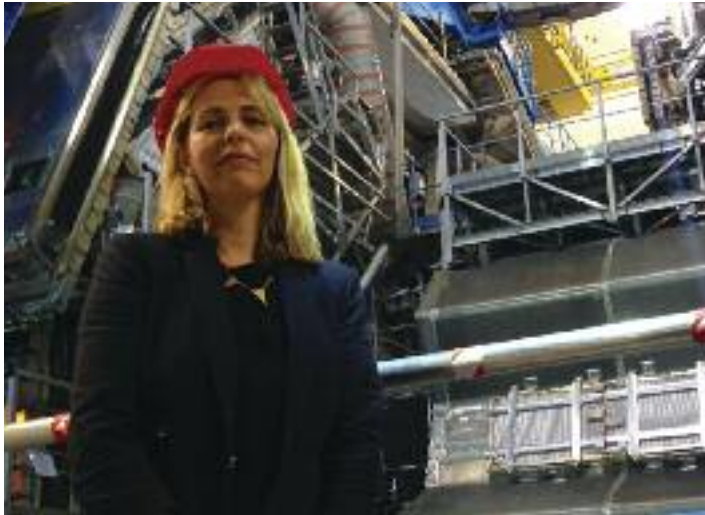
INSIDE THE LARGE HADRON COLLIDER

Dr Victoria Martin is a Reader in Particle Physics in the School of Physics and Astronomy at the University of Edinburgh. She has spent most of her academic career in Edinburgh, graduating with a BSc in Mathematical Physics in 1996, followed by a PhD in Elementary Particle Physics four years later. From 2000–2005, she worked at Northwestern University and the Fermi National Accelerator Laboratory in the US, before returning to Edinburgh to become a Lecturer in Physics. She is currently part of a research team working on the Large Hadron Collider (LHC) at CERN, which discovered the elusive Higgs boson (the central problem in particle physics) in 2012...

Physicists and many other scientists can work for several decades on a project without ever seeing the fruits of their labours. Like many of her colleagues, Dr Victoria Martin has been grappling with the mysteries of particle physics for years, and was part of the team that discovered the Higgs boson at CERN (the European Organisation for

Nuclear Research) in 2012; but, like Professor Peter Higgs himself, who waited 50 years for that magical moment when his theories were proved, her ultimate ambition is to make a contribution to the work of the next generation of physicists grappling with some of the same problems she has been facing for years. Hopefully along the way, says Martin, she will also confirm the recent findings about the Higgs boson and understand more about that other big question in particle physics – dark matter.

In modern science, individuals rarely make significant breakthroughs while working alone. Martin is part of a team of 3,000 researchers at CERN engaged in the ATLAS experiment, using the Large Hadron Collider (LHC) to investigate some of the most complex problems in physics, including the search for Higgs' elusive particle. And when papers are published describing their work, there are 3,000 names at the top, from about 100 different universities from all around the world. The team from Edinburgh currently comprises 20 researchers, with Emeritus Professor Higgs watching their progress with interest from his Edinburgh office.



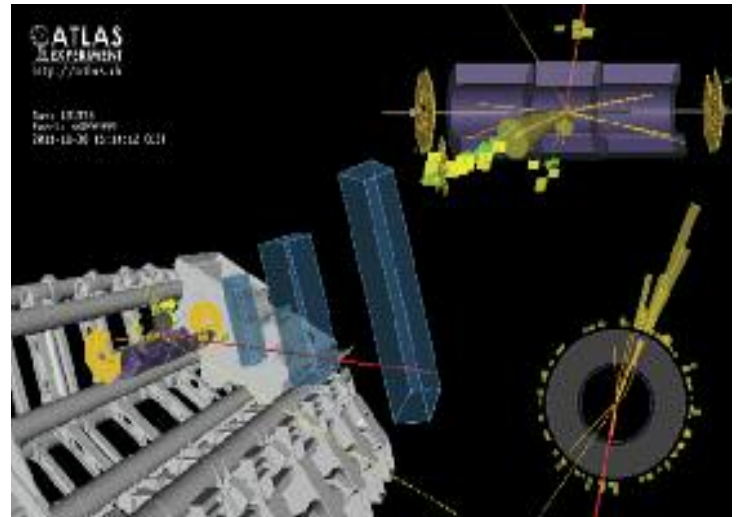
DR VICTORIA MARTIN

Collaboration is essential to every experiment being conducted at CERN. There are four main experiments (including ATLAS) currently being conducted, involving a total of 10,000 researchers, and this creates a web of international connections. For example, Martin, who is currently the Co-chair of the Young Academy of Scotland, works in the same team as the Co-chair of the Young Academy of Flanders, Jorgen d'Hondt. Even though it deals with extremely big questions, physics can also be a very small world; d'Hondt is from the same research institute as François Englert, who was jointly awarded the Nobel Prize in Physics with Higgs in 2013.

Martin's work is focused on the ATLAS experiment, observing what happens at one of the four points where atoms collide at near the speed of light inside the LHC – a donut-shaped tunnel 17 miles in circumference. Every second, ATLAS (which can be described as “a huge digital camera”) captures 40 million three-dimensional images of these collisions and, using intelligent “filters” and a bank of computers to process the data, researchers keep 100 of the images for every single second – the most likely candidates for the Higgs' boson and other strange phenomena such as dark matter.

When lots of pixels light up in the image, there is a greater possibility the particle is there, but the original experiment was also a “shot in the dark.” According to Martin, researchers did not know four years ago if the Higgs boson existed, and if it did exist, they didn't know how it would behave.

The “boson boffins” were divided into two teams, looking for different “classes of behaviour.” Martin describes this as looking for something unusual – such as a “jaggedy shape” in an otherwise very smooth image. One image would not be enough, she explains. At least a hundred images were needed to confirm that the Higgs boson really was there, even though it only existed for 10^{-23} of a second.



THE ATLAS EXPERIMENT – WHERE ATOMS COLLIDE

Then one day, four years ago, the eureka moment finally arrived – followed by ten days of nail-biting tension to analyse the data and confirm the results. Martin herself was becoming increasingly nervous. Professor Higgs was also beginning to feel the excitement as rumours started reaching him in Edinburgh, but Martin and her colleagues still couldn't break silence, despite all the pressure for more information.

Then the magic number – five standard deviations – was confirmed. And the screaming began. They had finally cracked it.

The data confirmed the initial results, but the people at CERN needed five or six more days before they went public. Meanwhile, at a conference in Sicily, Higgs was told he “may be interested in coming along to CERN” later that week for a special announcement, but still the news wasn't official. In Geneva, one of Martin's colleagues queued overnight with a few hundred others for a seat in the seminar room, and Higgs himself was overwhelmed, describing the historical event as like watching his football team winning the Cup. “It was a very emotional moment for the whole team at CERN,” Martin says.

“ So after this incredible discovery, what next? And what is the purpose behind the research? ”



FOR PROFESSOR HIGGS (THIRD FROM LEFT), THE DISCOVERY "WAS LIKE WATCHING HIS FOOTBALL TEAM WINNING THE CUP."

So after this incredible discovery, what next? And what is the purpose behind the research?

"Since we established its existence," says Martin, "my own work has focused on trying to characterise the Higgs boson. As soon as we make one, it disappears immediately. So it's a challenge to study its behaviour in detail." Other researchers are still on the search for dark matter, to explain how stars and galaxies move through the Universe, but even though Martin is carefully following progress, she is heading in another direction.

The search began in 1964 when Higgs first developed his "very simple" theory – describing the Higgs field, the Higgs mechanism and the Higgs boson (which accompanies the Higgs field and provides us with physical evidence of its existence). To understand why this is so important, says Martin, consider the fact that the Sun is still shining as brightly as ever, despite the fact it's full of hydrogen exploding all the time and forming helium, producing heat and light that make life possible on Earth. According to the basic laws of physics, the Sun should have burned up a long time ago, as one explosion leads to another in a huge chain reaction, but the Higgs field is delaying the "death" of the Sun by helping to slow down the interaction. If the Higgs field did not exist, says the theory, particles would not have enough mass to attract one another, and would float around freely at light speed.

"This is part of what we call the Standard Model," says Martin. "It's a very comfortable model, and explains almost all observations in particle physics to date, apart from dark matter. Understanding dark matter is one of the next big tasks for particle physics, along with, perhaps, super-symmetry and new effects of gravity, but that's probably another 50 years of research down the line."

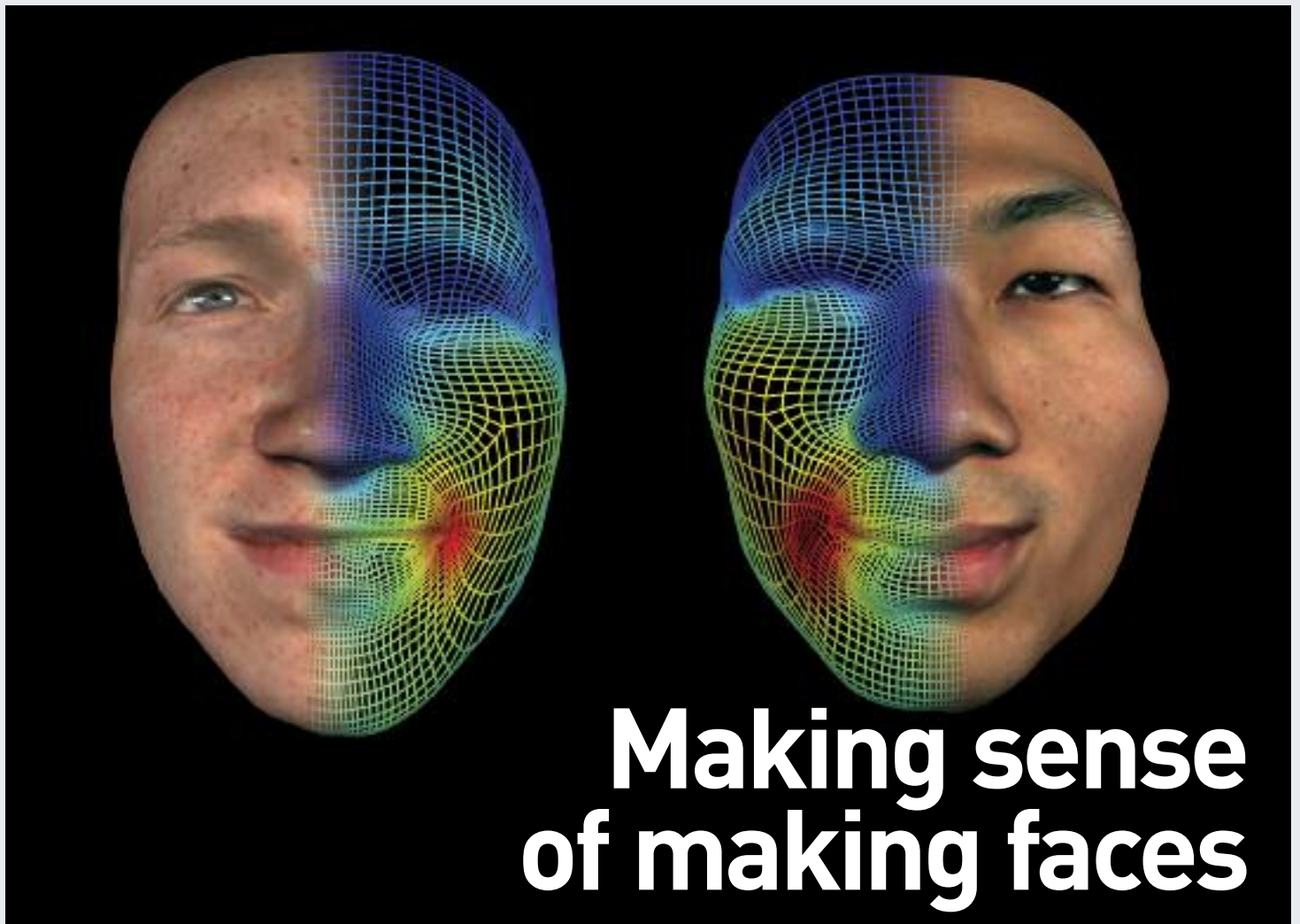
Martin's current research focuses on looking deeper into the properties of the Higgs boson, investigating some of the outstanding questions about it, including "its couplings to the Standard Model fermions, the quarks and the leptons," searching for evidence that the Higgs boson decays into "bottom quarks" (also known as beauty quarks). "An observation of the Higgs boson decaying into bottom quarks would provide strong evidence that the Higgs boson is well described in the Standard Model," she explains.

"Although we have found the Higgs boson, the work of the LHC is not at all over," says Martin. "After two years of upgrades, the LHC has restarted and is now colliding at even higher energy. And these more energetic collisions will be used to learn more about the Higgs boson, dark matter and perhaps other phenomena we've not even thought about yet."

Asked why all this matters, Martin quotes the Nobel Prize-winning physicist Sir Joseph John Thompson, who is credited with the discovery of the electron: "The electron: may it never be of any use to anybody!" In other words, we don't know yet what may result from the current research. There are numerous examples of technological by-products from work at CERN, including the World Wide Web, first developed by Sir Tim Berners-Lee to aid communication among scientists scattered all over the globe. The new generation of solar panels, says Martin, were also developed thanks to pioneering work on "super vacuums" for the LHC.

The next item on the agenda for Martin and colleagues is an even bigger atom smasher, which may not be constructed for decades. It isn't easy making history in physics, but Martin believes it is worth it.

Face Facts



Making sense of making faces

Face Facts is an innovative project set up by psychologists Dr Lisa DeBruine and Dr Rachael Jack of Glasgow University to reach out to the general public and share current thinking about how we form our opinions about people based on their face shape and colour and facial expressions. DeBruine's research focuses on kin recognition, facial resemblance and face perception – how humans use facial resemblance to tell who their kin are and how the visual system learns about faces. Jack is interested in human social communication – how people transmit and decode signals (e.g., facial expressions) for social interaction – with a particular focus on cross-cultural communication. Her approach is interdisciplinary, combining psychophysics, social psychology, information theory and social robotics.

Face to face with psychologists Dr Lisa DeBruine and Dr Rachael Jack of Glasgow University, you may feel they are analysing every single feature and every expression you make, for signs of hidden messages or even a family connection. But according to Jack and DeBruine, you needn't be concerned – we actually make up our minds about people without even thinking, just by "reading" their faces.

The first few seconds may be critical when you're deciding to buy a new home, but most of us usually take just a few milliseconds to decide how we feel about people, "without even making an effort," says Jack. When we look at someone's face, the morphology (form, structure, size and shape), complexion (the colour and texture of the skin) and facial expressions all send out various signals, she explains. For example, from face shape and colour, we see ethnicity, age and gender, and state of health. We also decide social status and sexual orientation, and weigh up potential sexual partners.



DR LISA DEBRUINE



DR RACHAEL JACK

“ **This new technology makes a huge difference to the scope of our research** ”

We are used to the expression “body language,” but we also use our facial muscles to communicate what we are thinking or feeling; for example, we scrunch up our noses to indicate disgust. And when it comes to interpreting facial expressions, some of us are more “literate” than others. It’s useful to make up our minds about people’s intentions (whether someone is threatening or friendly, bored or interested), but sometimes we jump to conclusions or make simple errors, based on the appearance of someone’s face.

Some of the conclusions we reach about people are common to all human beings, says Jack, but some of them differ from place to place, and can subconsciously influence our judgement. There are also cultural “rules” about faces and facial behaviour which become second nature. For example, in some cultures too much eye contact is considered rude, while others think avoiding it is rude. As Jack describes it, people engage in an “eye gaze dance” when they meet, and this sends out a lot of complex signals regarding our status (e.g., superior “looking down on” inferior) as well as our feelings. Sometimes we “second guess” what signals mean, but some characteristics can provoke completely opposite responses. For example, having a suntan is nowadays thought of as desirable and healthy in most Western countries, but used to be associated with “lower-class” people who worked in the open.

