

## Get into SHAPE!

**AVO GUEDEKELIAN:**  
A MEDICAL STUDENT, DANCER,  
PHOTOGRAPHER AND  
VIDEOGRAPHER, AVO REMINDS  
US OF THE VALUE OF BOTH THE  
SCIENCES AND THE ARTS



### ALSO IN THIS ISSUE

**JULIA BLACK**

PRESIDENT OF THE BRITISH ACADEMY AND AN  
ARCHITECT OF THE SHAPE CAMPAIGN

**JOHN SABRAW**

ACTIVIST, ENVIRONMENTALIST AND  
PROFESSOR OF ART AT OHIO UNIVERSITY

**POLAR STAR**

STATE-OF-THE-ART PEDAGOGIES  
TO TEACH 'SCIENCE AS A WHOLE'



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## Get into SHAPE!

Which word is a verb and a noun, is wonderfully flexible and has the power to steer you towards a rewarding career?

The answer is SHAPE. “SHAPE subjects help shape how we see the world, how we might change it, and how we express ourselves,” says Julia Black, President of the British Academy and one of the architects of the SHAPE campaign. “You can shape the future. You can say you’re a shaper or SHAPE person! The word itself seems to be quite inspirational and is giving momentum to our campaign.”

You can read more about SHAPE in an enlightening interview with Julia (pp 4-8), but, in a nutshell, SHAPE stands for Social sciences, Humanities, and the Arts for People and the Economy.

When we launched Futurum Careers in 2018, we saw ourselves, primarily, as a STEM education platform, integrating arts subjects within STEM under the banner of STEAM. But, as we have evolved, working more closely with researchers in social

sciences, humanities and the arts, it has become increasingly clear that we were shoehorning these subjects into a platform that did not speak for them or to teachers and students of SHAPE subjects. When the SHAPE campaign launched in 2020, we found the perfect mouthpiece.

Now, in 2021, we are proud to be a STEM and SHAPE platform, creating education and career resources from diverse research projects that are a true reflection of the world around us. STEM and SHAPE are not opposing forces – they are a collaborative effort, enabling people from a range of fields to solve some of the planet’s greatest challenges together.

As artist and environmentalist John Sabraw (p 36) says, “It’s not just about two disciplines working side by side in a space, it’s about people creating something new from collaborations. Now we’re asking: What is design, what is art, what is data, what is science, and what is the public outreach? It’s all becoming a little blurry and I like it.”

---

### KAREN LINDSAY

Director and Editor-in-Chief

### ERICA MORGAN

Assistant Editor

### ISLA FOFFA

Editorial Assistant

T: +44 117 9099150

E: [info@futurumcareers.com](mailto:info@futurumcareers.com)

W: [www.futurumcareers.com](http://www.futurumcareers.com)

---

### BRETT LANGENBERG

Director

### CHRIS DOWELL

Project Manager

### KIZZY DENNETT

Project Manager

---

## OUR WRITERS

Jacob Ashton, MA

Torin Cannings, MScR

Harry Carstairs, MPhys

Maureen Cohen, MPhys

Ben Harris, MSci

Rebecca Ingle, PhD

Sam Jarman, MSc

Paul Redmond, MA

Alex Triccas, MSc

---

## OUR GRAPHIC DESIGNER

Claire Leach, BA (Hons)

---

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# STEM, STEAM AND NOW SHAPE: CAN AN ACRONYM HELP VALORISE THE SOCIAL SCIENCES, HUMANITIES AND ARTS?

JULIA BLACK IS THE STRATEGIC DIRECTOR OF INNOVATION AND A PROFESSOR OF LAW AT THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE (LSE). SHE IS ALSO THE 31ST PRESIDENT OF THE BRITISH ACADEMY AND ONE OF THE ARCHITECTS OF THE SHAPE CAMPAIGN. JULIA TELLS US WHY SCHOOLS, TEACHERS AND STUDENTS SHOULD EMBRACE AND CELEBRATE THIS NEW ACRONYM FOR THE SOCIAL SCIENCES, HUMANITIES AND ARTS



## WHAT IS SHAPE?

SHAPE stands for **S**ocial sciences, **H**umanities, and the **A**rts for **P**eople and the **E**conomy.

## WHAT IS THE AIM OF SHAPE?

Launched in 2020, the SHAPE campaign aims to harness the collective power of social sciences, humanities and the arts to shape a brighter and more prosperous future.

## HOW DID SHAPE COME ABOUT?

Born from frustration at the lack of cohesion in shaping the narrative about the relevance of social sciences, humanities and the arts, the concept of SHAPE started to take shape when Julia invited people from the British Academy, the Academy of Social Sciences, the Arts and Humanities Research Council, the Economic and Social Research Council and other friends and supporters for a breakfast meeting at the LSE to “kick the tyres”.

## HOW CHALLENGING WAS IT TO COME UP WITH AN ACRONYM?

The team brought in a creative agency who came up with the SHAPE acronym. Julia explains: “We study people and the economy, and our studies are for people and the economy. To my amazement, people understand SHAPE more than AHSS (arts, humanities and social sciences) or SSAH, and they get excited about SHAPE because it reflects how they see what they do – SHAPE subjects help shape how we see the world, how we might change it, and how we express ourselves. ‘Shape’ is also a verb and a noun, and so wonderfully flexible. You can shape the future. You can say you’re a shaper or SHAPE person! The word itself seems to be quite inspirational and is giving momentum to our campaign.”

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[www.thebritishacademy.ac.uk/shape-at-the-british-academy](http://www.thebritishacademy.ac.uk/shape-at-the-british-academy)

 #thisisshape



## YOUR ACADEMIC INTERESTS SPAN SOCIAL SCIENCES AND HUMANITIES. DO YOU THINK THESE FIELDS ARE UNDERVALUED?

I wasn’t so aware of this as an issue until I moved into senior management, as Pro-Director of Research at the LSE, and became much more involved in policy work. My role was to create an environment for research to flourish and, particularly around the time of Brexit, we had to argue the case for funding. Many of my fellow pro-vice chancellors of research from other universities were putting forward examples from STEM to demonstrate the impact and importance of research. There were very few examples being put forward from the social sciences, arts and humanities. It became increasingly clear that these disciplines were falling off the edge in political discourse because politicians are always drawn to the new and shiny, to ‘pills and widgets’.

There are a number of reasons for this, but one reason is that the social sciences, arts and humanities don’t always produce something tangible. It’s not like creating an amazing pen that can write by itself or an invisible lotion that cures all cancers. People working in the social sciences, arts and humanities produce ideas, analyses, narratives or interpretations and so it’s harder to understand what it is they do. Moreover, these ideas, analyses, narratives and interpretations are always contested by someone else. So, we always look like we’re squabbling!



“ How do you reduce knife crime, or stop domestic abuse, or improve the justice system? These are all social science questions and social scientists have the skills and knowledge to answer them. ”

- JULIA BLACK, PRESIDENT OF THE BRITISH ACADEMY

#### WHY ARE SHAPE DISCIPLINES JUST AS VALUABLE AS STEM?

When I talk to policy makers, I remind them that government is an exercise in applied social science and it's important that they make this link. How do you reduce knife crime, for example, or stop domestic abuse, or improve the justice system, the functioning of the NHS, and attainment in schools? These are all social science questions and social scientists have the skills and knowledge to answer them.

Humanities subjects enable us to understand ourselves and others, and the values by which they and we live now and have lived in the past. The world is facing enormous challenges, and having a critical and ethical framework to guide decisions is critical. Furthermore, the value of the arts and culture to our sense of community and well-being is something we have probably all realised through the pandemic. Not only that but healthcare practitioners are now social prescribing, particularly in mental health, and encouraging patients to join a local group or choir, and to appreciate nature, self-expression and creativity, recognising that these activities are essential to well-being.

#### THERE IS A BIG PUSH FOR STEM IN EDUCATION. WHAT ARE YOUR VIEWS ON THIS?

As long as a child stays in education and training for as long as possible, it's a big tick in my book. And, as part of this, I'm absolutely all for encouraging kids, and especially girls, to do STEM subjects – but not by disparaging SHAPE disciplines. We have to recognise that you can't dismiss one group of subjects as 'worthless' in an attempt to get kids to choose the other. If we're going to educate the maximum number of kids for the maximum amount of time, we need to ensure they have a full set of opportunities available to them, both STEM and SHAPE. You can't say, 'Don't do SHAPE subjects because they're worthless and they won't take you anywhere', because that denigrates the whole education enterprise. We should be focusing on ensuring a broad-based curriculum and providing people – young and old – with learning opportunities for as

long as possible. There are groups of students for whom STEM subjects don't appeal. If they're then told that other subjects aren't worth doing, even though they might be of interest to them, what options are we giving our young people? What message does that send?

#### WHERE DOES SHAPE SIT WITH STEM AND STEAM?

SHAPE is not in opposition to STEM; these subjects work incredibly well together. Progress in English is linked to progress in maths. Many studies have shown the wider educational benefits of learning music. Although the questions and focus of STEM and SHAPE subjects may be different, the methodologies for answering them can be similar. And when you're asking about people's interaction with nature or the environment or physical space, then you inevitably have crossover between the two.

STEAM is a very specific subset of SHAPE within STEM; it captures the 'A' but not the 'S' and the 'H'. STEAM captures the value of integrating art and design with STEM, but not the value of integrating STEM with social sciences and humanities. In contrast, SHAPE enables us to talk about the value of integrating STEM with that much wider set of disciplines focused on people and societies. It's critical we recognise the value of that wider set of interactions. Getting to net zero, for example, will need new technologies which are well designed, but we also need full scale political, economic, behavioural and system changes too, for which the insights of all SHAPE disciplines are relevant.

#### IN JUNE, FORMER PRESIDENT OF THE BRITISH ACADEMY SIR DAVID CANNADINE WROTE AN OPEN LETTER TO SHAPE GRADUATES. WHAT WOULD YOU LIKE TO SAY TO SHAPE STUDENTS?