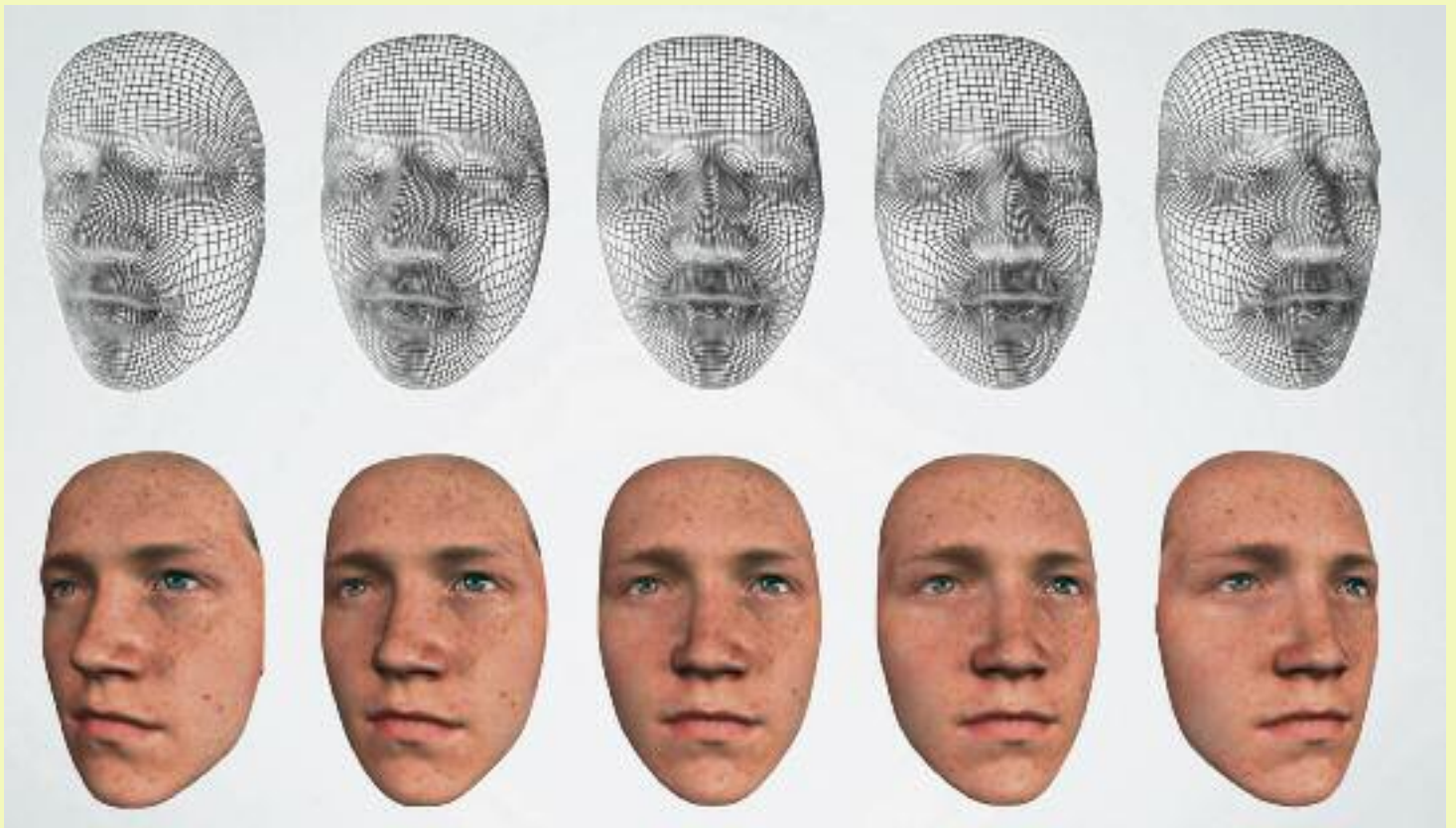
Sexual attraction is one of the most complex aspects of facial perception. As women’s hormones change at different stages of the menstrual cycle, there is evidence they are attracted to more masculine or feminine partners. People also view potential sexual partners as long-term or just one-night stands.

Our facial responses to environment are also important; for example, to signal disgust, fear or danger. And these expressions have evolved on the same path as language – just as grunts become words, so our facial expressions have become more complex over the millennia. “Our facial expressions have their own grammar and syntax,” says Jack.

In recent years, Jack’s research has focused on cultural factors, questioning orthodox thinking on social interaction and facial expressions. Earlier theories (proposed by Ekman in the late 1960s) suggested there were six “universal” facial expressions which all cultures shared, but Jack’s research has challenged this view. According to Jack, the earlier research was more “Western-centric,” but by using a more agnostic, data-driven approach, she has shown clear cultural differences in the facial expressions once considered universal, and that four (not six) facial expression patterns are common across cultures. To do this, she has taken full advantage of a new kind of software which generates a range of random dynamic facial expressions. She then asks people of different cultures which emotion they see in each facial expression: happy, surprised, fear, disgust, anger or sad. By doing so, she can identify the specific dynamic facial expression patterns that individuals in a given culture associate with different emotion categories. She has also recently extended her work to 60 emotions across two cultures – a first in the field. “This new technology makes a huge difference to the scope of our research,” says Jack, “but the most important thing was taking an agnostic approach, to avoid preconceptions about which facial expressions communicate which emotions.” Another major difference was that Jack did not average out the results across participants, which would eliminate individual nuances in face signalling, but focused on the responses of individuals within each culture to understand variance within a population. Thus, Jack’s approach of using psychophysics allows her to arrive at more objective conclusions about these subjective emotions.



Psychophysics:
quantitatively investigates the relationship between physical stimuli and subjective sensory experience and perception.



WHEN IT COMES TO INTERPRETING FACIAL EXPRESSIONS, SOME OF US ARE MORE "LITERATE" THAN OTHERS

For Jack, there were two major breakthroughs involved in the process. First, she realised that the differences between different cultures were masked in the early research, which meant an opportunity to do some new research, taking advantage of the new technology available, including "generative face grammar" software developed by her colleagues at the Institute of Neuroscience and Psychology in Glasgow, Professor Philippe Schyns, Dr Oliver Garrod and Dr Hui Yu (now at the University of Portsmouth). The second breakthrough was that she discovered there are only four facial expression patterns that are common across cultures. "I didn't set out to get four," she explains, "but that's what I found in my data across several studies."

So why does this matter? Apart from learning more about how human beings operate, this knowledge could be useful in designing a new generation of digital tools – for example, what are called "companion robots," or digital avatars used in automated customer service. Instead of graphics artists designing the facial expressions using their own cultural perceptions, psychologists can help to make the artificial faces seem more culturally sensitive and therefore more "human."

Family business

DeBruine's path to face research was somewhat unusual: "In psychology, they say that researchers tend to study what they have or what they lack. I was adopted, so family resemblance and how we 'know' who our relatives are has

always interested me. I didn't look like anyone else in my family, until my son was born eight years ago. So when I started a PhD with Margo Wilson and Martin Daly, the two evolutionary psychologists who have done the most to bring an evolutionary perspective to the study of family relationships, it was only natural that my project would be on the cues that indicate kinship and influence kin-directed behaviour."

While doing research at McMaster University in Canada, DeBruine used commercially-available morphing programs to manipulate family resemblance, then later started using special software developed by Professor Dave Perrett at the University of St Andrews, which brought her to Scotland in 2004 to become a "full-time face researcher," while retaining her interest in kinship.

After 12 years focusing on face perception, including how individual differences in pathogen disgust and regional differences in pathogen exposure influence how we see faces, DeBruine returned to her study of kinship, and won a five-year ERC Consolidator grant to do research into "How do humans recognise kin?" The aim of this new project is to determine "how we perceive the various potential cues of kinship (including facial and odour similarity, co-residence, maternal perinatal association and cognitive knowledge of kinship) and integrate them to modulate our prosocial and sexual behaviour." And Face Facts has a key role in gathering the necessary data, as well as in public engagement.

The Face Facts Team

The other members of the Face Facts team include psychologists, biologists, computer scientists and anthropologists: Professor Philippe Schyns (Director of the Institute of Neuroscience and Psychology at the University of Glasgow); Professor Benedict Jones; Dr Amanda Hahn; Dr Oliver Garrod; Claire Fisher; Michael Kandrik; Chengyan Han; Dr Ross Whitehead; Dr Iris Holzleitner; Shona Fridh; Chaona Chen; Jiayu Zhan; Danielle Morrison; and Megan Sutherland. The support team also includes Glasgow-based Dimensional Imaging and the Glasgow Science Centre.



THE FACE FACTS PROJECT HELPS TO MAKE PSYCHOLOGY FUN

On the road

The Face Facts project goes on the road to science festivals and other events, and also has a web site (<http://facefacts.scot>) where visitors can blend different faces together or use their own “selfies” to transform their faces – feminise or masculinise, or look trustworthy, dominant, heavier or slimmer. You can also look at pictures to decide which baby looks cuter, and who looks healthier or more aggressive. Another popular activity is creating an “average” face by blending multiple faces together and sampling common features. The touring exhibition uses three special pods and nine cameras to capture three-dimensional images of faces, using a system developed by Dimensional Imaging of Glasgow.

According to DeBruine, the Face Facts exhibit has two main aims: to educate the public about the multidisciplinary nature of modern experimental psychology, and to highlight the research on faces being done at the Institute of Neuroscience and Psychology, including the collection of 3D face captures from families in Glasgow, which is part of DeBruine’s research into kinship.

Jack adds: “It’s a fun way to get people into psychology, and talk about exciting scientific ideas, making complex issues more digestible. We work in the same basic field, but have different specialist interests. Lisa’s work has focused primarily on static face features (e.g., morphology, colour), the biological phenomena and kinship; while I have focused more on dynamic expressions and cultural factors; and so our interests and research findings are highly complementary.”

“

By touring with Face Facts, we are also challenging people’s assumptions about what psychology is.

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The technology is much more advanced than it used to be, including the cameras and imaging software, but what makes it work is the “funfair” appeal – like playing with a high-tech hall of mirrors. And the same technology is what enables Jack and DeBruine to do their research, drawing on the vast computing power now available.

“By touring with Face Facts, we are also challenging people’s assumptions about what psychology is,” says DeBruine. “Many younger people may have preconceived ideas which limit their choices, and we hope this opens their minds.”

“Psychology can be perceived as fluffy or ‘just common sense,’ and not as objective or as technical as other mainstream sciences,” says Jack, “but most people are interested in cultural differences, or how we are similar across cultures; which grabs their attention, and gets across the message that psychology has real-world impact.”

After all, to build companion robots which people accept in their everyday life, you first have to understand humans.

Decoding the genes of cognition

"BY ANALYSING THE CLINICAL DATA, A MORE ACCURATE PICTURE SHOULD THEREFORE EMERGE." PHOTO BY REBECA DIAZ

Dr Silvia Paracchini has been a Royal Society University Research Fellow at the University of St Andrews since 2011. Her research group at the School of Medicine investigates the genetic components of behavioural traits such as handedness and common neurodevelopmental disorders such as dyslexia, to understand the mechanisms underlying human cognition. She graduated in Biological Sciences from the University of Pavia in 1998 and gained her DPhil in Human Genetics from Oxford University in 2003.

What's the connection between dyslexia, left-handedness, schizophrenia and ADHD? According to Dr Silvia Paracchini of the University of St Andrews, it is probably something to do with the genes. And when we solve the biological puzzle of these common cognitive traits and disorders, we will also be closer to knowing how the human brain develops and how it evolved.

Following a recent trip to Hong Kong and Japan, supported by the Scottish Funding Council, Paracchini has also embarked on a journey to understand the cultural factors involved in the development of certain conditions, as well as understand the fundamental biology. In Japan, for example, the incidence of dyslexia is well below the global average of 5–10%, and awareness of dyslexia is relatively low. In Hong Kong and many other countries, there is still a stigma attached to left-handedness, and these cultural characteristics may disguise the true incidence of such common traits. By analysing the clinical data as well as

studying the genes involved, a more accurate picture should therefore emerge, which can then be compared to the data already collected in other countries.

Genetic screening so far has only covered white European populations, and Paracchini's new project will extend this analysis to Asia, taking into account the fact that different languages (as well as different alphabets or character sets) have a major influence on the development of dyslexia; for example, there are also different patterns in the incidence of dyslexia between English and Italian speakers, even though they use the same alphabet. Part of the project, which is also supported by a Great Britain Sasakawa Foundation grant, will include setting up a network of clinicians, psychologists and epidemiologist, to collect behavioural and genetic data in Asia.

It is clear that many risk factors, both genetic and environmental, are involved in the development of dyslexia. Paracchini says that most of them (about 70%) are expected to be in our genes, and her research group has identified a handful of candidate genes. One of the most interesting features of these genes is that they seem to control the early phases of brain development through biological processes also involved in establishing our left and right asymmetries; so by studying these genes in detail, the researchers hope to understand better how the brain works and how it develops. "Dyslexia provides us with a window into brain development in general," Paracchini explains.



DR SILVIA PARACCHINI

“

Not surprisingly, we are now observing that genes identified while studying one particular disorder quite often contribute to another condition.

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Left-handedness is one of the more curious topics being investigated by Paracchini, and one of the breakthroughs in this research happened “by accident,” when a new PhD student revisited clinical data left lying around in a drawer and discovered a link between dyslexia and left-handedness. There had been anecdotal evidence of links between left-handedness and dyslexia in families, but the new evidence seemed to confirm this. “The link, however, is more complex than expected,” says Paracchini. “While left-handedness does not have a higher incidence in people with dyslexia the genetic association with handedness appear to be specific to dyslexia. This association with handedness also points to the biological pathway involved in establishing our left/right body asymmetries (e.g., heart on the left and liver on the right).”

Paracchini has spent the last 14 years studying dyslexia. After graduating in Italy, she studied for her PhD in Human Genetics at Oxford, focusing on the development of genotyping methods and screening of large cohorts of data for genetic associations with prostate cancer and male infertility. This led to her research in dyslexia, mapping the first candidate gene in 2004, followed by the publication of a paper in 2006 which established the molecular mechanisms by which genetic variants in this gene could influence dyslexia. This research also found that the same genetic variants associated with dyslexia influence reading abilities in the general population.

“By using living models (human cells and zebrafish) to test the function of the genes identified from genetic screenings, we can understand what they are doing at molecular level,” says Paracchini. “Hopefully, by studying gene function, we can understand the connection between dyslexia and handedness. The genes we have identified so far have relatively small effects, so we still need to identify more candidate genes. That is why we are conducting larger genetic screenings. Ultimately, we hope this will lead to understanding the biological mechanisms behind different traits and disorders.”

To explore the phenomena further, Paracchini is also planning new research into the relationship between

dyslexia and the arts, working with an artist based in Northern Ireland. There are also interesting links between brain symmetry, dyslexia and specific language impairment (SLI), as well as an apparent connection between left-handedness and the ability to recover from strokes – all of which will need to be investigated further.

Further progress, Paracchini explains, will depend on the technologies used to generate and analyse the genetic data, given the very large volumes involved and the challenge of making sense out of the data. This is a problem for human genetics in general, but dyslexia research presents additional caveats. “The diagnosis of dyslexia is not an exact science,” she says. “It also covers a spectrum, like autism. Dyslexia can be considered as the end of the scale of reading abilities observed across people, but it can be an arbitrary decision where to draw the line to decide who has dyslexia and who hasn’t.”

In the past, researchers focused on people with dyslexia only and excluded from their studies individuals with ADHD or language impairment, which often “co-occur” with dyslexia. “The rationale was to have a ‘pure’ population that would help to identify which genes contribute to dyslexia specifically. But this was probably a mistake,” says Paracchini.

There are clearly very interesting connections between all these different conditions, and understanding the connections between them will help reveal the inner secrets of the brain; thanks to genetic research and more in-depth analysis of clinical data. “We do not expect to identify genes which contribute to dyslexia, SLI or ADHD specifically, but rather to understand the role of genes during neurodevelopment,” Paracchini explains. “Not surprisingly, we are now observing that genes identified while studying one particular disorder quite often contribute to another condition.”

More “happy accidents” may also help in the search, as the history of science through the centuries has shown, but Paracchini will rely on purely scientific methods to make her next breakthrough.

Professor Mirela Delibegovic



Diabetes cure not just a dream

Professor Mirela Delibegovic leads a research team at the School of Medical Sciences, in the Institute of Medical Sciences (IMS), University of Aberdeen. Her research focuses on the role of tyrosine phosphatases in cell signalling and disease, with a specific emphasis on obesity, Type 2 diabetes, cardiovascular disease and non-alcoholic fatty liver disease (NAFLD).

"One day, a shell landed right on our school. But in Bosnia in those days, it was normal."

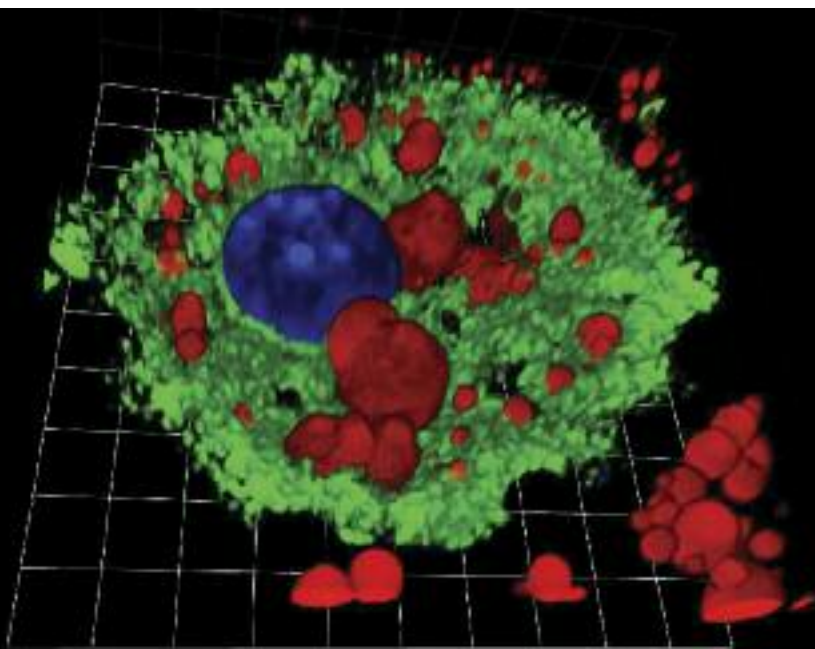
Twenty years later, Professor Mirela Delibegovic has gone back to school in Scotland, as part of a project called *Research the Headlines*, set up by the Young Academy of Scotland (YAS), reaching out to schools to get students thinking more deeply about how "research is discussed and portrayed in the media." The students talk about the latest news that "chocolate is good for you" and review another article which says smoked salmon has more fat per gram than margherita pizza. For Delibegovic, this is one of the most enjoyable activities of the week, and she's delighted that the students know so much about science and don't "swallow everything they read in the papers" without checking the facts.