You've got skills, knowledge and insights about people and societies, which you can use to address issues that are really important to you. As David said, don't let anyone do you down. Go and make the most of your unique skills!

# WHAT TEACHERS AND SCHOOLS SHOULD KNOW ABOUT SHAPE

A group of SHAPE collaborators ran a pilot project in eight schools across the UK's four nations, introducing SHAPE to a cohort of 12-14-year-olds and to a group of 20 teachers from across the SHAPE disciplines. The aim of the pilot was to increase the visibility of SHAPE subjects, to demonstrate the relevance of SHAPE subjects and to encourage a personal connection with SHAPE subjects.

Working with organisations experienced in object-based learning, such as museums and universities, the team devised a suite of three workshops and an extensive teacher training programme. The learner workshops focused on three everyday objects – trains, masks and shoes – and encouraged students to explore them from the perspective of multiple SHAPE disciplines, as well as to consider the links between SHAPE subjects and with STEM. The teacher training supported teachers to consider their own positionality towards SHAPE and to facilitate 'SHAPE' thinking amongst their learners.

Why trains, masks and shoes? Trains, masks and shoes are everyday objects that are within the lived ecosystems of the learners' life experiences. The intention is to encourage an understanding that no object is neutral and that we need to interrogate the everyday, every day, as a way to better understand the world. Take trains, for example. How do you say train in different languages? What is the etymology of train? When were trains invented and how have they evolved over time? What are trains' role in literature and film? What are the environmental and economic issues surrounding HS2? Once questions like these had been explored, pupils were given guidance on how to employ methodologies used in the SHAPE disciplines to take on the role of a SHAPE professional and create a product (a survey, a vlog, a story or a business pitch).

As a follow on to this pilot project, the team is now looking into developing a series of creative resources that will enable teachers,

The pilot project was delivered online. These screenshots are of some of the SHAPE team's education resources relating to trains.

Trains can represent many different things in literature and film. They can be both one thing and its opposite.

Like the parallel tracks that the train runs on, these opposite themes run parallel to each other when depicting trains in literature and film.

**? Match up each trope with its opposite, i.e. a number and a letter.**

**Discuss** your own examples of when these tropes are used in literature and film.



1. running to catch a train
2. jumping from a train
3. romantic encounter
4. special adventure
5. quiet contemplation
6. safety

- a. comedy
- b. daily commute
- c. danger
- d. jumping onto a train
- e. running away from a train
- f. fighting on top of a train

Since their invention, trains have so captured the human imagination that they were one of the first things to be filmed by the Lumière Brothers.

The famous clip of a train arriving at La Ciotat in France was released in 1895, when viewers saw the footage they reportedly rushed from their seats, convinced that the train would burst from the screen and crush them- they had never seen a moving image quite like it!

Now such a clip seems quite normal, dull even, but at the time it was magical.

**Watch** the video to see the first recording of train on film.



The idea of trains as magical has remained in the popular imagination. Trains feature in all sorts of books, films and stories, both for children and adults.

Click [here](#) to learn more about the Lumière Brothers.

Let's begin with some slow-looking.

**Look** at the pictures below.

**Discuss**...

- What makes each train different?
- How are the trains being used?
- Where might you see each train?

The word 'train' comes from 'traynyn'.



students and carers to see where SHAPE subjects might lead in terms of careers.

### PROJECT EVALUATION

Outcomes from the pilot project confirmed that this approach positively influenced teacher and learner attitudes towards SHAPE subjects. The external evaluation found that the workshops increased learner interest in learning about SHAPE subjects in school, with 67% of learners saying they were 'much more' or 'a little more' interested in learning about SHAPE subjects after taking part.

The experience also impacted on intentions around post-16 qualifications, with 58% saying they are 'much more' or 'a little more' likely to take SHAPE subjects. The project supported learners to think more broadly about SHAPE careers: previously "they [SHAPE subjects] felt like hobbies to enjoy but not careers. Now I'm thinking a little more about these subjects and considering my strengths within them." (Learner feedback.)

Moreover, through the pilot project, teachers benefited from collaborating with other teachers from other nations and from a broad range of subject areas: drama, art, business studies, history, languages, maths, geography, etc. Many teachers commented that they were not previously aware of object-based learning and that they enjoyed learning a new skill and would continue to develop this facilitative SHAPE approach.

Teachers were challenged to look beyond their own discipline and skills, thinking in more interdisciplinary and cross-curricular way. Julia explains, "Bringing teachers together from across a range of disciplines to teach the same materials was a fascinating experience. Teachers varied in their comfort levels when asked to teach 'beyond their subject area' and to think in interdisciplinary ways. Teachers learned from one another's skills, broadening their own SHAPE perspectives and skills."

For more information, contact: [info@thisisshape.org.uk](mailto:info@thisisshape.org.uk)



## ABOUT JULIA

Julia wanted to be a ballet dancer when she was younger before realising, aged 11, that she was never going to be a ballet dancer. After hearing someone talk about the University of Oxford, Julia decided she wanted to go there. She succeeded and studied law. Armed with a first degree in jurisprudence, Julia was offered a training contract at a law firm, but a friend convinced her to continue with her studies and so Julia studied for a DPhil relating to the regulation of the financial services sector.

"My interest in law is not so much about the courts and how to resolve disputes, but more about how the state uses law to get

people to change their behaviours," says Julia. "I was also really interested in companies or any social organisations that were doing socially beneficial activities but without state involvement. The FSC label on loo rolls or tissue boxes, for example, is not a legal system. The FSC has been set up by social groups and works across multiple countries. I'm interested in how and why systems like that work. This is why I've ended up traversing the whole social sciences. How do you get people, social groups and organisations to change what they do so that it is socially beneficial? And why do some do that themselves? And do you maintain that change over time? These are questions I still don't know the answer to."



# HOW DO WE GET MORE WOMEN ON COMPANY BOARDS?

DESPITE PROGRESS IN RECENT YEARS, WOMEN REMAIN UNDERREPRESENTED ON COMPANY BOARDS. THIS IS A PROBLEM: RESEARCH SHOWS THAT COMPANIES WITH WOMEN IN TOP POSITIONS BENEFIT IN NUMEROUS WAYS, INCLUDING THROUGH NETWORKING AND FAMILY-FRIENDLY POLICIES. DR HELEN KOWALEWSKA OF THE UNIVERSITY OF OXFORD IS INVESTIGATING DIFFERENCES IN COUNTRIES' SOCIAL POLICIES TO UNDERSTAND HOW THE UK COULD IMPROVE GENDER DIVERSITY AT THE TOP DECISION-MAKING LEVEL

## TALK LIKE A SOCIAL POLICY ANALYST

**BOARD OF DIRECTORS (OR BOARDROOM)** – a committee that represents the owners or shareholders of a company and makes important business decisions

**BOARDROOM QUOTA** – quotas or targets for increasing the proportion of women in the boardroom

**EXECUTIVE** – the definition of 'executive' differs from company to company but, in general, executive-level jobs include business owners, presidents (or vice-presidents) of a company, and chief executive officers (CEOs)

**FTSE 100** – the Financial Times Stock Exchange 100, also known as the FTSE 100 (or, informally, 'Footsie') is an index of the 100 companies listed on the London Stock Exchange with the highest-

value shares. There are also FTSE 250 and FTSE 350 companies, which include the FTSE 100 index

**GENDER DIVERSITY** – gender diversity in the workplace commonly refers to an equal or near-equal ratio of men and women in a company

**SOCIAL OR WELFARE POLICY** – guidelines, principles, legislation, and activities that meet human needs for security, education, work, health and well-being

**UNDERREPRESENTATION** – Insufficient or disproportionately low representation. For example, if women are underrepresented on company boards then it means there are far fewer women than men at the top decision-making level

It was in 1997 when Marjorie Scardino became the first woman to head a FTSE 100 company. By 2011, 12.5% of FTSE 100 board positions were held by women and, in 2018, that figure rose to 29%<sup>1</sup>. While the number of women on company boards is heading in the right direction in the UK, women at the top decision-making level are still underrepresented, with men making up the majority.

“Large businesses often have a board of directors that represents the interests of the company’s owners or shareholders,” says Dr Helen Kowalewska, based at the University of Oxford’s Department of Social Policy and Intervention in the UK. “The board is

responsible for making important business decisions, such as how to invest profit and setting company targets.”

Different countries appoint directors to company boards in different ways. In most cases, it is the shareholders who vote on the directors they would like to hire (or fire). But, in some countries, employees can also vote; in others, the board of directors appoints new members.

Helen is a social policy analyst investigating the impact that government social policies have on female representation in the business world. Her goal is to understand why some countries

do better than others and how the UK can improve gender diversity on company boards.

## WHAT ARE THE BENEFITS OF HAVING WOMEN ON EXECUTIVE BOARDS?

Better female representation on boards has positive consequences throughout the company. In the first instance, a variety of perspectives, backgrounds and experiences can be key to a company’s success, and one way to harness these varying perspectives is through gender diversity. Companies with gender-diverse boards are more likely to have a better understanding of their customers and clients, many of whom will be women. And this is not the only benefit.



“Many studies have found an association between gender-diverse leadership teams and better pay and career prospects for women further down the company hierarchy,” Helen explains. There are several reasons for this. Female leaders can act as mentors to women in more junior roles, helping them to navigate the workplace and build professional networks. Networking is very important to individual career advancement and for finding new jobs. Indeed, Helen cites a study that investigated hiring practices in US law firms. The study found that women’s chances of being hired improved by 13% in female-led vs male-led firms.

Moreover, it has been shown that higher representations of women at the decision-making level lead to more family-friendly company policies, practices and cultures. Women still do the majority of childcare, which can be difficult to balance with a demanding career. With family-friendly policies, like work-from-home options and on-site childcare, women are more likely to stay in their jobs and progress up the career ladder.