As a mother, she also likes working with children, but she is also keen to get back to her lab in the Institute of Medical Sciences (IMS) at the University of Aberdeen, where she heads a research group seeking to "cure" diabetes.

The road to Aberdeen has been a long and sometimes very difficult journey via Tuzla (Bosnia's third-largest city), Edinburgh, Essex, Dundee and Harvard, but Delibegovic will never forget how the Bosnian War tore her family apart in the mid-1990s. Her elder sister Almira moved to Scotland soon after the start of the conflict, to study law. At first, her mother did not want her only other daughter to follow – until another shell came down, this time much closer to home. And reluctantly, she packed her off to Scotland.

In Edinburgh, the 17-year-old Delibegovic soon settled down to life as a student in exile, completing her secondary education in the capital city, thanks to a George Heriot's school studentship. Initially, she wanted to go on to study medicine, but finally completed a degree in pharmacology at the University of Edinburgh and moved north to Dundee to gain her PhD in Biochemistry, specialising in the study of obesity and diabetes, funded by a Royal Society Postgraduate Studentship.

DIFFERENTIATING C3H10T1/2
ADIPOCYTES TRANSFECTED WITH
AGPAT1 (IMMUNOSTAINED IN
GREEN), WITH LIPID DROPLETS
IN RED (LIPIDTOX 647) AND DAPI
STAINING OF THE NUCLEUS"
BY ELISA PERSIANI



Her family history also played a role in her choice of research. Several family members had developed Type 2 diabetes, while others seemed immune, and Delibegovic was interested in finding out why by studying the mechanisms of the disease.

During her time in Dundee, under the wing of Professor Patricia Cohen, Delibegovic developed an interest in special proteins called phosphatases, which she was researching as part of her PhD studies. She then became interested in a phosphatase called PTP1B (protein tyrosine phosphatase 1B) which seems to play a key role in the body's immune system, and went to a conference in Marburg (Germany) to find out more about the latest research into PTP1B, which suggested that it could prevent obesity and protect against diabetes development. Initially, researchers had suspected that the protein may also cause cancer, but this proved to be wrong. What fascinated Delibegovic was that this seemed to solve a conundrum: until then, it had seemed to be impossible to cure diabetes (obesity being a major risk factor) without causing cancer. Another complication with candidate treatments is that some may lead to terrible mood swings and even make some people feel suicidal. If PTP1B could cure or prevent diabetes, the next step was to study its effects on different parts of the body, including the brain. For example, isolating its effects on muscle, fat and liver cells while preventing it from crossing the "blood-brain barrier."

Since then, Delibegovic has focused her attention on this potentially "game-changing" protein. But in the early days, her quest for a cure met with sceptical reactions. For example, at her Viva, when her examiners quizzed her in defence of her PhD Thesis, one of the interrogators asked her what she hoped to achieve in her future career. Without hesitation, she answered that she wanted to "cure diabetes," and overheard one of the panel describing her wish as "naïve." But ever since then, she has done her best to prove the sceptics wrong, and is already making significant progress.

The road to Aberdeen

Delibegovic has always been interested in diabetes and that was why she decided to do her final year undergraduate project at SmithKline Beecham Pharmaceuticals (now Glaxo-SmithKline) in Harlow in Essex, where she worked on a new class of anti-diabetic drugs which got approved for use in patients while she was working there. She then did her PhD in Dundee on a diabetes project, before she got a fellowship to continue her work on diabetes at Harvard Medical School, spending four years there from 2003 to 2007. Her husband, Dr Nimesh Mody, whom she met at Dundee, went with her to Harvard to pursue his own specialist interest in cancer and diabetes, and they both returned to Scotland in 2007 – with their newborn son, Seid.

"Scientists are always asking themselves 'am I doing the right thing?'" says Delibegovic. "I had started work on a new pathway, linking the immune system with diabetes, and my preliminary studies suggested that PTP1B could be important, but the step up from researcher to leader of my own research group was a big move to make. Suddenly I would be responsible for other people's careers, and would have to ensure that we had enough funding in place. It was like running a small business."

In terms of research, the big question was, why do we gain weight and what is the link between obesity and insulin resistance? What is the link between cardiovascular problems, weight gain and diabetes? And what is the link between diabetes and Alzheimer's disease? A high percentage of Alzheimer's patients also have diabetes (for example, a study of the Mayo Clinic Alzheimer Disease Patient Registry revealed that 80% of patients with Alzheimer's exhibited either impairments in glucose tolerance or diabetes), but researchers still have to establish if diabetes is a consequence or a risk factor in developing Alzheimer's.

“If we can treat diabetes and other diseases like cancer, why not ageing?”

At Harvard, Delibegovic was funded by the American Heart Foundation, but back in Scotland, the big question was where the funding would come from – and the answer was Diabetes UK and the British Heart Foundation. “I sat at my computer and surveyed the empty lab,” says Delibegovic. “The project was starting from scratch, and it was not until the next year that I got my first grant and was able to hire my first post-doc assistant, then my first PhD student.”

Researchers have established that the PTP1B protein has the potential to protect us from infections by “turning on” our immune system in response to particular triggers. The protein also acts in the opposite way by switching off the immune system when it becomes overactive; for example, it may help to reduce inflammation or treat conditions such as septic shock or rheumatoid arthritis. What makes PTP1B so special for Delibegovic is that it may enable us to develop pharmaceutical solutions which cure diabetes without complications.

Delibegovic is also interested in using PTP1B to target specific locations, without any damaging side effects. “We wanted to know if it had global effects,” she explains, “or could be used to lose weight, for example, without affecting the brain. And we found that we can use it to target the liver or muscles or fat cells, to protect the body against diabetes, without any weight loss.”

Some of the research involves working with mice. Because it is important to find out if the protein works in adults, and monitor progress from early life onwards, mice are useful because they are “middle-aged” after a year and can be fed special diets; so researchers can study the effects of changes in nutrition in mice, then try to reproduce the same results in humans. Delibegovic uses a range of molecular biology, biochemical, pharmacological, cellular and gene knock-out mouse models as well as tissue biopsies and plasma samples from human volunteers. “This allows us to create a truly integrative physiology approach to understanding the aetiology of these diseases, as well as

possible therapeutic intervention points,” she explains.

Healthy ageing

While focusing on diabetes, Delibegovic inevitably starts to see other connections and wants to investigate other diseases. And her next “dream” is to understand why we get old – and hopefully slow down the process of ageing. The same mechanisms that lead to disease are connected with ageing and even though Delibegovic continues – for the time being – to focus on obesity and diabetes, and related issues such as nutrition, ageing will inevitably be a hot topic in future.

Anti-ageing and cognition have enormous potential for treatments based on proteins such as PTP1B, she says. “If we can treat diabetes and other diseases like cancer,” she says, “why not ageing?” This means finding out why we age in the first place and studying the role of nutrition in much greater detail. As societies get older, finding cures for age-related conditions such as senile dementia are also becoming more urgent, and scientists have recently established something called ‘Type 3 diabetes’ to describe the form of Alzheimer’s disease which results from resistance to insulin in the brain.

In fact, says Delibegovic, researchers are beginning to establish a lot of new things about insulin and diabetes, in the search for more effective and economical treatments, aimed at individual forms of the disease such as late-onset Type 1 diabetes, as well as early detection and prevention.

Will the research at IMS lead to commercialisation of patented treatments? Delibegovic says you can “never say never” and believes that PTP1B has huge potential for a breakthrough in the treatment of different conditions and, ultimately, the development of a new class of drugs. “I am always looking out for something new,” she adds.

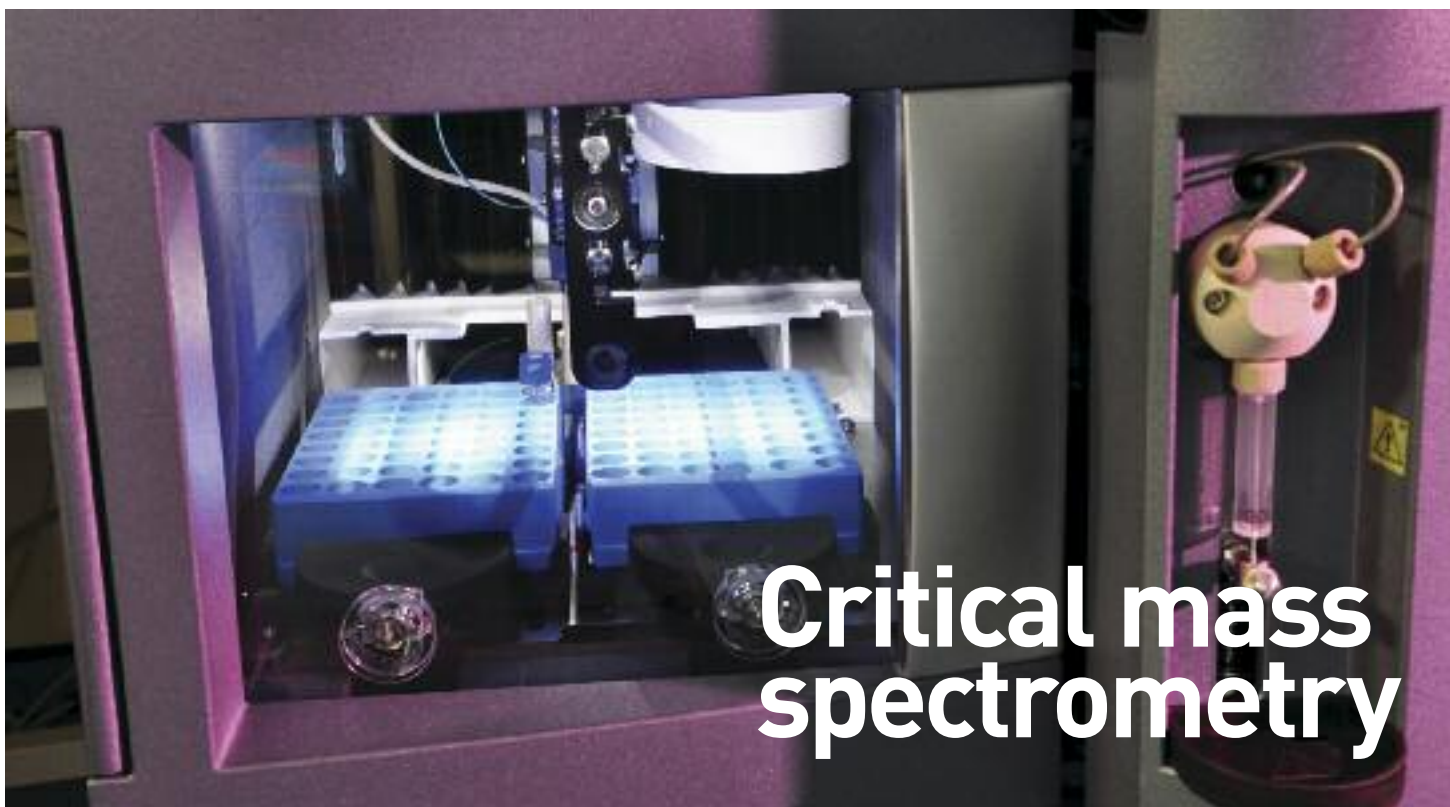
What is diabetes?

Diabetes is a group of metabolic diseases in which there are high blood-sugar levels over a prolonged period. Symptoms include frequent urination, increased thirst and increased hunger. Diabetes can cause many complications such as cardiovascular disease, stroke, chronic kidney failure, foot ulcers and eye damage. The disease results from the pancreas not producing enough insulin, or the cells of the body not responding properly to the insulin produced.

There are two main types of diabetes:

Type 1 results from the pancreas failing to produce enough insulin. The cause is unknown and it is usually diagnosed at a young age.

Type 2 is a condition in which cells fail to respond to insulin properly. As the disease progresses, a lack of insulin may also develop. The primary cause is excessive body weight and lack of exercise.



MASS SPECTROMETRY IS NOW MORE WIDELY USED IN MEDICAL RESEARCH

Dr Mary Doherty is a Senior Lecturer in Mass Spectrometry, based in the Lipidomics Research Facility at the University of the Highlands and Islands (UHI) in Inverness. Her research focuses on using mass spectrometry to understand fundamental biological and biomedical problems, including diabetes and cardiovascular disease, as well as help develop more sustainable protein production in aquaculture and new materials for medical devices.

When Dr Mary Doherty first graduated 20 years ago with a Degree in Chemistry from the University of Edinburgh, there wasn't even a word for the science on which she would be focusing only seven years later. In 2002, she was offered a post at the University of Liverpool to specialise in something called "proteomics," a term coined just five years before to describe the global study of the structures and functions of proteins. And just to make the new job even more pioneering, Doherty and her new colleagues in Liverpool also started using a technology not often used in biology before then – mass spectrometry.

Now a Senior Lecturer in Mass Spectrometry at the University of the Highlands and Islands (UHI), based in Inverness, Doherty has witnessed a spectacular growth in the use of the technology over the last two decades.

In the past, it was primarily used in the petrochemical industry, but Doherty now uses it for everything from analysing new kinds of materials for medical devices to measuring the effects of stress on zebrafish. Her department also carries out research for a wide range of clients, from fish feed manufacturers to leading pharmaceutical companies, combining fundamental research with commercial work.

Doherty has been fascinated with enzymes and proteins since her earliest days as a student, and as her work progressed, she started to focus on "the functional characterisation of electron transport proteins," to understand more about proteins – how they are made and broken down in cells and generate the energy cells need to grow. One of her specialist subjects is enzyme kinetics – measuring how quickly proteins cause a reaction and how fast they change, so we can understand the properties of individual proteins and use them to develop new products, as well as to improve nutrition or health. For her PhD Thesis, she focused on one special protein, isolated from a marine organism; but when she moved to Liverpool in 2002, she was able to study whole "cohorts" of proteins at once, taking advantage of the latest advances in mass spectrometry and recent breakthroughs in genomics which had led to the sequencing of multiple proteins. "I had dabbled in the use of mass spectrometry in Edinburgh," says Doherty, "but the Liverpool project was much more advanced, looking at hundreds of proteins at once."



DR MARY DOHERTY



INSIDE THE LIPIDOMICS RESEARCH FACILITY IN INVERNESS

Before she worked in Liverpool, Doherty studied for her Master's Degree in St Andrews, going back to Edinburgh to get her PhD then moving to New York in 2001, where she continued to focus on enzyme kinetics, after arriving on one of the first flights to cross the Atlantic in the wake of 9/11.

Mass spectrometry in focus

After a year in New York, as a Postdoctoral Research Associate at the Albert Einstein College of Medicine, Doherty spent the next eight years in Liverpool, developing her expertise in mass spectrometry. One ground-breaking project involved feeding chickens with various amino acids (the building blocks of proteins which enable cells to multiply and grow) to study the effects of different diets so researchers could develop better feedstuffs to improve production of poultry and eggs. "Mass spectrometry had a huge impact on what we were able to do," says Doherty. "It was the enabling technology for our research."

Since moving to Inverness in 2010, to lead a research programme in proteomics, Doherty's projects have focused on cell culture, algae and fish, using mass spectrometry to observe what happens in their cells when fed with different proteins, and "understand the mechanisms of protein synthesis and degradation."

Mass spectrometry enables researchers to analyse what happens in the cells of plants and animals by feeding them with amino acids or other small molecules which have been chemically altered to trace their incorporation into the cells, using a technique called "stable isotope labelling". For example, by replacing the hydrogen atom in a particular protein with deuterium, you make the atom "heavier" and therefore much more visible and easier to trace using mass spectrometry, and Doherty has used this in her recent work to analyse protein synthesis and degradation – the rate at which proteins are created and die.

"We take small molecules, usually amino acids, and change them into something else," says Doherty, "then see what happens when we feed them to the fish by analysing the proteins in the individual tissues such as muscle, liver or heart."

The work at UHI

The team at UHI handle a wide range of projects, including looking at what happens when a new kind of synthetic material (a metal-organic framework) for a healthcare device comes in contact with living tissue such as muscle, to make sure it's safe. The new material, developed by a team at the University of St Andrews, releases gases such as nitric oxide and hydrogen sulphide, which can be lethal in excessive doses but are also naturally present in the body; so the project helps to measure the effect of different versions of the framework which release each gas at different rates, depending on design.

Another project focuses on zebrafish, analysing the effects of stress on their hearts – ultimately to develop better fish oils, improve aquaculture and improve the health of fish and humans. According to Doherty, the researchers are interested in how stress changes the development of cells and how the proteins are synthesised, focusing on the rate of production rather than the volume. Doherty also reveals why the zebrafish make such good models – their stripes are like barcodes which enable researchers to track the behaviour of each individual as they swim around the tank.

“researchers are encouraged to engage with industrial partners as well as carry out pure research, and this is a major attraction to her and the rest of the team.”

What is mass spectrometry?

Mass spectrometry (MS) is an analytical chemistry technique which helps identify the amount and type of chemicals present in a sample. Mass spectra are used to determine the elemental or isotopic signature of a sample, the masses of particles and molecules, and to elucidate the chemical structures of molecules such as peptides and other chemical compounds. Mass spectrometry works by ionizing chemical compounds to generate charged molecules and measuring their mass-to-charge ratios. Mass spectrometry is used in a wide range of fields, including new-born screening, drug testing and whisky production, and is now a fundamental tool in biological research.