Studies have also found that bringing more women into leadership positions can help tackle workplace sexual harassment. Worryingly, recent surveys have found that sexual harassment – unwanted sexual behaviours, such as sexual comments, touching, groping and assault – is commonplace across UK workplaces. A BBC survey in 2017 found that 40% of women and 18% of men had experienced unwanted sexual behaviour in the workplace. “Women in board roles are more likely to take claims of sexual harassment seriously and to push firms to do something about it, as they are more likely to have experienced sexual harassment themselves,” says Helen. They are also less likely to be the perpetrators of sexual harassment. Therefore, getting more women into board positions can help to create safer workplaces for all.

#### WHICH COUNTRIES DO THE BEST AT FEMALE REPRESENTATION?

The Hampton-Alexander Review, backed by

the UK Government, set a target of one-third of board positions in FTSE 100 companies being filled by women by 2020. In 2018, with almost 29% of board positions being held by women, that target was close to being met. “However,” Helen says, “37% of the FTSE 350 have not met this target and, compared to countries with similar economies, the UK could do better.” France, Norway and Iceland have consistently had more than 40% female representation on boards in the last five years.

#### WHICH POLICIES ARE MOST SUCCESSFUL AT INCREASING FEMALE PARTICIPATION ON COMPANY BOARDS?

Companies take different approaches to female board participation, with varying results. “The research finds that countries divide into three broad groups,” Helen says. “First, there are those with no policies to redress the lack of women on boards. These countries, which include most of the Eastern European states plus the US, continue to lag far behind on women’s board membership. They also have relatively ungenerous welfare states.”

The second group consists of countries with voluntary regulations for board diversity. These regulations recommend that companies take action to increase female board representation, but there are no consequences if the company fails to do so. Voluntary boardroom quotas work better in countries with more generous welfare policies and legislation that supports working mothers (like Sweden has). Other countries with smaller welfare states and less support for women’s employment (like Spain) have not been as successful with a voluntary approach.

Finally, a third group of countries has mandatory regulations for gender quotas in the boardroom. Companies that do not achieve a mandatory percentage of women on their board face fines or other penalties. Countries with mandatory regulations are the most successful at achieving a high level of gender diversity. Norway was the first European country to implement a mandatory quota



#### DR HELEN KOWALEWSKA

Postdoctoral Researcher  
University of Oxford, UK

#### FIELD OF RESEARCH

Social Policy

#### RESEARCH PROJECT

Analysing the social policies that best support women’s employment, women’s representation in top jobs, and gender-friendly workplaces

#### FUNDER

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for boards, which came into force in January 2008. France and Italy are among those that have since followed suit.

#### WHAT CAN THE UK DO TO IMPROVE GENDER DIVERSITY ON COMPANY BOARDS?

The UK falls into the second group, where there are voluntary regulations in place for female board representation. But, as Helen’s research has found, voluntary targets are not so successful in increasing female representation when broader policy supports for women’s employment are lacking.

“For the UK’s voluntary approach to be successful, a two-pronged strategy is needed,” says Helen. “This is where the government applies pressure on companies to appoint more women to boards and enhances policy supports for working motherhood, as in Scandinavian countries.” Social policy studies like Helen’s are key to helping the government make these policy and societal improvements.

1. [www.gov.uk/government/news/record-number-of-women-on-ftse-100-boards](http://www.gov.uk/government/news/record-number-of-women-on-ftse-100-boards)

# ABOUT SOCIAL POLICY ANALYSIS

The academic study of social policy focuses on how societies meet human needs (like education and healthcare), respond to inequalities, and bring about social change. It considers the role of government provisions (like laws, benefits and services) as well as the role of families, companies, charities and other organisations in the distribution and redistribution of resources and opportunities.

## WHAT TOOLS DO SOCIAL POLICY ANALYSTS USE IN THEIR RESEARCH?

Social policy analysts are social scientists. Like other social scientists, they use both qualitative and quantitative methods in their

work. This might include carrying out surveys to determine people's beliefs and opinions, or analysing long-term business data to discover statistical trends and correlations.

Helen's research involves performing a literature review: reading all published data about a particular social policy issue and logically dissecting it to draw broad conclusions which are useful to policymakers. Helen has also used a technical method called fuzzy-set qualitative comparative analysis. This method allows her to compare how welfare state interventions and gender boardroom quotas interact in industrialised countries.

## HOW CAN SOCIAL POLICY ANALYSIS HELP CHANGE THE WORLD FOR THE BETTER?

Social policy analysis seeks to find causal relationships between government policies and real-world outcomes. Put simply, social policy analysts figure out what actually works. The findings of social policy analysis are crucial in helping governments and institutions to decide which rules and incentives are effective to achieve positive outcomes for the people they govern. Analysts like Helen, who write articles and give interviews for the public, can also influence public opinion about what goals are worth aiming for and what steps government should take to achieve them.