“Our team started with an empty room in what might be perceived as the middle of nowhere, and now the centre has a worldwide reputation.”

And it's not just proteins the team are interested in. Since moving to Inverness, Doherty has become increasingly involved in applying the techniques developed in proteomics to understand the roles of different fats, or lipids, in the body. “One fat is not the same as another. They are key components of cell membranes but can also act as signals for the cell, and we are interested, for example, in understanding how specific lipids both cause and resolve inflammation.”

At UHI, says Doherty, researchers are encouraged to engage with industrial partners as well as carry out pure research, and this is a major attraction to her and the rest of the team, helping to make sure they have enough funding and can plan for the future.

Collaboration key

In addition to her work as a lecturer and a researcher, Doherty is also the Head of Postgraduate Researcher Development at UHI, monitoring the experience of post-graduate students at different campuses, from Skye and Stornoway to Perth, to ensure “that they all get a place at the table,” covering every department including social sciences and arts as well as science and technology. She is also a Visiting Reader at Robert

Gordon University in Aberdeen, and a member of the Young Academy of Scotland's international committee. She has also been active in Scottish Crucible, helping “to develop strategic partnerships across the research spectrum” in Scottish universities, and is responsible for the university's application for accreditation by the Athena SWAN Charter, which encourages and recognises equal treatment for men and women in higher education and research.

Just as mass spectrometry has a critical role to play in biological and biomedical research, collaboration is key to the future success of the Lipidomics Research Facility, set up five years ago with funding of £2 million from the Scottish Funding Council, Highlands and Islands Enterprise and the European Regional Development Fund. The facility is also one of Doherty's proudest achievements, and one of the first specialist centres of its type in the country, attracting researchers from all over the world, including the United States and Europe.

“Our team started with an empty room in what might be perceived as the middle of nowhere,” says Doherty, “and now the centre has a worldwide reputation.”

Dr Francisca Mutapi

Modern solution for ancient disease



TREATING BILHARZIA CAN MAKE A HUGE DIFFERENCE TO CHILDREN'S COGNITIVE FUNCTIONS. PHOTOS ON PAGES 19–23 BY JUSTIN BROWN

Dr Francisca Mutapi is a Reader in the School of Biological Sciences at the University of Edinburgh. She focuses on global health and tropical diseases, specialising in the study of bilharzia. She gained her first degree in Biological Sciences at the University of Zimbabwe, then studied for her DPhil in Biological Sciences at the University of Oxford, as a Beit Scholar. She then worked at the Institute of Tropical Medicine in Antwerp and went on to lecture at Oxford (Department of Zoology), Birkbeck College (Department of Microbiology) and the University of Glasgow (Department of Clinical Veterinary Studies), before she moved to Edinburgh on an MRC Training Fellowship.

When she was growing up in Zimbabwe, Francisca Mutapi was warned to be careful of snails – they could make you fall sick. Nowadays, Dr Mutapi knows better than most that one of Africa's most troublesome diseases, bilharzia, is caused by a worm which develops in freshwater snails, but she also knows that humans are responsible – the parasite is spread when people with bilharzia urinate and defecate in freshwater rivers and lakes, where the excreted eggs hatch and multiply inside the snails. And not only does she have a scientific understanding of how the disease affects hundreds of millions of people worldwide, she has also

done something about it, to improve treatment and reduce the numbers who contract it in the first place.

Bilharzia (also known as schistosomiasis or snail fever) is the second most prevalent tropical disease in Africa after malaria, but even though malaria is one of the world's greatest killers, bilharzia can lead to complications such as chronic fatigue and anaemia, as well as poor growth and cognitive functions, and even potentially fatal conditions such as bladder cancer and increased susceptibility to HIV/Aids. Another problem is that it often eludes diagnosis for years; e.g., professional cyclist Chris Froome, who wasn't diagnosed for several years until a blood test in 2010. Froome's team believed the treatment of his illness may explain his "rapid transformation" from 84th place in the Tour de France to winner in 2013. Another celebrity victim, Prince William, contracted the disease on safari in Africa in 2003 and went for treatment in Dundee at Ninewells Hospital.

“not only does she have a scientific understanding of how the disease affects hundreds of millions of people worldwide, she has also done something about it”



The disease was also documented in the Dead Sea Scrolls and ancient Egypt, where 5,000-year-old mummies have been diagnosed with the infection. It has also been suggested that bilharzia was the cause of the biblical “curse of Jericho”. Worldwide, says Mutapi, bilharzia affects about 250 million people, with 700 million more at risk of infection. One of the problems is that clinical signs are diverse, including blood in urine, which can lead to misdiagnosis; and if untreated, further complications such as fibrosis and calcified bladder, or enlargement of the liver, spleen and kidneys. In some regions, when young men pass blood in their urine, it is seen as a sign of maturity and can often go unchecked for years. That’s why education is a key part of the global solution, says Mutapi. You not only have to avoid risks, but also recognise symptoms in order to treat it correctly.

The progress of bilharzia is very unpleasant – the larvae of the parasites enter the bloodstream and when they mature and mate, the eggs laid by the females cut their way out of the blood vessels into the intestine or the uro-genitary tract, causing wounds which can become infected or expose sufferers to sexually transmitted diseases

including HIV/Aids. When they’re at the stage infective to humans, the parasites are also quite “clever,” Mutapi explains, because they seem to know the time and adapt their behaviour by coming out of the snails into the water to fit in with their hosts. Experimental studies show that when snails are moved from areas where the hosts come to the water in the morning to areas where the hosts come to the water in the evening, the snails change their ‘infective parasite-shedding patterns’ from morning to evening.

The disease is also found in other regions of the world apart from Africa, including South America and China, and has also been recently detected in Corsica.

The learning curve

Mutapi’s knowledge of bilharzia has developed over other years of study. And today she is also a determined scientist, advocating evidence-based control strategies, who has played a significant role in persuading governments in Africa, as well as the World Health Organisation (WHO) and leading pharmaceutical company Merck KgaA, to make bilharzia control a public health priority.

The story starts when Mutapi was at university in Zimbabwe, studying biology under her mentor, Vic Clarke, who introduced her to the study of bilharzia and other parasitic diseases. After graduating in 1991, Mutapi spent the next two years at veterinary college, then won a Beit Scholarship which enabled her to go to the University of Oxford to gain her doctorate, studying under Professor Mark Woolhouse, now the Professor of Infectious Disease Epidemiology at the University of Edinburgh.

For Mutapi, going to Oxford was a major decision. At her interview before she went, she was “interrogated” by a roomful of academics and leading professionals who revealed that her mentor (who also gave his protégée an excellent reference) had told them that her plans to go to Oxford were “completely against his advice” – and nobody dared contradict him, Mutapi explains, with a smile.

When she got to Oxford in 1993, bilharzia became the major focus of Mutapi’s research, and gradually the evidence began to point in several clear directions. In places where there was high transmission, there was also high resistance to infection, and this suggested people could acquire protective immunity to the disease. The big question was how – and what were the immunological mechanisms which lead to this immune resistance?

To answer these questions, Mutapi did extensive field work, asking boys and girls in Zimbabwe to allow her to study their urine, faeces and blood. And the “biggest compliment” Mutapi received at the time was from a colleague working on a laboratory model of the disease who said her results were as good as the data you’d normally gather from mice in the lab – a world apart from field work in rural Zimbabwe.

Mutapi was most interested in analysing differences in acquired immunity and tracking the progress of young people given a drug called praziquantel, developed by Bayer in the 1970s, which seemed to make the younger people’s immune systems mimic those of older people with resistance to bilharzia. Her hypothesis was that the drug was acting in the same way as a vaccine, presenting parasite proteins to the host immune system which led to a protective immune response. “We knew it worked in killing the worms,” says Mutapi, “but it seemed there were also additional longer-term benefits beyond killing the worms. It seemed the drug could also be used as a vaccine and thus prevent the clinical symptoms, as well as reduce re-infection.”

After publishing her Thesis, Mutapi went to Antwerp to continue her research, and got involved in solving an interesting puzzle. After the authorities in Senegal had built a dam in order to improve the production of sugar cane, there had been an epidemic of bilharzia among local people. The studies in Senegal confirmed Mutapi’s original results that treatment of bilharzia-infected people in this epidemic environment also resulted in a change in their immune system, promoting responses associated with reduced re-infection. And she continued these studies when she returned to Oxford to take up a departmental Lectureship in the Zoology Department.



DR FRANCISCA MUTAPI

Around this time, Mutapi applied for a number of posts and was faced with a difficult choice when all the applications were successful at once. In the end, she took on two of the jobs – lecturing at Birkbeck College (where one of the interview panel was Professor Tim O’Shea, now Principal at Edinburgh) and the University of Glasgow, before she moved to Edinburgh in 2001. “Some people said I was mad to leave Glasgow, because I had a tenured position,” Mutapi reveals, “but I wanted to learn more about the immune system and the mechanisms involved in disease, including proteomics.” Mutapi also realised she needed to develop her “molecular and immunology techniques,” to address the questions she was asking, and this drove her decision to go to Edinburgh to work with Professor Rick Maizels at the Institute of Immunology and Infection Research, “and focus on the immunology and molecular biology of the host–parasite relationship.”

This new research enabled Mutapi to identify more candidate proteins for bilharzia vaccines in one single year than the collective effort in the field had produced in the preceding decade. But despite this progress, the question remained: “Why does it take so long to develop protective immunity naturally in humans? And how does treatment speed it up?”

“ it seemed the drug could also be used as a vaccine and thus prevent the clinical symptoms, as well as reduce re-infection ”



To attain protective immunity, Mutapi explains, the body needs a certain amount of the relevant proteins, and because the worms live for a long time, it can take decades to attain this protective “critical protein mass” naturally. “It’s no good waiting several years for all the worms to die,” she says. And this led to the realisation that treatment provides this critical mass by killing all the worms at once. It also followed that if treatment works so well, why not treat the whole population to prevent the disease from getting a foothold to start with?

The road to effective treatments still faced a lot of scientific obstacles, however, including the hygiene hypothesis – the suggestion that if you get rid of the worms, people will get sicker by exacerbating other conditions such as asthma. To counter this, Mutapi and colleagues got funding from the Wellcome Trust (2006–2010) to conduct research on “immune modulation,” proving that the treatment would not induce harmful responses to other conditions. Thus, in addition to giving more detail on how drug-induced resistance developed in treated people relative to naturally acquired resistance, this study also proved that treatment of bilharzia did not result in worse health for the people receiving the treatment.

Get them young

The next challenge faced by Mutapi was back in Zimbabwe in 2010, when she played a key role in persuading the Ministry of Health to conduct a national bilharzia survey. Health officials recognised the scale of the problem, but getting a national control programme underway was another matter entirely. Learning from colleagues in Zimbabwe who had run very similar programmes for HIV/Aids, Mutapi and collaborators from Zimbabwe got support from UNESCO, WHO, the Ministry of Health and other stakeholders to develop a control policy, draw up a plan of action and budget for a five-year National Bilharzia Control Programme. The control programme was launched in 2012 to annually treat all school-age children in primary and secondary schools in rural areas throughout Zimbabwe. The control programme in Zimbabwe has so far been such a success that it is being used as a model example by WHO, and Mutapi’s colleagues in Zimbabwe are now involved in helping roll out bilharzia control programmes in several African countries – targeting a total of 100 million young people.

But even that was not enough for Mutapi, because the control programmes were targeting only school-age children and neglecting preschool children and infants: “We proved that the drug is effective,” she continues, “but why only give it to children aged six and above? Why not infants and pre-school children as well? After all, small children are exposed to the infective water just the same as everyone else.”

There were several reasons for neglecting these younger children. The first problem was that there had not been clinical trials for the safety and efficacy of the drug in children less than four years old; so that was the next step, followed by the need to develop a form of the drug that would be easy to administer to infants – the tablets are too big and have a bitter taste and WHO no longer recommends liquid formulations for children. Mutapi and colleagues communicated the need for a soluble, better-tasting tablet for young children to WHO, which then presented their case at the London Declaration of Neglected Tropical Diseases in 2012 (supported by WHO, the World Bank, the Bill

& Melinda Gates Foundation and the world’s leading pharmaceutical companies), which set out a roadmap for a new approach to tropical diseases, including the development of new drugs for bilharzia. And late in 2015, Merck KGaA announced a new paediatric formulation for bilharzia – the latest advance in the battle against the disease. This drug is now awaiting clinical trials to which Mutapi will contribute.

For Mutapi, the fight never ends. She has focused lots of energy on trying to understand bilharzia and how best to control it. She has also played a major part in launching health initiatives which promise to reduce the worst effects of the disease; not just fatigue and cognitive problems but low productivity and sometimes fatal conditions. And after her success in Africa and global health, Scotland is next on the list. Her expertise is being funnelled into the Health and Well Being working group set up by the YAS to address equality and poverty issues in public health, starting with communication and education.

“ For Mutapi, the fight never ends. ”





Dr Nasar Meer is a Reader in Comparative Social Policy and Citizenship in the Faculty of Humanities and Social Sciences at Strathclyde University, a Routledge 'Super Author' and a Royal Society of Edinburgh (RSE) Research Fellow. He was previously at Northumbria University, a Lecturer at the University of Southampton, and a researcher at the Centre for the Study of Ethnicity and Citizenship (CSEC) at Bristol University, where he remains an Honorary Fellow. In 2013, he was a Minda de Gunzberg Fellow at Harvard University, a Visiting Fellow with the Institute for Advanced Studies in the Humanities (IASH) at the University of Edinburgh, and a member of the British Council's Outreach Programme. He studied at the Universities of Essex, Edinburgh and Bristol, and has held visiting fellowships with the W.E.B. Du Bois Institute for African and African-American Studies, Harvard University, and the University of Aarhus. He was elected to the Young Academy of Scotland (YAS) in 2014.

"We think we choose our topics, but sometimes our topics choose us," says Dr Nasar Meer, whose subject for the last few years has been something close to his heart – and his family background.

Meer's parents came to Yorkshire from Pakistan in the early 1960s. His father worked in cotton mills and timber mills, and his mother was trained as a teacher, but she could not teach when she arrived here because she was only qualified

to teach in Urdu and soon had a young family to raise. Both parents were determined that their children got a good education and Meer went on to get his first degree in politics and sociology at the University of Essex, before heading to Edinburgh to do his Master's degree – and meet his future partner. After graduating in 2002, he spent a year "knocking on doors" doing social statistics in Glasgow, then something happened that completely changed the course of his career – 9/11.

What happened that day and the events it triggered had a huge impact on Meer, and got him asking questions like: "Where do Muslims fit in public life?" Such enquiries also took him to the University of Bristol, to study for his PhD under Professor Tariq Modood, the founding Director of the Research Centre for the Study of Ethnicity and Citizenship. "My family had mixed views on my choice of topic," says Meer. "They wondered why I chose to study faith and identity even though I was not religious, but I explained it had little to do with religion as belief."

Nowadays, Meer finds himself asked all the time about Muslim affairs. "The more you work with a particular topic, the more it draws you in," he explains. "and you quickly become what people describe as an expert."

Meer changed the title of his Thesis several times. It started as *An anthropology of how young people practice their faith and how they define their identity* and evolved into a study of *Citizenship and 'double consciousness'*, based on qualitative field work and policy analysis, but also drawing on the British Social Attitudes survey and Home Office data.

"I guess there was a novelty to Muslim identity," says Meer, "still forming and finding its feet – which I came to name Muslim consciousness in my first book. The core issues that I focused on – the relationship between Western, and especially British, Muslim identities and prevailing citizenship regimes – remain as topical as ever and in many respects have become more salient than seemed possible when I started."

One of Meer's conclusions was that younger Muslims in Britain have a different 'Muslim consciousness' to that of their parents. They are largely "uncoupled from traditional languages" and read the holy texts in English, while their parents' views are coloured by "a tapestry of oral customs" and traditional stories. As a result, the younger Muslims tend to learn about Islam in English and are curious to find out more, while the older generation tend to follow their faith as a matter of routine. "Minority identities have changed and developed over time," says Meer. The first phase was the "familiar old story" about immigrants settling down in a new country, the same as any other group, like West Indians in the post-Imperial era. In the second phase, generations "re-imagine their identities," in much the same way as "nations are imagined communities."

Meer also says that national identity and ethnic identity are two different things, and vary from country to country. For example, ethnic minorities in England tend to see themselves as "British," while in Scotland they're more likely to define themselves as "Scottish."

There are also different notions of citizenship and identity in England, where many Muslims want similar kinds of "accommodations" in schools to other religious minorities, and "decent political representation," as well as stronger anti-discrimination laws. But one of Meer's key observations is that "Muslim identity is often reduced to religious belief alone, in a way that overlooks how Muslims have used the category of 'Muslim' without any unanimity on Islamic matters (precisely in fact as Jewish minorities have historically negotiated and continue to debate what being 'Jewish' means). This point is not widely stressed." The events of 9/11 may have changed the public attitude to Muslims in Britain, but Meer points out that there have also been similar "controversies" in previous decades, including the fatwa on the novelist Salman Rushdie in 1991. In one way, the story of Muslims in Britain has been progressing on parallel tracks, he suggests, with foreign affairs shaping people's perceptions at the same time as integration and pluralisation continue, regardless of what happens overseas.

“Scotland's independence Referendum shone the spotlight on ideas of identity and nationhood like never before.”

The Muslim community also plays a major part in civic society and welcomes internal debate. "There is much more to it than many people think," says Meer, "in terms of media and cultural consumption – even dating." For most Muslims, what goes on abroad is not the biggest issue, and Meer believes that the success of the community is reflected in the diversity within Muslim society, which sees itself as just the same as other communities but, at the same time, "not pretending not to be Muslim."

In his studies of citizenship and identity, Meer also takes account of attitudes versus behaviour, saying it can be misleading to focus on what people say, rather than what people do. Social scientists should never ignore what they hear – it's all part of the data they gather – but they are always after concrete evidence.

Social scientists can also use their evidence to puncture myths and stereotypes, according to Meer. For example, "Index of Similarity" surveys suggest that Muslims are more "geographically dispersed" than most other ethnic or religious minorities – unlike the concentrations of some groups, they tend to spread out all over. "What Muslims can't control," Meer says, "is the rate at which white ethnic groups around them move away and retreat to the suburbs."



DR NASAR MEER

“There is still a lot of tension, but there's also momentum. And social scientists can help us move forward together by telling a valid and compelling story.”

Seismic events

Meer's career has been deeply affected by three different "seismic events," starting with 9/11 in 2001. The next event was European enlargement in 2004, which allowed him to research patterns of migration and citizenship and consider how different European Union members have incorporated or excluded religious minorities. "It was a more optimistic time for the idea of a cosmopolitan and open European Union," says Meer, even though the reality sometimes was very different to the "open and pluralistic" rhetoric of policy makers. Most nations, he reflects, continue to define themselves according to ethnicity, language and a "glorious history," but sometimes they also rely on religion in their efforts to "re-imagine the nation." To some extent, this is also true of Europe as a whole: "With the refugee crisis, with the horrors of terrorism, we see the idea of a 'Christian Union' re-emerging," says Meer.

The third event to change the direction of Meer's academic career was Scotland's independence Referendum in 2014, which shone the spotlight on ideas of identity and nationhood like never before. This led to an RSE Fellowship to focus on *To what extent has Scotland developed a distinctive approach to citizenship?*

According to Meer, the Scottish Government and the UK Government are starting to take different approaches to equality policy, even though this matter is largely reserved. He believes there is a 'policy window' in Scotland on this area, even though the Scottish approach relies on rUK components.

The debate about Scottish independence continues to have a huge impact. "We can't look at notions of citizenship independent of the national question," says Meer. "It is linked to 'What is Scotland?' and what we want Scotland to be in the future. Do we do things differently, and if so, how and why?"

In Scotland, he explains, employers are required by law to gather data on employees and "monitor ethnic minority participation." This means the Scottish Government has opened up a space in

equalities policy through the "Scottish Specific Duties," even though equalities is still largely reserved.

On identity issues, Scotland is generally different, says Meer. Ethnic minorities regard themselves as Scottish, unlike ethnic minorities in other countries which have had referendums, such as Quebec, or countries that would like referendums, such as Catalonia and the Basque region.

On the other hand, Scotland has never really been "stress-tested," Meer says, in terms of dealing with a significant population change and the politicisation of this in electoral terms. Nor has Scotland responded to the controversial accommodations which have been sought in England – e.g., legal pluralism and Sharia Councils – or embedded a routine anti-racism which England has seen for decades. Nor is it clear to Meer how Scotland will "re-make" the national story and national symbols, asking: "The Saltire is a Christian cross. Will that be up for revision in the way the Canadians changed their symbol from a cross to a maple leaf?"

Controversial territory

Is there a no-go area between politics and social science? How does a social scientist remain objective dealing with issues which so many other people feel so strongly about and see primarily in terms of ideology? For Meer, the social sciences use the same basic principles as other scientific disciplines to prove or disprove any theory, but sometimes it's hard to avoid getting into controversial territory.

For example, current arguments about immigration to Europe have polarised political opinion, but social scientists have had to be more balanced in their study of the problem. Meer and his colleague, Dr Daniela Sime, (also a YAS member) have written a short article about the "myths" repeated in the media about immigration, debunking statements such as "taking some immigrants now will encourage more to come" and "immigrants come for the benefits, they don't contribute," which was published in the YAS blog, *Research the Headlines*.

Meer quotes another common statement that "some migrants may be radicals," but points out that radicalisation occurs via the Internet, rather than face to face or via what people perceive as "invasion." And Meer believes that it is possible to remain "scientific" regarding these topics by studying the evidence and how this is or is not used. "The social sciences use similar methodologies to tell a story about how societies have evolved and how they might continue to do so, and while these are no less rigorous, we also want to understand how people 'interpret' the world and then 'act' on these interpretations," says Meer. Sometimes, however, no matter how much social scientists quantify data, non-social scientists say it is "just common sense."

In Meer's opinion, the current immigration debate maps onto other issues which are centuries old, even though the urgency of the recent "crisis" can distort public opinion. It is also very close to Meer's specialist subject – nationhood, citizenship and identity. Quoting Pericles, who said "we are we because we are not they," Meer explains that even though the modern world is a different place, making it much easier for people to communicate and travel, and work in virtual offices, many of our notions of identity have hardly changed at all, and many of the risks we face are also very similar. "Ben Franklin said something like, 'those who sacrifice liberty for security deserve neither,' and I tend to think that we should approach rebalancing our security and liberty with great caution," says Meer. "Above all, we should be careful not to characterise the issues as peculiar to our times."

Ultimately, Meer is most concerned with our priorities as a society – most of the things we want are secondary to having a harmonious society, because this is the prerequisite to enjoying the things that we want. "We have to reconcile diversity and unity," he says. "There is still a lot of tension, but there's also momentum. And social scientists can help us move forward together by telling a valid and compelling story."

Research the Headlines



DR SINEAD RHODES TAKES THE YAS PROJECT TO SCHOOLS

***Research the Headlines* is a project set up by the Young Academy of Scotland to improve the general public's understanding of research, and improve communication between researchers and the media. To achieve its aims, it publishes a blog which highlights both good and bad reporting and encourages people to dig deeper into the facts. Sometimes, the blog also publishes stories the mainstream media seem to have missed...**

If you believe everything you read in the papers, then cancer is cured every day, scientists discover genes for everything under the Sun and there are aliens living on comets.

Every day, the media are full of sensational news about the latest scientific research: "Chocolate makes you live longer, red meat causes cancer, avocados are fattening, Alzheimer's disease is infectious, magnets make you less superstitious, people with tattoos are more rebellious, wine is good for you, etc." Sometimes, there is good news and bad news together: Google may be ruining our memories but eating grapes may prevent memory loss.

Many people take such dramatic announcements with a large pinch of salt, but misleading headlines can do lots of damage to the research community as well as the press,

not only by misrepresenting research but by encouraging a cynical view of reporting of science in general. Some members of the media may even have biased agendas which they wish to promote – e.g., their views on climate change – or be more willing to sensationalise in the race for greater audience figures, promoting urban myths and conspiracy theories. And when this affects vulnerable people or government policy, "bad science" can be dangerous as well as very costly.

The media are not to blame for everything, however. Researchers can present their findings badly, or simply do bad research. Communications consultants and press offices can also distort what their clients are trying to say, so the media end up repeating – and sometimes amplifying – the errors.

“**“bad science” can be dangerous as well as very costly**”

“We all have an equal interest in improving the presentation of science and ultimately people’s understanding of science.”

These are just a few of the issues discussed in a blog called *Research the Headlines* set up by a diverse group of researchers from the Young Academy of Scotland (YAS) just over two years ago. The original aim was to use the blog as a platform to educate the general public about how research is reported, at the same time as to improve communication between researchers and reporters, with the motto, “don’t stop at the headlines.” And the idea has blossomed since then. The blog’s success is evident from its recent selection as one of ten finalists in the UK Blog Awards 2016, with the winners to be announced in April at a London awards ceremony.

“Everyone should take responsibility,” says Dr Sinead Rhodes, a Senior Lecturer in the School of Psychological Sciences and Health at the University of Strathclyde, founder and co-chair of *Research the Headlines*. “We all have an equal interest in improving the presentation of science and ultimately people’s understanding of science.”

Rhodes and her team are also quick to praise good reporting – when it’s accurate and educates people on issues which matter. “Things may get lost in translation,” says Rhodes, “but if you search the media, lots of good research gets excellent coverage.”

The idea of *Research the Headlines* is not to knock the media or anyone else, Rhodes explains. “When we pick up a paper or read stories online, we hope that the reporting is fair and accurate. Many times it is, but sometimes the reporter, the press officer or even the researcher can get it wrong,” Rhodes wrote in *The Herald* last year. Let’s not forget, she adds, that very few reporters have been trained as researchers.

Another problem is when “scientific research” has no evidence to back it, or when the study is poorly conducted – e.g., the sample is too small or biased. One example of this is the headline, “Two minutes exercise will stop ageing,” which appeared on the front page of a newspaper last year, based on a study conducted with 12 participants. Dr Alan Gow, an Associate Professor in Psychology in the School of Life Sciences at Heriot-Watt University and co-chair of *Research the Headlines* alongside Rhodes, blogged about that very coverage. Gow notes: “This was a front-page splash, and many would be forgiven for thinking that position necessarily denotes a strong and robust study methodology. The headline leaves no room for doubt either; it didn’t say ‘two minutes exercise might be good,’ or ‘better than nothing,’ it said this ‘will stop ageing.’ Sadly, this seemed to be a case of an over-zealous press release, and the research paper actually showed no benefit for the intervention reported versus a control group.”

Sometimes, says Rhodes, there is actually little or no research study behind the news item, and efforts to trace the evidence lead to an opinion in a book or similar article, not a proper scientific study.

“It’s all about miscommunication,” says Rhodes, whose introduction to the media eight years ago was a lesson she’ll never forget. Rhodes had published two separate papers describing her research on Attention Deficit Hyperactivity Disorder (ADHD) and a parallel study in the use of stimulant medication (Ritalin) to treat ADHD. One month later, a journalist then wrote a story based on the two papers published by Rhodes, making a misleading connection between them, but Rhodes was unaware of this until a few months later. “My main concern was that the story had misrepresented my findings,” says Rhodes, “but I was also surprised at the process – how long it took for the story to get in the paper, and the fact that I had not been asked for a comment.” This experience persuaded Rhodes to join a committee set up by the British Psychological Society to liaise between researchers and the media, and later she became Press Officer for the Society – a stepping stone towards *Research the Headlines*.

How the project took off

Research the Headlines was set up in 2013 to help the media, researchers and the general public “have a better feel for how well findings are represented, or highlight examples that might not justify the coverage.” Rhodes also says the group was inspired by the NHS health blog *Behind the Headlines* and wanted to broaden the scope of the project by capitalising on the multi-disciplinary skills of YAS members. Another inspiration was Sense About Science, a charitable trust which sets out to help people “make sense of scientific and medical claims in public discussion.”

The original title for the YAS project was “media relations,” but Rhodes and her team felt that this would send out the wrong message, because their intention was not just to help the researchers but also the press and the public.

About 30–35 YAS members have been involved with the project since it started, but anyone can make a contribution to the blog, which is updated about twice a week. Rhodes herself has written a number of posts on her specialist subject, cognitive functions in children, asking, for example, whether dummies delay babies’ speech or if iPads are bad for young children.

In the process of addressing the media issues, the project also helps with general research education by giving helpful pointers on the basics of various subjects including statistics, e.g., how to assess what risk means and the difference between correlation and causation. This means the project may be greater than the sum of its parts, because it encourages people to be more enquiring and learn more about general science and health. “We talk about how research is presented,” says Rhodes, “and to some degree, this stimulates interest in science in general.” Gow adds: “We know many of our readers will not have had previous training in research, so for them, general tools for interrogating research being reported in the media might be as useful as providing additional details on some specific topic.” The ‘How To’ series produced by the group is often referred to in its more regular posts, highlighting the simple but recurring issues in research as reported in the media, and explaining how to weigh the evidence and how research is conducted.

For Rhodes and her colleagues, it’s also important to point out that their work will not be the last word on science or media issues. They also have to practise what they preach. “We can never be fully objective,” says Rhodes. “We try to stick to general principles and if we express an opinion, we make clear it is an opinion, rather than a view based on the scientific evidence.” After all, adds Gow, the group wouldn’t want to break one of its own How To tips: “Exaggeration and opinion versus research evidence.”

Miscommunication may be the heart of the problem, but sometimes truly “sensational” stories can slip through the media net, and this is dealt with in a section called ‘Under the Radar’ Another useful section is the blog’s ‘How To’ guides, explaining how to weigh the evidence and how research is conducted.

Rewrite the Headlines

Out of the initial project, another idea emerged – *Rewrite the Headlines*. Funded by the British Academy and the University of Strathclyde, this was a competition run by Rhodes and Gow. Primary schools across Scotland were invited to take part, and over 5,000 pupils from 95 schools were registered. *Research the Headlines* contributors, other YAS members and university colleagues then visited many of the schools to run workshops with the children, and where the group couldn’t get to a school, materials including a short video were provided so the school could host its own workshop. The plan behind the workshops was to “explore what research is, where it comes from and why understanding new findings might be important, before showing how those often specialist descriptions are translated into news stories.”

After a workshop with a YAS member or teachers using the group’s materials, the pupils do three things:

- 1 Find a story
- 2 Rewrite the headline
- 3 Explain the thinking behind their new headline



“ Rhodes believes it’s important to reach out to children as soon as they start to read about science in the media ”

Most pupils soon discover how hard it is to “rewrite the headlines.” How can you be concise and accurate and also be punchy? The tendency is to write much longer headlines, says Rhodes, because it is hard to include all the relevant facts.

For example, one headline suggested: “Chocolate is good for you – official.” One pupil rewrote this to say: “Chocolate is good for you but only if you eat a wee bit.” But above all, says Rhodes, the message to the pupils is always “don’t stop at the headlines” – read the whole story, look for clues and check the source of the story, then find out more and make up your own mind.

Rhodes believes it’s important to reach out to children as soon as they start to read about science in the media, and has found that children as young as nine are already aware of research. Rhodes is also keen to stress that the group draws attention to good reporting as well as inaccuracies, whether from researchers or the media, so people can “evaluate the research evidence that will affect their lives.”

While the primary school workshops focus on headlines, and going beyond them, the competition also included a stream for undergraduate students. Their task was to find a media report on some recent research, and write their own blog “highlighting the good, bad and (if necessary) ugly,” comparing this with the original published research. Gow explains: “We know our students have the necessary skills in critically evaluating research, and we want to let them showcase those skills with this new competition. We feel it’s also important to remind them that their skills can and should extend beyond their coursework; they need to remember to use those skills in continuing to question the information presented to them, no matter what context that’s in, and become critical consumers of it.”

As with the blog, the competition is careful to not be another exercise in “bashing the media” from the comfort of an academic ivory tower. Both Rhodes and Gow note that a balanced approach is required, especially when the report or the research completely misses the mark, because this ensures a dialogue between researchers, the media and the public in general.

Gow adds: “We know that the media reporting of research can often be very good, but there are also a number of potential weak points in the process where inaccuracies sneak in. Discussing those weak points and known pitfalls in as constructive a manner as possible will hopefully produce the most benefit.”

The winning primary school class was from St Roch’s Primary and Hearing Impaired School in Glasgow, who turned the recent headline *Processed meats do cause cancer – WHO*, into *Eating processed meat slightly increases risk of cancer*. Abbey Wrathall won the undergraduate prize with her blog entry, *So, should you wait until Monday to take your child to hospital?* In her post, the University of Edinburgh student discussed recent media stories about whether “weekend versus weekday” hospital admissions might be associated with poorer outcomes.

Future plans

Future plans include engaging children in the final year of primary school with a broader set of tips on how to research the headlines, and getting their parents involved, as well as focusing on several specialist subjects such as mental health, chronic health and genetics. The YAS team has applied for additional funding, with an emphasis on health education – e.g. diabetes and depression, nutrition and exercise.



DR SINEAD RHODES

“Reaching out more to the eldest of the primary school children we are currently engaging with (aged 11–12), interacting with parents and giving everyone ‘homework’ would greatly extend what we’re doing,” says Rhodes. The idea is for parents to sit down with their children and ask a series of pertinent questions relating to media stories:

- 1 Does the article feature another independent opinion?
- 2 Does it cite the original paper?
- 3 Has it quoted the researcher?

As Rhodes points out, the researcher may not even know that the story has ever appeared, as she learned from her personal experience.

The original vision of *Research the Headlines* was to focus on writing the blog, but the team didn’t want to “get stuck in retweeting,” so the project has gradually shifted its emphasis so that more people are engaged online as well as face to face. Page views have meanwhile increased to about 400 hits a day, and Rhodes attributes this partly to being so active in schools. In addition, the NHS *Behind the Headlines* team now name and link to the *Research the Headlines* website as one of the “Editor’s pick of the blogs” on their own health blog posts.

One day, Rhodes and her team will stand down from their YAS roles, but she is determined to make sure the project continues. And what is her advice to any student or parent who wants to know more about science? “Ask for evidence,” she answers. “Go beyond the headlines – read the full story and look for clues to evaluate it.”

For more details, please go to
<http://researchtheheadlines.org> or follow the blog
[@ResTheHeadlines](#) on Twitter.

Don't stop at the headlines

Research the Headlines (<http://researchtheheadlines.org>) publishes posts on a wide range of topics, drawing attention to bad research and bad reporting – and the problem of writing a story or headline which captures attention as well as the truth.