## HOW TO BECOME A SOCIAL POLICY ANALYST

- It is a good idea to gain some experience through an internship or voluntary work. For example, Helen's first experience in this field was collecting data for the 'Caught in the Act of Protest' research project. In the UK, Operation Black Vote, Citizens Advice Bureau, Adam Smith Institute, YouGov, W4MP (Working for an MP), and NatCen all offer internship and/or volunteer opportunities: [guides.careers.sussex.ac.uk/politics/experience](https://guides.careers.sussex.ac.uk/politics/experience)

If you are in the US, you could try an internship like the Library of Congress Volunteer Internship Program ([www.loc.gov/crsinfo/opportunities/volunteer.html](http://www.loc.gov/crsinfo/opportunities/volunteer.html)).

- You can read about Helen's career journey for inspiration, here: [www.southcoastdp.ac.uk/my-southampton-research-journey-from-undergrad-to-postdoc/](http://www.southcoastdp.ac.uk/my-southampton-research-journey-from-undergrad-to-postdoc/)
- Getting involved with local government is also a great way to learn how policy is implemented in the real world.
- The average salary of a social policy analyst in the UK is £36,000.

## PATHWAY FROM SCHOOL TO SOCIAL POLICY ANALYSIS

Helen recommends GCSE and A-level options in subjects like sociology, politics, economics and history. Maths, especially statistics, is also important if you want to use quantitative research methods.

A bachelor's degree in a subject like economics, political science, sociology or law is a necessary foundation for a career as a social policy analyst.

Policy analysts will often pursue a postgraduate degree in a more specialised subject, such as social policy or public policy. However, a PhD is not a requirement unless you want to be an academic researcher or lecturer.

## HELEN'S TOP TIPS

- 01** Make the most of any opportunities that come your way.
- 02** If money is a barrier, there are lots of funding opportunities available to support your university studies, especially at master's and PhD levels.
- 03** Mentorship is really, really important! Finding senior (women) academics who believed in me, challenged me and helped me to navigate the world of academia was crucial.

## HOW DID HELEN BECOME A SOCIAL POLICY ANALYST?

### YOU HAVE A BSC DEGREE IN POLITICS. WHO OR WHAT INSPIRED YOU TO STUDY POLITICS?

It had always been programmed into me that I would go to university. I went to a selective school where the emphasis was on academic attainment. There was a point when I considered not going to university, but after leaving school, moving out, and working in various temp jobs for a couple of years, I decided I would definitely like to go. I chose to study politics simply because I had taken it at A-level and really enjoyed it. But I had always been politically engaged. At home, I would often have debates with my dad growing up!

### DID YOU WANT TO BE A POLITICIAN WHEN YOU WERE YOUNGER?

Not really. To be honest, I didn't know what I wanted to be. Once I had definitely decided

I wanted to go to university, I chose a subject that I found interesting – politics – and thought, I'll figure it out when I get there, which is indeed what ended up happening!

### YOU ALSO HAVE AN MSc AND PHD IN SOCIAL POLICY. WHAT IS IT ABOUT SOCIAL POLICY THAT FASCINATES YOU?

I'm particularly interested in the ways in which social policies can help to reduce gender inequalities, especially in the workplace. For example, maternity leave policies are important so that women can keep their foot in the labour market and not be unfairly penalised for having children. But maternity leave can also reinforce certain inequalities. Time spent out of work can lead to missed opportunities for career development and employers may be more reluctant to hire women in assuming

they are more likely to take career breaks. So, for me, it's really interesting to think about some of the unintended consequences of policies, too, and how we can resolve them for a fairer society.

### WHAT DO YOU LIKE TO DO IN YOUR SPARE TIME?

I'm a keen runner and took part in the New Forest Marathon a couple of years ago. I find running a great way to de-stress and help my body catch up with my mind after a busy day of thinking. I also love baking for my family. Other than that, I enjoy spending as much time as possible with my husband and daughter and getting out in the fresh air and countryside.



Helen presenting her research at the Nordic Welfare Research Conference in Helsinki



Helen with her mum and PhD supervisor, Prof Traute Meyer

# THE POWER OF HUMAN RIGHTS IN THE MODERN WORLD

PROFESSOR TODD LANDMAN, A POLITICAL SCIENTIST AT THE UNIVERSITY OF NOTTINGHAM IN THE UK, IS DEVOTED TO PROMOTING AND PRESERVING HUMAN RIGHTS IN ORDER TO END MODERN SLAVERY

## TALK LIKE A POLITICAL SCIENTIST

**DEMOCRACY** – a type of government where the people living in a country can vote to choose the way the country is run

**EXPLOITATION** – treating people unfairly in order to benefit from the work they do. For example, people may be forced to work against their will (forced labour) or forced to work to pay off an unfair debt (bonded labour)

**HUMAN RIGHTS** – principles that protect all humans by promoting equality and freedom

**MODERN SLAVERY** – the recruitment of people for the purpose of different forms of exploitation

**POLITICAL SCIENTIST** – a researcher who analyses political activities and behaviour such as government policy and international agreements

**RIGHTS PROTECTIVE COUNTRIES** – countries that protect and enforce human rights through law

“Human rights are a celebration of human dignity,” says Professor Todd Landman, a political scientist at the University of Nottingham. These rights are our rights. A set of protective principles that provide a framework for laws around the world, allowing us all to live our lives free from fear, exploitation and oppression.