Making a meal of it

After the World Health Organization (WHO) ranked processed meat as Group 1 carcinogenic, in the same category as smoking, the media made a meal of it and “vegetarians around the world felt redeemed,” cancer researcher Marcos Vidal wrote in *Research the Headlines*. But this does not mean that processed meat is equally dangerous, Vidal explained. “Smoking accounts for the deaths of one million people per year worldwide, while about 34,000 deaths could be attributed to diets high in processed meat.” In addition, wrote Vidal, people could become so tired of hearing that so many factors are carcinogenic that they might choose to ignore this information altogether.

Militant tattoos

“People with tattoos are more likely to be aggressive,” a recent headline in *The Telegraph* suggested. In *Research the Headlines*, Alan Gow explained that the recent research had concluded that more rebellious people “may respond to disappointing and frustrating events by getting tattooed.” They also said tattoos may signify defiance or dissent, or express anger. But the researchers also noted that knowing if someone has tattoos does not necessarily help you predict how aggressive the person may be, or vice-versa. And the content of the tattoo may also be a clue.

The media reporting was generally accurate, said Gow, but it would be misleading to suggest that people with tattoos are angry rebels: “Tattooing might be associated with those traits at a group level (albeit in a very small way), but it’s not predictive of an individual’s likely behaviour.”

Magnetic distraction

“Could your views on God and immigration be changed by using magnets?” *MailOnline* asked readers. “Psychologists have discovered it’s possible to significantly change a person’s beliefs simply by targeting their brain with magnets,” the article continued. “People subjected to this treatment reported that their belief in God dropped by a third, while there was an increase in positive feelings towards immigrants.” YAS member Gavin Buckingham then took a look at the journal which published the original research to see how accurate the story was, and discovered that the problem was the research itself. He concluded: “No comparison of the treatment and control groups’ religious or political ideologies prior to treatment is given in the paper, and each group only contained 19 individuals. With such small numbers, it would only take

one or two more ‘extreme’ individuals being randomly allocated to the treatment group to make such a difference.”

Examining the differences before and after the treatment would also have been more convincing, said Buckingham, who also pointed out *MailOnline* was “not too far off base” in its reporting and included many quotes from the authors, plus relevant graphs from the journal.

At the other end of the spectrum, however, *The Express* wrote: “A bizarre experiment claims to be able to make Christians no longer believe in God and make Britons open their arms to migrants, in experiments some may find a threat to their values.” Buckingham commented: “As far as I’m concerned, such overly-editorialised nonsense has no place in science reporting, diminishing public trust in basic science and generating unnecessary hysteria.”

Fat-headed headlines?

The media love to write about “superfoods” and love it even more when research seems to question their superfood status – e.g., when the *Daily Mail* published the headline: “Are avocados a superfood... or just superfattening?” Even though the article refers to the “high fat content of avocados,” it is also highly positive about the health benefits of avocados, explaining that the monosaturated fats in avocados are considered to be “good fats” – it’s the headline which “could be considered misleading, or certainly very selective,” wrote Sinead Rhodes in *Research the Headlines*. The article also emphasises the healthy role of avocados and similar foods while stressing caution about eating too many. Another headline suggested that “salmon could be worse for you than a margherita pizza because of high fat content,” without mentioning the similar “good fats” in salmon.

Under the radar

Research the Headlines has a section called ‘Under the Radar,’ which recently highlighted a truly “sensational” story published on the Cornell University arXiv server, which revealed that Chinese scientists have been operating a robotic telescope on the Moon for the last 18 months, after its delivery on board China’s first lunar lander, taking advantage of conditions on the Moon to observe the sky in greater detail than is possible closer to home. Because the story had been missed by mainstream media, YAS member Dr Duncan Forgan, a Research Fellow in the School of Physics & Astronomy at the University of St Andrews, and a regular contributor to *Research the Headlines*, wrote: “It’s not very often that I’m utterly gobsmacked when I read the day’s latest physics and astronomy articles, but today I was, thanks to one rather unassuming paper, which hasn’t quite yet made a splash on the news networks.”

A pixel paints a thousand words



DR MHAIRI TOWLER

She is equally at home in a laboratory, an academic conference or gallery. One minute, she is a scientist, then the next an animator or entrepreneur; but even though she wears so many hats, Dr Mhairi Towler is a single-minded person whose animation company is changing how researchers communicate complex ideas in simple ways that anyone (including investors) can see...

It may not be as big as Disney, but Dundee-based Vivomotion is emerging as a leading animator – not making children's cartoons but producing two-dimensional and three-dimensional visuals to illustrate the work of scientific researchers. And CEO and founder Mhairi Towler is the scientist and artist behind it.

When she was at high school, Towler didn't think that she would ever be a scientist, and when she graduated with a PhD in Molecular and Cell Biology from the University of Dundee (UoD), she didn't think she'd ever make a living as an artist. But somehow she has managed to do both at

once by combining her passion for art with her knowledge of science to create a very innovative new type of business. "I did my Higher Art," she says, "and always liked painting and drawing, but this is something totally different."

After finishing her PhD, Towler worked from 2000 to 2004 as a Wellcome Trust Postdoctoral Fellow at the University of California in San Francisco, then returned to Dundee for the next seven years as a Senior Postdoctoral Researcher, focusing on "the role of AMPK in cells and tissue," and completing a postgraduate certificate in teaching and learning in higher education, in her spare time. During this period, she also got involved in several "sci-art" projects working with artists, and "spotted a gap in the market to help scientists explain what they do by using animation." Her motives were not just commercial, however; she also wanted to "bring science to life" and "help translate the work of researchers so more people know what they're doing," including other scientists, investors and the general public. "You could work on an experiment for months," Towler explains, "but no-one would know anything about it."



VIVOMOTION BRINGS SCIENCE TO LIFE

Towler also feels very strongly about animations; not only because they make scientists look good when giving a lecture and attract public attention, but because they can help win new business as well as investment in industries such as biotechnology or pharmaceuticals, where you need to stand out from the crowd.

Towler hatched her plans for Vivomotion while still a researcher, but before she officially opened for business, she decided to go back to university to study animation, and graduated with a Masters in Animation and Visualisation from Duncan of Jordanstone College of Art & Design in Dundee. And by developing her knowledge of the graphic arts and digital technology, Towler was finally able to link up her interest in science and art – and also “connect people in different worlds.”

Vivomotion was set up in October 2012 and Towler’s first client was UoD’s Professor Colin Watts, who needed visuals for a project he was working on to do with proteases – enzymes which break down proteins. Since then, she has worked with over 30 different clients – an average of one a month for fees which range from roughly £500 to £5,000.

While studying for her Masters in Animation, Towler carried out a placement with Dr Paul Harrison from the University of Dundee who was, then, “Artist in Residence” with Epigenesys, an EU-funded research initiative, producing visuals to promote greater public awareness of epigenetics, culminating in an exhibition called *Visions of Epigenetics* at the Cité Internationale des Arts in Paris. In 2015, Towler also exhibited at the Institute of Medical Sciences at the University of Aberdeen; took part in a show called *Transmissions: Exploring the Microbial World* at the LifeSpace gallery in UoD, showing the formation of a bacterial waterproof coating, in collaboration with YAS colleagues Dr Nicola Stanley-Wall from UoD and Professor Cait MacPhee from the University of Edinburgh; and exhibited at *Nature’s Equations* at the Dundee Science Centre.

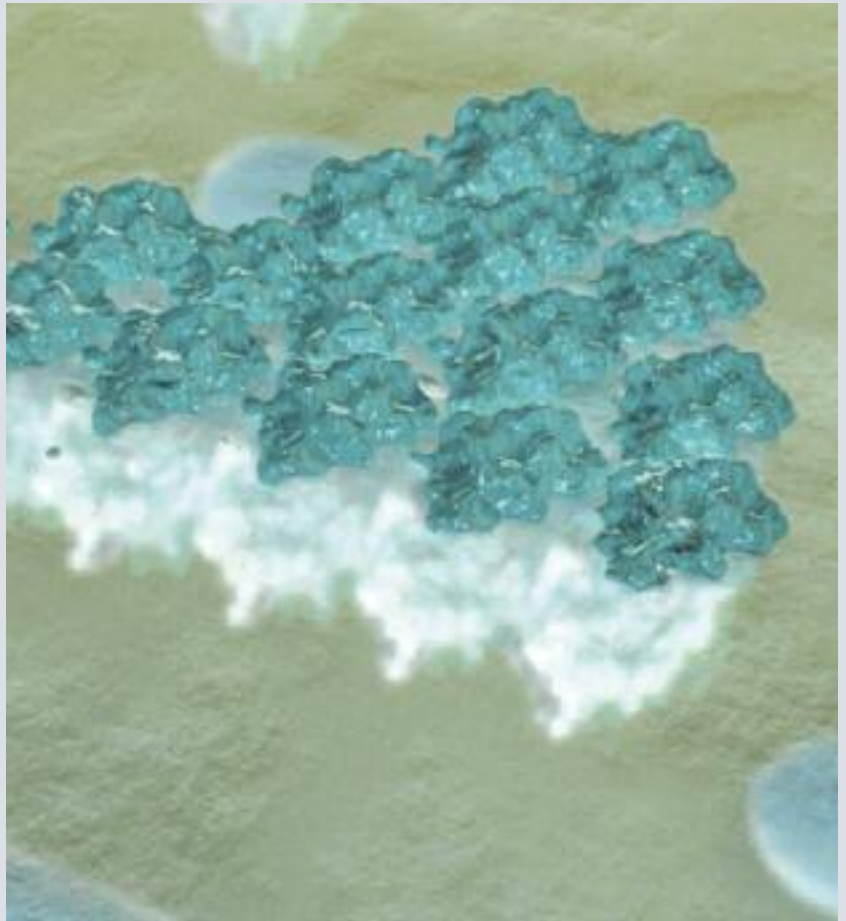
Epigenesys led to Towler’s first experience of working with an international client, holding workshops for biologists and producing an animation called *Epigenetics: Myths, Mysteries and Molecules* for the Institute of Molecular Biotechnology in Vienna. This early success also gave Towler the confidence that her business could “go global,” and she has since worked with a number of overseas clients, including one which resulted from the Paris exhibition, via Twitter, and contacts in New Zealand and the Netherlands.

One of her most challenging projects to date is to produce an animation for a client in Marseilles. According to Towler, the biologist is working very closely with her company to try to explain his research so the artists can create three-dimensional graphics, showing proteins at the molecular level and how bacterial cells move in response to certain signals. The project is particularly challenging, says Towler, because the scientist is having to think very deeply in order to give his instructions, in the process understanding more about the science in three-dimensional terms. As a result, the animations have gone through a number of versions, as the client “crystallises his hypothesis.” For Towler, this is also a good illustration of the collaborative process which is usually needed to produce such animations. The client does not simply tell the artist what to do, but discusses the process in detail, adjusting the visuals in tune with the science.

“And by developing her knowledge of the graphic arts and digital technology, Towler was finally able to link up her interest in science and art”

Down to business

Like any other new business, Vivomotion could apply for different funding streams. Three years ago, Towler got a start-up grant of £3,000 through E-zone at Dundee City Council and used the cash to buy essential hardware and software. She also had support from several other organisations, including Business Gateway Dundee, The Scottish Institute for Enterprise, Cultural Enterprise "Starter for 6" programme and the University of Dundee, winning a Graduate Enterprise Fellowship from the Enterprise Gym which provided her with office space as well as a mentor. But instead of focusing her efforts on start-up competitions and applying for grants, Towler says she was "forced to go out and get clients" – which proved to be the best approach to building her business and also encouraged her to streamline operations, working with freelancers rather than employing people right from the start. Freelance animator Fraser Murdoch has worked with Towler since the beginning, but Towler hopes he will be able to go full-time as soon as the team grows.



“ it takes a rare combination to be able to translate the science into something visually attractive ”

As well as producing bespoke animations and graphics for clients at home and abroad, Vivomotion also runs workshops to help academics present their research at conferences or for publication. Its clients include biotechnology, pharmaceutical and medical companies, science centres and schools, and Towler is confident turnover this year will top £60,000.

Along the way, she's also won a string of awards, including "Independent Woman of the Year" at the annual Women Ahead Business Awards in 2013, the "Most Innovative Start-Up Of The Year Award" from the Association of Scottish Businesswomen and the Principal's Prize for Enterprise and Entrepreneurship from UoD. Most recently, Vivomotion received a special commendation at the *Courier* Business Awards, in the category of Young Company of the Year.

Because she is a scientist, describing herself as "a scientific visualisation practitioner," Towler clearly has an advantage in terms of the jargon, but it takes a rare combination to be able to translate the science into something visually attractive – and accessible to different types of viewers. You also need a business brain to set up any company, and Towler first showed signs of being an entrepreneur while at school, selling earrings at a local craft shop in Fife.

Another major factor in her business development was making visuals for her own research in cell biology, using fluorescent labels for proteins so they could be filmed as they moved through the cell. These may not be Hollywood movies, but 3D animations can make "stars" of bacteria and molecules, and Towler can spot the potential.

In a recent interview with *The Herald* newspaper, Towler said her "biggest bugbear" was "when people think that 30 seconds of animation takes 30 seconds to make." Just like the time it takes to carry out experiments, it takes time to create stunning visuals. It has also taken three years to establish her business, but already she is thinking of expansion, and has ambitious plans to build an animation studio based in Dundee, working for the international life sciences sector, employing a sales team as well as designers. She already has her eyes on the waterfront area being developed in central Dundee, but Towler's horizons are clearly much broader, including e-books and more educational projects. Maybe Disney is the model after all...

Professor Matthew Smith

Historian looks to the future



PROFESSOR MATTHEW SMITH

Professor Matthew Smith is the Co-Director of the Centre for the Social History of Health and Healthcare (CSHHH), Director of Research for History and Deputy Head of the School of Humanities at the University of Strathclyde. He came to Scotland in 2011 after four years at the University of Exeter's Centre for Medical History, where he gained his PhD. His research interests focus on the history of mental health and psychiatry, allergy and immunology, and food and nutrition. He has also written books and published papers on the history of food additives, ADHD (Attention Deficit Hyperactivity Disorder) and food allergy, and has done research on social psychiatry in the US, investigating how psychiatrists and social scientists viewed the connection between mental illness and social deprivation after the Second World War. In 2015, he also played a key role in the launch of an innovative project at Pinkie St Peter's Primary School in Musselburgh "to increase child resilience and wellbeing" in future generations...

After finishing high school in Canada, Matt Smith flipped a coin to decide if he would study maths or history. Twenty years later, as Senior Lecturer in History at the University of Strathclyde, he was visiting a primary school in Musselburgh, East Lothian to watch a group of pre-school children talking to puppets, as part of a project

to improve educational attainment and reduce the number of referrals to child and adolescent mental health services in Scottish schools.

Smith's history as an historian makes colourful reading, and his own experience at high school, combined with his later professional work as a youth counsellor and careers advisor, has had a big impact on his attitude to education and what school is for.

As well as focusing on controversial topics in research such as mental health, ADHD and food allergy, Smith has always been concerned with how we measure educational success and prepare young people for their future lives and adult careers. He is also concerned that parents and the educational system in general have unrealistic expectations which put too much pressure on children, and may even be a factor in the emergence of ADHD in recent decades. Expectations change as each new generation is born, but children do not change, says Smith. The main objective of education should be to ensure every student leaves school with a thirst for education, not just academic qualifications. Everyone should also be able to choose different options – too many people end up doing jobs that make them unhappy. "Having an appetite for lifelong learning is much more important than passing some tests," he continues. "We should be aiming to empower every student." Smith also draws attention to his own university's mission – to be "a place of useful learning" – and says this is consistent with his personal views.

These ideas also come from Smith's professional experience in Canada, where part of his job was to identify adolescents with ADHD and refer them for treatment, as well as work with children from dysfunctional backgrounds who had dropped out of school. They are also the issues which fuelled his later academic career, focusing on medical history, including the history of ADHD, the modern name for hyperkinesis or hyperactive impulse disorder.

Smith himself also admits that he is not immune to career doubts. Even in his late thirties, as an established post-doctoral researcher, he wondered if he would have a future in history or academia. For students with ADHD, the problem can prevent them even finding a career in the first place, but Smith has learned that cause and effect can be complex – involving brain development as well as school environment and social factors. He also believes that a lot of the problem is “less to do with children and what they need and more about what adults need,” and that being diagnosed with the disorder can depend more on where you live than on medical science.

Smith's other specialist topic is the history of food additives, which may also be associated with ADHD and other psychological disorders. For example, food dyes have been blamed for causing hyperactivity and Smith says this is based on historical fact – the food dyes used in industry were based on by-products of coal tar which were also used to develop the first generation of antibiotics as well as early anti-psychotics. “Researchers noticed that the coal-tar dye-based drugs calmed rats down,” says Smith. “And it's historians who make these links – the history of medical science can have a huge impact on our understanding of cognitive disorders, working side by side with psychiatrists and teachers.”

In Smith's opinion, his profession should also be “more bullish” to emphasise how our society got where it is, so we can make better decisions in future and answer the “difficult” questions. “To understand the history of science is empowering to people,” he adds, explaining how our attitudes to mental disorders and medical treatment are closely linked to social and political environment. For example, Freudian psychoanalysis used to talk a lot about our lives as sexual beings, but it was very much a product of its own time and place. It is not that the theory was “wrong,” Smith explains, but developments in psychiatry since then have taught us that Freudianism was not the whole explanation, and tended to revolve around the day-to-day concerns of its middle-class patients, even though members of all classes suffer from the same psychological problems.

Lessons from history also inspire innovation, including the creation of a new educational project at Musselburgh's Pinkie St Peter's Primary School, where Smith has played a major role in partnership with teaching staff and healthcare professionals.

The Pinkie Project

One of the most critical factors in every child's development is what is known as “attachment,” and this is one of the themes of the project at Pinkie which Smith helped to launch



in 2015, with £15,000 of funding from the Scottish Universities Insight Initiative. “It all boils down to attachment,” says Smith. “As children grow up, there are very few people they can trust and turn to for advice, and that is why school has a key role to play, especially if there is no-one at home to provide this role for them.” The other theme is all about building a bridge between school and community, overcoming some of the psychological and physical barriers which sprang up in the wake of the tragic events at Dunblane. On a simple level, this means the community learns about what's going on at the school, while former students are also encouraged to maintain their links with their alma mater.

The project took off after Dr Iain McClure, a consultant child and adolescent psychiatrist at NHS Lothian, heard Smith talking on a radio programme about hyperactivity. McClure was concerned about the number of referrals to mental health services in his own region, and identified Pinkie as a suitable school for a trial because its catchment area is a microcosm of the country as a whole in terms of social deprivation versus relative wealth. And the key question was: “What can we do to improve things?”

“enhancing equality, boosting well-being and realising potential in Scottish schools”

After Smith and McClure shared their thoughts on the subject, they made a presentation together at a conference on “Contemporary Childhood in Scotland,” and invited Sarah Ogden, the Principal at Pinkie, and some of her deputies, to join them to discuss what they could do. Lots of good ideas were put on the table, including the suggestion that educational success should be measured in terms of the long-term results, paying more attention to people’s achievements in later life rather than only at school. “We also agreed it was better to try to prevent problems rather than just diagnose them and treat them,” says Smith.

The motto for the project is “enhancing equality, boosting well-being and realising potential in Scottish schools.” Smith comments: “We knew it would be difficult to tackle inequality, but we also wanted education to be linked with social services and housing; and we also agreed that the challenge was to make the children at the school more resilient.” Two other members of the Young Academy of Scotland who played a key role in driving the project are Stella Chan (a child psychologist at the University of Edinburgh) and Annie Tindley (an historian from the University of Dundee).

The next step was to hold a symposium at Pinkie school, inviting 18 speakers from Scotland and beyond to present ideas on how to boost resilience, improve achievement and prevent mental illness – suggesting everything from yoga to improvements in diet. Soon after this, they organised a workshop for teachers, and out of this emerged a programme of activities now put in action at the nursery school and at primary level, including the puppets. “Children say things to the puppets that they wouldn’t say to anyone else,” Smith explains.

Other activities include a Nurture Room, which helps to “de-escalate behavioural problems” by taking the children away from their classmates and talking to them one-to-one in a secure, non-threatening environment, rather than “sending them for punishment,” excluding them from classes or giving them a talking-to in public. More subtle changes mean that teaching assistants no longer spend all of their time in the classroom but use private spaces for more individual attention. Altogether, it’s a much more sympathetic and constructive approach,” Smith explains.

Another scheme, inspired by the Room 13 arts-based project started in Fort William, involves children from Primary 5–7 interviewing fellow students and local residents for radio podcasts, as well as using the stories for history lessons and creative writing projects. This means that the children are not only learning useful academic and technical skills, such as how to operate the audio equipment, but are also reaching out to the community. “All these activities improve communication and help bridge the gap” says Smith, “but it also helps the children understand themselves and other people better, and boosts their self-confidence and sense of worth.”

How measure success?

Smith recognises there is no simple formula for personal or academic success. For example, South Korea and Finland are poles apart in terms of educational methods, but both rank very highly on the international league tables for educational standards.

As well as questioning the way we measure academic achievement, Smith is also concerned with how to measure the effectiveness of the techniques used at Pinkie. “The teachers can see it is making a difference,” he says, “but how do we prove it?” For example, after the puppets were introduced into the nursery classes, the teachers noticed more interactions and less misbehaviour, as well as much more positive reactions and improved communication, but this is only anecdotal evidence and it will take many years to measure long-term benefits. Independent assessment would help, but that would also require extra funding.

Smith himself is planning an initiative to follow progress over the next ten years, in terms of mental health as well as educational achievement, by interviewing children involved in the project “about their experiences of wellbeing and emotional difficulties... to assess the interventions made at Pinkie.” He also hopes to roll out similar projects to capture the patient experience of the health service in general, using oral history to understand performance, rather than relying on the verdict of professionals delivering the services who may have a vested interest in results.

In medical emergencies, people immediately call for a doctor, but perhaps our politicians and policy makers will turn more to historians in future, if Smith’s research continues to contribute to the complex debate about health and education.

Pinkie: Key Recommendations

- 1 Promotion of wellbeing, resilience, attachment and other components of positive mental health has to be a core activity at Scottish schools in order to prevent mental ill health and to help children reach their academic and emotional potential.
- 2 Schools need to integrate in meaningful mutually beneficial ways with the communities in which they exist.
- 3 Educational services also need to be better integrated with health services, welfare services policing and charities, in order to facilitate better mental health promotion.
- 4 Mental health is multi-faceted and has to be understood as such in order for effective mental health promotion. It is important to recognise all the various factors that contribute to mental health, but also identify the aspects that schools are best placed to effect.



Ambitious for ambition

Dr Olga Kozlova is the Enterprise Creation Manager at Heriot-Watt University, supporting spin-out businesses and enterprise activities. She is also the Director of Converge Challenge, a company creation competition for staff and students at universities and research institutes in Scotland, set up to produce the next generation of entrepreneurs, offering hands-on help and practical support – as well as awarding tens of thousands of pounds to start-up companies with the potential to become successful businesses...

It's a long way from studying fungus in Russia to nurturing young businesses in Scotland, but Olga Kozlova has learned something new every step of the way. And she is passing on her knowledge and experience – and her ambition – to the next generation of entrepreneurs now emerging from universities all over Scotland.

After graduating from Kazan State University with a Master of Science Degree in Microbiology, Kozlova came to Scotland in 1999 to do her PhD research in cell biology, but she knew she didn't want to be a scientist all of her life, and three years later set her sights on going into business. Thanks to an RSE Enterprise Fellowship, she started to

pursue her dreams and established a company called LUTESS, building tools for researchers to help develop anti-fungal drugs. But despite support from Scottish Enterprise's SMART award, Kozlova soon learned her first business lesson when she struggled to raise enough money to keep LUTESS going – most clients wanted bespoke solutions and development costs were too high to make production viable.

Kozlova had many ups and downs in the search for investment: "I spoke to some investors and it seemed to go well, then they invested in my competitors. On the other hand, sometimes you have to say 'No' to investors – when I walked away from one deal, it was probably the best decision I ever made. Sometimes, the relationship may simply not work on a personal level, and that's why you need to have options."

LUTESS closed its doors in 2007 and Kozlova spent the next two years as Business Development Manager at Edinburgh Napier University, helping researchers to form links with business and do collaborative research.

For Kozlova, the challenge was to change the view of companies in Scotland, so they didn't see the universities as ivory towers. "Our job was to talk to both and bring them together as partners," she says, "helping them draw up agreements on funding and timescales."



DR OLGA KOZLOVA

After two years at Napier, Kozlova moved on to Heriot-Watt University, as Enterprise Creation Manager, supporting spin-outs, and soon afterwards took on her job at Converge, to help produce the next generation of entrepreneurs. The programme started “with a blank page” as a business plan competition in 2010 and now attracts almost 200 entries a year, awarding total funds of £100,000, including a top prize of £60,000, plus training and mentoring programmes.

One of Kozlova’s key roles today is to act as a mentor to budding new entrepreneurs, and she also knows what it is like to be mentored. “You can be lucky with mentors,” says Kozlova, “but more than anything, you have to know how to use them. Too much advice can be confusing.”

So what is Kozlova’s advice to young scientists thinking of forming a business? “A lot of graduates come out of university still excited about science,” she says. “They may also be passionate about innovation, but they have to have a product and a market for their offering. They need to know their customers and also be able to pitch their ideas. The science is important but as far as your investors are concerned, they think – science, so what!”

As well as having brilliant ideas and raising investment, entrepreneurs should be careful to focus on some of the basics of business, and not forget about themselves. “It helps to have a business partner,” says Kozlova. “Starting up a business can be stressful and lonely, and sometimes you have tunnel vision, so having someone who can pull you back is useful.” In addition, she says, start-ups should go out and talk to their potential customers, and make sure that there is demand for what they are doing. As an academic, you can publish exciting research but there may be no market for many years into the future. Market reports only tell you so much, says Kozlova – you usually have to find out for yourself.

Running her own company, Kozlova met many different types of investors, including business angels, venture capitalists and high-net-worth individuals. “You have to understand investors and their investment portfolios,” she advises. “You have to find out what’s important to them and how they make their money. When someone gives you money, you should also remember it’s their money, too. And never forget, it’s just business.”

Before you pitch to investors, make sure that you have a product ready for market, and a market which is ready for the product. Also, says Kozlova, build a team, even if it is only two or three people to start with. Engage with customers as early as you can, and if you also manage to generate sales, you will have much more “traction,” she adds. And don’t worry about someone stealing your ideas – at least not to start with.

But even before you reach this stage, she also advises, ask yourself why you want to go into business. Ask yourself if business is for you. And don’t be scared of failure.

How Converge Challenge works

Converge Challenge is designed to help Scotland grow as a “can-do” competitive economy, says Kozlova, by providing the right support at the right time to the innovators of the future. Successful candidates get help in a number of ways, including practical advice on how to measure demand for their products. At business training held every year, there are also lessons in how to pitch your ideas – including the classic 60-second elevator pitch. “We take people with ideas and expose them to the commercial world,” Kozlova explains. “We also help with basic marketing techniques like using social media.”

Converge also “encourages people to get out of the lab,” says Kozlova. “They have to go out to the scary world of business and talk about money.”

Thirty projects are selected for the Converge Challenge shortlist (out of 186 entries in 2015), and the candidates all go for three days of training to learn how to “engage with their market,” write their business plan and make presentations. The Top 30 projects then produce their business plan and ten of them are chosen to go through to the Final, when they pitch to a panel of business “gurus” who vote for the winners.

“ You can be lucky with mentors, but more than anything, you have to know how to use them. ”

Converge Challenge: Impact

- 450 entrepreneurs have entered the competition over the last five years
- 48 entrepreneurs trained in the programme have formed companies – a success rate of 40 per cent
- 80 per cent of these companies have secured funding worth an estimated £14 million and employ about 140 people

“
we need to be much more ambitious.”



For projects which are still at an earlier stage, the Converge Challenge KickStart Awards provide £2,000 in cash for a new business venture, with £1,500 each for the two runners-up. Successful candidates are also fast-tracked to the following year's Converge Challenge Top 30 shortlist. Converge has also set up Social Enterprise awards, in partnership with Firstport, with a first prize of £5,000 and two runner-up prizes of £3,000.

The winners of the £60,000 top prize in Converge Challenge get more than just money, however, they also get business support including access to lawyers, accountants and IP (intellectual property) advisors, plus advice on branding and design. Not everyone can win a top award, but according to Kozlova, all entrants value the experience and the Top 30 also get training and business advice. “They also interact with other people,” Kozlova continues, “and get the opportunity to build their own networks. Some of them are also inspired to do better in future.” About a fifth of entrants also pull out early, or decide that business is not for them. Or it may be too early for some, adds Kozlova.

Converge Challenge also works with other partners in Scotland such as Scottish Enterprise, Enterprise Campus, the RSE, the Scottish Institute for Enterprise and Scottish EDGE to provide appropriate business support, and the entrepreneur “ecosystem” is becoming much stronger in Scotland, Kozlova believes, with more collaboration than ever before.

Changing times

Many business ideas need long-term support, especially in areas such as life sciences, where patent protection and clinical studies are such critical issues, but over the last few years, one of the changes in the business world is the rise and fall of companies developing apps – a market that can change so fast your product could be out-of-date before you even manage to release it. Data analytics is also becoming big business, says Kozlova, and this shows through in companies such as Shot Scope Technologies, a finalist in 2014, which has since secured £415,000 in funding, led by business angel syndicate Equity Gap, plus £50,000 from Scottish Edge, for its innovative “golf performance tracking technology.”

Overall, entrants are becoming much better prepared, says Kozlova, but for all budding businesses, there is less and less money around and it's harder to get. “After 2008, the banks disappeared,” says Kozlova, “and the venture capitalists moved further afield, looking for investments of at least £10–15 million.” The business angels are filling the gap, she continues, and crowd-funding also provides a solution for many young entrepreneurs – in some cases, customers also become your investors.

Investors need an exit, says Kozlova, but the funding climate also needs to change: “We need more gross capital – longer-term investors who buy out the business angels and inject a few million to enable the entrepreneurs to continue to grow the business internationally, as well as get a return on investment.”

So what does the future hold for Kozlova and Converge Challenge? The Scottish Funding Council and eight research-intensive universities (Aberdeen, Dundee, Edinburgh, Glasgow, Heriot-Watt, St Andrews, Stirling and Strathclyde) have already guaranteed funding through until 2018, and the emphasis will be much more on quality and strengthening the business ecosystem. “We want to work more strategically,” Kozlova says, “and focus on the people with the best chance of success.” Another recent change is sending out roadshows to engage with the business community all over Scotland.

As well as her work at Converge, Kozlova is also now involved with the Young Academy of Scotland as a member of its Industry Working Group, and the Business Innovation Forum set up by the RSE. “It's good so many people want to be involved,” she says, “and want to change the world.”

And what does Scottish business need to do to be more successful in future? “We need more companies with the potential to grow – companies of scale,” says Kozlova. “We need to get the pipeline going, aim higher and aspire more. We have some great examples of success but we are not consistent enough. We need role models in a wider range of sectors. We need more opportunities for undergraduates and post-graduates. And we need to be much more ambitious.”

Dr Duncan Forgan



DR DUNCAN FORGAN

Dr Duncan Forgan is a Postdoctoral Research Fellow in the School of Physics and Astronomy at the University of St Andrews. He describes himself as “either an astrophysicist, an astrobiologist or a scientist in search of extraterrestrial intelligence (SETI), depending on who asks the question,” but the focus of his research is the use of numerical simulation to understand star and planet formation, as well as atmospheric models of unusual planetary systems and theoretical calculations of how alien civilisations might evolve and become detectable. He also works on problems related to the emerging field of astrobiology – the study of life in the Universe – which brings together academics from across the physical sciences, including astronomy, physics, chemistry, geology and biology.

Life has never been the same again for Duncan Forgan since he set his eyes on Arthur C. Clark’s famous science fiction novel *2001: A Space Odyssey*. And 20 years later, he is still on a similar quest – using simulation rather than a spaceship in his search for intelligent extraterrestrial life.

“We all go through our dinosaur phase,” he explains, “and I was always interested in space.” His passion for space exploration was also ignited by an inspirational teacher at secondary school, who made him think hard about physics and encouraged him to go to university in Edinburgh to study astrophysics, then become a Postdoctoral Research Fellow at the Institute for Astronomy, also in Edinburgh.

Now based in St Andrews, Forgan came to international media attention in 2009, when he published a paper describing a new algorithm which he had developed to work out the possibility of finding intelligent life forms in space – and suddenly found himself under attack from his colleagues as well as an overnight media star.

The story began after Forgan attended a lecture on SETI (the search for extraterrestrial intelligence) during his first year as a PhD student. Although SETI was outside the scope of his PhD Thesis, Forgan told his supervisor that he had an idea for a project – to create an algorithm for a new simulation which would also improve Drake’s Equation, an argument to estimate the probable number of extraterrestrial civilisations in the Milky Way.