The concept of human rights is hundreds of years old, but the official ‘human rights’ were established in 1948 under the Universal Declaration of Human Rights. These rights were developed through discussion and agreement between individual countries and the United Nations, and they shape both national and international laws.

Today, there are more than 60 recognised human rights, across categories such as civil and political rights, economic rights and social and cultural rights. As threats to the planet and environment continue to grow, there is also an emerging demand for environmental rights.

## WHY DO HUMAN RIGHTS MATTER TO ALL OF US?

Human rights allow us to have freedom of religion, belief and thought, free expression

and speech, and the freedom to form groups such as political parties and trade unions. They provide us with the right to a fair trial and protect us from torture or inhumane treatment. We are all entitled to fair working conditions, education and healthcare thanks to our human rights, and they protect us against unnecessary interference into our private lives.

“Human rights recognise our inherent dignity by virtue of being human, which includes the rights of refugees, migrants, asylum seekers, and stateless peoples,” says Todd. “Wrapped around the rights themselves is the principle of non-discrimination in our exercise and enjoyment of our human rights.”

## WHAT HAPPENS WHEN HUMAN RIGHTS ARE ABUSED?

Common examples of human rights violations include unfair treatment of people accused of crime, forced labour and mistreatment of migrants. Preventing access to education or adequate healthcare also constitutes a violation of human rights. Many people around the world live and work in conditions that do not allow them to enjoy their human rights, and we need to realise that global supply chains often hide issues of human rights abuse within them.



**PROFESSOR TODD LANDMAN**

University of Nottingham, UK



**FIELD OF RESEARCH**

Political Science, Human Rights



**RESEARCH PROJECT**

Investigating modern slavery from a human rights perspective to understand the nature of the problem and develop interventions that will help to end the practice



**FUNDERS**

Economic and Social Research Council, International Justice Mission, Global Research Challenge Fund, Nuffield Foundation, US Trafficking in Persons Office

“Do you know where your mobile phone was produced?” asks Todd. “Do you know what conditions each component was produced in?”

“The most common portrayal of human rights is that they are rights for criminals, immigrants, refugees and other ‘unwanted people’,” explains Todd. Often, people don’t appreciate the everyday freedoms that human rights provide. In rights-protective countries we are all allowed to have individual beliefs without the fear of a ‘knock at the door’ from the authorities. “Human rights should be seen as basic protections for human flourishing,” adds Todd.

**HOW DOES TODD STUDY HUMAN RIGHTS?**

Todd’s research is based on the application of human rights in different countries around the world. He generates large datasets, collating decades’ worth of information about treaties and measurements of human rights in different countries. He then uses statistical analyses to establish relationships between human rights and other variables, such as the level of democracy, economic development or the presence of violent conflict. His current research applies this quantitative analysis to data on modern slavery.

Todd also conducts qualitative research, comparing different countries to help understand historical processes of human rights advance and the political processes involved in bringing about better protection of human rights.

Human rights research is a highly interdisciplinary field, addressing many different

issues affecting people in the world. “My research involves a combination of international law, international relations, political science, economics and geography,” says Todd. His current research on modern slavery uses geospatial analysis and satellite images to understand which places across the world have a high probability of forced labour taking place.

**WHAT IS MODERN SLAVERY?**

Modern slavery is a term that covers a variety of practices, including forced labour, sexual exploitation, bonded labour, human trafficking and other forms of exploitation. “The most recent estimate of modern slavery is that there are 40.3 million people enslaved around the world, and no country is free of slavery,” says Todd. Complex individual, community and national factors make people vulnerable to becoming enslaved. According to a recent report from the Council of Foreign Relations, human trafficking alone is worth over 150 billion dollars a year to perpetrators.

**WHAT HAS TODD LEARNT ABOUT MODERN SLAVERY?**

There is still work to do on defining modern slavery. Todd analyses the relationship between globalisation and modern slavery and assesses the effectiveness of measures to end the practice. His work on forced labour in the brick kiln industry in South Asia is examining geographical factors that increase the prevalence of modern slavery and he is investigating its impact on environmental degradation.

Todd’s recent findings suggest that globalisation is not related to high levels of

slavery and that international trade affects modern slavery in developing countries. It is also difficult to monitor and evaluate organisations that aim to help survivors of modern slavery, due to the way their programmes of intervention are set up. Todd has demonstrated that extending support for survivors of modern slavery in the UK will provide benefits that greatly outweigh the costs to the government.

**CAN POLITICAL SCIENCE AND HUMAN RIGHTS HELP TO END MODERN SLAVERY?**

Political scientists and human rights researchers like Todd try to understand the nature and extent of modern slavery. Statistical analyses of their data can help to explain the variation in the prevalence of modern slavery around the world. And their results can be used to advise governments and organisations on how best to end modern slavery.

The United Nations have a goal to end modern slavery by 2030. “I hope that my work helps to reach this goal,” says Todd.