ASTRONOMY CAN BE A "GOLDEN WEAPON" FOR PUBLIC ENGAGEMENT IN SCIENCE

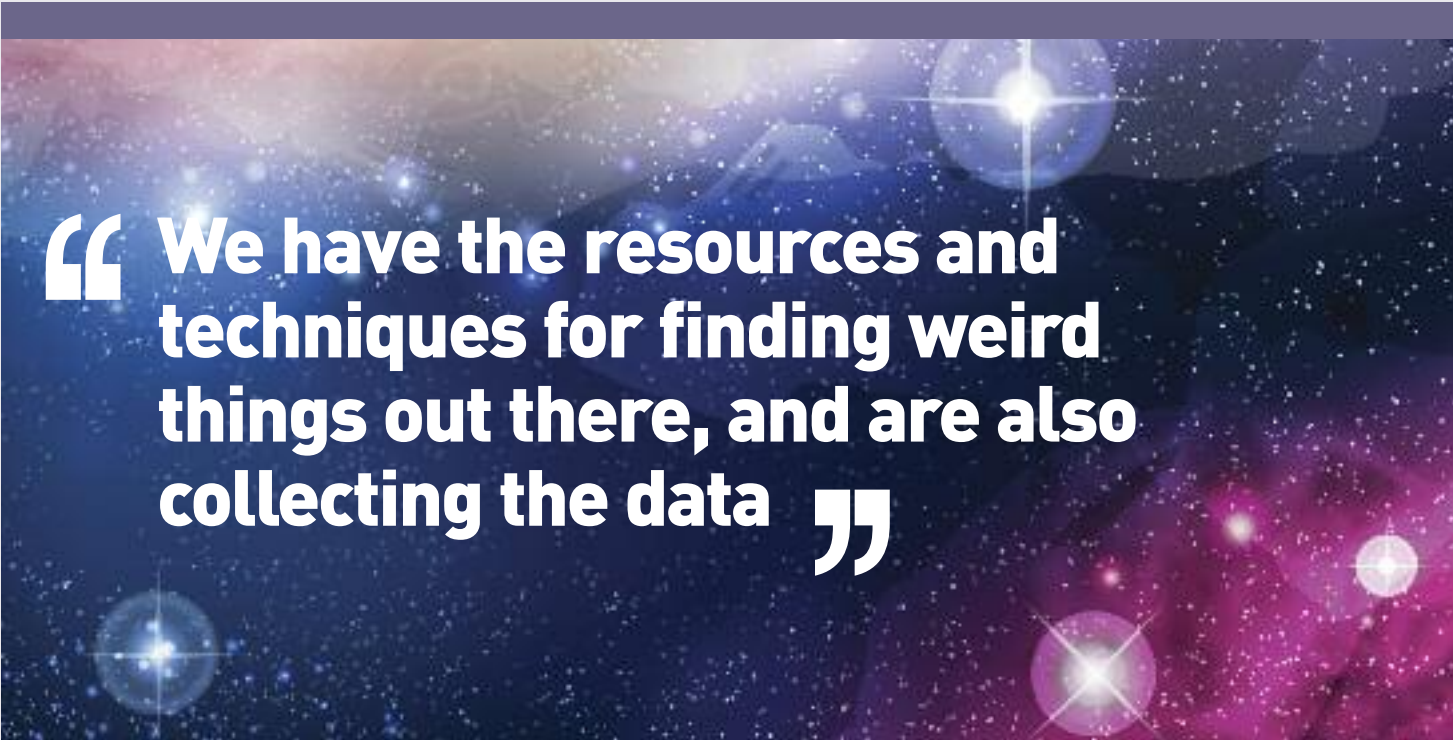
Forgan says the first step in the process is to estimate the simple possibility of life, then the possibility of intelligent life, then the chances of a civilisation which would wish to communicate with other life forms and, finally, a civilisation which has already sent out a signal. In addition, you have to take into account many factors such as habitability, as well as key milestones a planet must pass to survive long enough for animals to evolve and develop complex brains, then go on to develop technological tools.

One problem with Drake's Equation, says Forgan, was that you could "stack it to suit your own theories" however you liked. "It may be useless in predicting intelligent life, but it tells you what the problem is," he also explains. "My improvement was to take what we were learning about extra solar planets, and conduct simulations based on that data, rather than having to squeeze all that data into some very simple terms in Drake's equation." But according to Forgan himself, even this new simulation was not good enough to work out the possible existence of alien life. "It was an elegant approach to the problem, but there are simply too many parameters," Forgan continues. "Key factors also change as life evolves – it is not just a question of where to find life forms, but when."

Other complications are the biological side effects of civilisations emerging and what are called "false positives;" for example, basic theories may suggest you need a constant store of oxygen for life to survive, but there may be alternative ways to replenish supplies. "You can't reduce it to a single equation," says Forgan, "but you can reduce it to a single algorithm, much the same as those employed in war games."

His simulation may not have provided all the answers, but it was a useful tool for building galaxies – and also hit the headlines as soon as the paper was published and found by the press. Forgan thought his paper was "a way of explaining how complex the problem is," but the media focused on a few simple numbers which suggested that he really could predict the probability of alien life. And if the media were right, he says, it must be an extremely busy galaxy, according to the numbers they reported.

In his simulation, Forgan suggested three different scenarios: one which took a generous approach to probability, one very strict scenario and one which assumed there were lots of "just habitable" planets; but a "cosmic storm" erupted when several other scientists accused him of making unscientific predictions, without even reading his original paper. "It was a baptism of fire," says Forgan, describing his appearances on TV and his arguments with colleagues.



“ We have the resources and techniques for finding weird things out there, and are also collecting the data ”

In Forgan's view, the process helped to “quantify our ignorance, and how bad we are at finding the answers,” but the episode was also useful media experience and opened up a few doors in the world of research. He plans to run the simulation over again in the very near future, incorporating lots of new information, including data from the latest Kepler mission, but next time he will exercise more caution. Since reviewing his earlier project, Forgan also questions how we start the search for alien life. For example, do we use radio or optical telescopes? Do we focus our attention on a small patch of sky or study the whole sky at once, looking for very small changes? “Or do we stare out at the universe and look for something weird?” he asks. “All we need to know is what to look for,” he adds, “and how to study the data.”

As part of the search for intelligent life, Forgan also wonders how we would be able to detect dead civilisations, in the knowledge that our own planet now has the power to destroy itself. And if we did detect the signs of “suicidal” civilisations, perhaps we could then learn from their mistakes, he suggests.

The search for intelligent extraterrestrial life will always be philosophically intriguing and stimulate progress in science, particularly in computation, but it also encourages many young people to think about science as a future career. Astronomy in general is another “golden weapon” for public engagement in science, and a major driver of technology – for example, charge-coupled devices in smartphones were first developed for astronomy.

SETI is not Forgan's only passion, however. In his “day job,” he explores the “local Universe” – how stars and planets form from clouds of dust and gas, and how they die, and what makes planets suitable for life. Part of this involves studying brown dwarfs, substellar objects not big enough to sustain fusion reactions in their cores, unlike stars such as our own Sun. Another of his favourite topics is protoplanetary discs – frisbees of matter which form around stars at the same time that solar

systems are born, then go on to form planets. According to Forgan, “we must unlock their secrets if we are to understand the solar systems we see in our galaxy.” His work sets out to help us understand how planets are born in these discs, and how they grow, move and interact with each other to produce the rich variety of planetary systems seen in the galaxy today, as well as the newly discovered “free-floating” rogue planets which wander around without stars.

Although his Master's project focused on the use of data analysis in astrophysics, studying “how the behaviour of super-massive black holes in the centres of galaxies is connected to their neighbours and the surrounding environment,” Forgan knew from early on in his academic career that he wanted to do theoretical work. “As a theorist, the whole thinking process is different,” he explains. “Instead of working with the data you observe to test a theory, you start off with a theory of your own and generate the data that observers might see.” He is also keen to stress the contribution of astronomy and physics to science in general and to our sense of perspective. “The more we learn about how the Universe works,” he explains, “the more it puts us human beings in context.”

Forgan's career path has taken him to interesting and “unexplained” places in physics and astronomy, as well as astrobiology, but his core work remains simulation, and this is where his research will continue to focus. Nowadays, he may not be spending much time on the search for intelligent life, but he returns to the subject again and again, not just because it's interesting but also inspiring. So what does he really believe?

“When it comes to whether or not there's intelligent extraterrestrial life, I'm a pessimist,” Forgan replies. “But what I believe doesn't matter, because it's still worth doing the experiment. We have the resources and techniques for finding weird things out there, and are also collecting the data. Why not check before we give up? After all, we haven't failed yet.”

Dr Christian Rutz

Research to crow about

Dr Christian Rutz is a Reader in the School of Biology at the University of St Andrews. His research group studies one of the most remarkable animal tool users – the New Caledonian crow. Living on a remote tropical island, these birds use sticks and pieces of leaves to forage for nutritious grubs and other hidden prey, exhibiting a degree of technological sophistication which rivals even that observed in our closest relatives, the chimpanzees. In the course of his field study, which recently celebrated its tenth anniversary, Rutz and his team have developed a range of innovative technologies, including bird-mounted miniature video cameras and proximity loggers, which enable the researchers to remotely document the foraging behaviour and social interactions of these shy forest birds...

They are not an endangered species and they live on the opposite side of the world from St Andrews, but New Caledonian crows are the focus of one of the most innovative ornithological field studies ever conducted – and one of the animal kingdom's most ingenious users of tools. Dr Christian Rutz and his research group at the University of St Andrews are leading the way in trying to explain the crows' remarkable behaviour, using some ingenious tools of their own, including tiny video cameras, or 'crowcams,' so small (weighing less than a £2 coin) that they can be attached to the tails of the birds, providing a crow's-eye view of their use of foraging tools, without restricting the birds' natural behaviour.

According to Rutz, New Caledonian crows provide one of the most interesting examples of tool use among birds and mammals, not least because they are the only animals

apart from humans that naturally manufacture 'hook-shaped' tools. Other birds also use tools – for example, woodpecker finches, Egyptian vultures and palm cockatoos – but New Caledonian crows have "a much more diverse tool repertoire," using at least three different tool types, multiple variations of the basic designs. The crows use their tools to extract invertebrate prey from rotting timber and vegetation, and Rutz believes they may use particular tool types or design variants for specific foraging tasks, similar to humans using different tools for different jobs.

The big mystery is why so few animal species use tools to start with. "We know that tools are useful," Rutz explains, "yet very few animals use them. So, why?" Apart from improving our understanding of New Caledonian crows, as a particularly interesting case study, Rutz hopes that in the longer term his research will provide new perspectives on the evolution of animal tool behaviour more generally, and ultimately shed fresh light on the remarkable sophistication of human technology.

One major challenge is to understand the specific function of tool use, and to document what components of the crows' diet are obtained by using tools. Recent research by Rutz's team suggests that prey obtained with tools is important for raising their young. "Perhaps crows that are good tool users raise more, or healthier, chicks," Rutz speculates. "Studying the energetics of animal tool use can provide insights into the ecological conditions under which this rare behaviour can evolve."



DR CHRISTIAN RUTZ (PHOTO BY PRINT & DESIGN UNIT, UNIVERSITY OF ST ANDREWS)

Rutz is very careful not to make the assumption that tool use – or technological skill – is the same thing as intelligence. Chimpanzees or crows may not build space shuttles or televisions, but Rutz is more concerned with simply understanding the evolutionary processes which lead to the development of rudimentary tool behaviour. Tool use is also relative to individual needs and conditions; for example, in many foraging situations, a simple stick or an unmodified stone tool will suffice. There are also many interesting examples of invertebrate tool use: hermit crabs protect themselves with shells and some spiders carry around their webs and actively cast them over unsuspecting prey. “These examples challenge the notion that big brains, and advanced levels of intelligence, are required for tool behaviour,” Rutz cautions.

Accordingly, when it comes to the crows’ cognitive abilities, Rutz describes himself as an agnostic. “These birds clearly do impressive things with their tools, but controlled experiments are required to establish what exactly they ‘understand’ about the underlying physical principles.”

Mainstream ecology

So how did Rutz get interested in this particular species? Like many other scientists, serendipity played a big role in choosing what direction to take in his future career. “For my PhD, I studied the foraging ecology and population dynamics of northern goshawks,” says Rutz. “This was ‘mainstream’ ecological research. At the time, two friends of mine were studying captive New Caledonian crows for their PhDs, and we started collaborating. Having seen these crows use tools in captivity, I immediately started wondering about the ecological conditions on their home island. And I simply had to go there, to see for myself.”

After completing his DPhil Thesis at Oxford in 2005, Rutz launched his field project on New Caledonian crows as a Junior Research Fellow. In 2009, he was awarded a prestigious BBSRC David Phillips Fellowship, worth almost £1.5 million, which enabled him to set up his independent research group at Oxford and to expand the scope of his crow project. Three years later, Rutz and his team moved to the University of St Andrews, a world leader in the fields of animal social learning, culture and tool use, and this offered lots of opportunities for exchange and collaboration. Within months of their arrival, several new collaborations were forged. The team now conducts fieldwork in seven study sites across the island, covering a range of different crow habitats.

In some study populations, about 80–90% of the resident crows have been marked with colour rings and wing-tags, enabling field workers to document the behaviours and life histories of individual birds. Rutz does not like ‘naming’ his subjects, however, since this may unconsciously bias observations. For example, if the birds were called ‘Marie Curie’ or ‘Albert Einstein,’ because they had excelled at certain tasks, observers may expect to see unusual behaviours, but this is not the case if neutral codes (e.g., ‘ER4’) are used.

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A NEW CALEDONIAN CROW WITH A STICK TOOL. (PHOTO BY SIMON WALKER)

New Caledonian crows are naturally shy, and even in areas where they have been habituated to the presence of humans, data collection is not easy – they enjoy observing their observers. They also live in difficult terrain (tropical forests on very steep slopes), so following and watching them can be a challenge. “During an early brainstorming session,” explains Rutz, “we thought it would be great if we could see exactly what the crow sees, and the idea of using miniature crow-mounted video cameras was born.” Suitable systems were not available at the time, so Rutz’s team took on the challenge of designing their own cameras.

In describing how the cameras were developed, Rutz stresses the importance of lateral thinking and interdisciplinary skills. “I enjoy reading very broadly, exploring seemingly unconnected literatures,” he says, “as well as unconventional methodologies.” Sometimes, when he spots an exciting connection, these insights lead to new discoveries about his study system. Miniature video cameras have since been used by other teams

on a wide range of other bird species and are quickly becoming part of field ornithology’s basic tool kit. More recently, Rutz used cutting-edge wireless sensor network technology to chart the social dynamics in one of his crow populations. “These ‘proximity loggers’ enabled us to record remotely who meets whom,” he explains. “It was a bit like looking at human friendship networks on Facebook or Twitter.” Rutz’s pioneering contributions in this area have been recognised with several awards and prizes.

The mission

So what does Rutz hope to achieve with his study? How long will his project continue? And what will constitute ‘success’ for his research?

“My ambition is to chart the ecological conditions under which tool use is profitable for these birds,” Rutz explains. “Once we understand their foraging ecology, we can make cautious inferences about the evolutionary origins of their unusual tool behaviour.”

The unique conditions in New Caledonia have enabled something special to develop, ever since crows first arrived on the island several million years ago. According to Rutz, the use of tools evolved over time, as crows discovered novel foraging opportunities and potential tool materials. One big advantage for New Caledonian crows is that they have no major predators, so they can concentrate harder on what they are doing. Or as Rutz says: "They have plenty of time on their hands." It sometimes takes crows several minutes to manufacture a satisfactory tool, and even more time to extract prey from tree holes or from behind bark – activities which demand the birds' full attention. There are also no primates or woodpeckers on this remote island that might compete for similar embedded foods. Rutz explains: "These crows have essentially filled a 'woodpecker niche', but instead of using their bills to extract insects from timber, they use tools."

The last common ancestor of crows and humans would have lived about 310 million years ago (170 million generations), while other primate tool users, such as chimpanzees, only "split from the human lineage" about six million years ago (250,000 generations). Tool behaviour in humans and crows must have evolved independently, and Rutz notes that this independence of origin provides an opportunity to search for commonalities. In a sense, crows may provide a window into our own evolutionary past, and help explain how rudimentary tool use may arise. "We may learn a lot through these comparisons," says Rutz, "but we should also be cautious. After all, New Caledonian crows manufacture stick tools, not supercomputers."

At the same time, Rutz rejects out-dated thinking that ranks animals according to their technical skills, with humans sitting at the top of the tree.

Rutz expects to spend the rest of his career studying New Caledonian crows. Their tool behaviour was first described in print in the early 20th Century, but a lot of research remains to be done. Hard fieldwork has provided important insights into the species' natural history, and is now paving the way for tackling some particularly exciting objectives. "We recently discovered that crows in one of our study populations make very complex hook-shaped tools, and we are keen to investigate what these are used for," says Rutz. Hook making was a key innovation in early humans, and New Caledonian crows offer unique opportunities to examine the evolutionary and ecological context of this very special capacity.

"I think I am quite good at spotting opportunities," says Rutz, but the miniature cameras are only a small hint of what he still hopes to achieve. One future project, for example, may examine laterality in New Caledonian crows' tool handling – the birds hold their stick tools in their bills and are either 'right-cheeked' or 'left-cheeked'. This work will be carried out in collaboration with biomedical scientist Dr Silvia Paracchini, another member of the Young Academy of Scotland who is also based at St Andrews.

Explaining crow behaviour may seem like an unusual approach to understanding humans, but Rutz hopes to "establish the New Caledonian crow as a useful model system to shed light on the mysteries of human evolution and, along the way, pioneer new research methodologies." Maybe crows and humans have much more in common than we used to believe...

Call to action

Over the last ten years, Dr Christian Rutz has established a solid foundation – both scientifically and logistically – for a world-leading, long-term research project. To consolidate and expand his research activities, he has now decided to set up a permanent research station on the west coast of New Caledonia, close to several of his most intensively studied crow populations. The station will provide sleeping and living quarters for up to ten fieldworkers, a lab for processing biological samples and data, and aviaries for housing birds, for the brief duration of behavioural experiments. Since conventional funding sources do not support this kind of capital overseas investment, Rutz is seeking philanthropic support for his ambitious initiative. Once one or two principal donors have been found, the station will be named in their honour. An indigenous tribe has already promised to donate land in a prime location, and the local authorities have confirmed their long-term support for the project. A research station would enable Rutz's team to intensify their research efforts, especially by collecting data year-round, rather than during comparatively brief, annual expeditions. Rutz has worked closely with diverse New Caledonian communities over the years and sees an opportunity to develop these relationships further; for example, by setting up a local field assistant scheme. While the focus will remain on studying New Caledonian crows, Rutz hopes that, ultimately, he will be able to host other international research groups, to facilitate broader exploration of the island's remarkable fauna and flora.





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