# ABOUT POLITICAL SCIENCE

Political science is a branch of social science that involves the scientific study of politics. This includes analysis of political activities and behaviour as well as laws and international agreements.

## WHAT IS REWARDING ABOUT RESEARCH IN POLITICAL SCIENCE?

“Political science focuses on real world problems and global challenges,” says Todd. These are complex issues affected by a vast range of factors from political power and economic structures to geographical distributions of raw resources. Political scientists study these issues to help build a better, fairer future. Todd enjoys designing and conducting his research projects, as well as travelling the world to work with

international organisations and foreign ministries, and teaching students to challenge ideas about politics and power.

## WHAT ISSUES FACE THE NEXT GENERATION OF POLITICAL SCIENTISTS?

Todd explains that the current key issues in political science are, “the deterioration of democracy, the rise of nationalism and populism, the ever-present threats of conflict, war, and terrorism, and environmental degradation and climate change.” The consequences of these will need to be addressed by the next generation of political scientists. “Human rights run right through each of these main issues, but in different ways,” explains Todd, “which will

require the continued focus on asking the right questions to address the issues.”

## WHAT SKILLS WOULD YOU GAIN FROM STUDYING POLITICAL SCIENCE AND HUMAN RIGHTS?

Political scientists develop analytical skills, the ability to understand political concepts and the ability to communicate complex issues in an understandable way. Political scientists travel the world and learn to relate to and appreciate people from all over the world with a wide range of beliefs and opinions. “Human rights have given me a moral compass to approach the world,” says Todd, “grounded in what ought and what ought not be in place to maximise human flourishing and human dignity.”

## EXPLORE A CAREER IN HUMAN RIGHTS

- Human rights expertise is needed in many areas of life. You could work in law, politics, business, charities, international organisations, creative arts, advocacy, data analysis...
- Listen to Todd’s podcast ‘The Rights Track’ to gain an understanding of human rights issues ([www.rightstrack.org](http://www.rightstrack.org)).
- The United Nations Office of the High Commissioner for Human Rights ([www.ohchr.org](http://www.ohchr.org)), Amnesty International ([www.amnesty.org.uk](http://www.amnesty.org.uk)) and Citizens UK ([www.citizensuk.org](http://www.citizensuk.org)) all provide opportunities to get involved with the promotion of human rights.
- Todd and his colleagues give talks to schools near the University of Nottingham. Take a look at your local university’s website to find out if their Social Science faculty provides outreach opportunities.
- According to Glassdoor, the average salary for people working in the field of human rights is £35,600.

## PATHWAY FROM SCHOOL TO POLITICAL SCIENCE

- “Study history, science, maths, philosophy, law, politics and economics to get a grounding in how the world works and moves through time,” says Todd. “Acquire digital skills (data management and visualisation), logical reasoning and an ability to read complex text fluidly.”
- Most universities will offer a degree in politics, political science or international relations

## TODD’S TOP TIPS

- 01** Keep an open mind about the opportunities available to you. The world is constantly changing so be ready to adapt and have the creativity to solve problems.
- 02** Follow your passions outside of work and education. You will gain unique skills through sport, music, art, volunteering and any other hobbies.
- 03** Take time out from the daily grind. Reading, reflecting and being mindful are great ways to do this. You will work better when you are refreshed.

# HOW DID TODD BECOME A POLITICAL SCIENTIST?

**WHAT WERE YOUR INTERESTS WHEN YOU WERE YOUNGER?**

I grew up on a farm in rural Pennsylvania. I was an avid reader (especially of Sherlock Holmes and Alfred Hitchcock), a keen swimmer, sailor, skater, trombone player and magician.

**HAVE YOU ALWAYS BEEN INTERESTED IN POLITICS AND HUMAN RIGHTS?**

I did my first degree in political science at the University of Pennsylvania where I studied Latin American languages, history and politics. During this time (the 1980s), Latin America was undergoing profound transformations, experiencing military rule, civil war and transitioning to democracy. I then completed a master's degree in Latin American studies, and these studies forged an interest in democracy and human rights in the region. My interest became more global as I progressed, completing a master's and PhD in political science.

**WHAT INSPIRED YOU TO WORK IN THE FIELD OF HUMAN RIGHTS?**

While I was a student, I was asked to develop crime scene photographs from the site where a group of Jesuit priests and their maid had been murdered in El Salvador in 1989. Seeing the images come to life motivated me to study human rights and commit myself to their advancement.

**WHAT ARE YOUR AMBITIONS FOR THE FUTURE OF YOUR WORK?**

My ambitions include academic leadership, research and publication, and continued engagement with the international human rights community with a particular focus on ending modern slavery.

**AS WELL AS BEING A PROFESSOR OF POLITICAL SCIENCE, YOU ARE ALSO A PROFESSIONAL MAGICIAN! CAN YOU TELL US ABOUT THIS?**

I started magic when I was 8 years old thanks to a school friend. I was mentored by a local magician and took part in magic conferences. I performed throughout school and university, and continued to perform when I moved to the UK in 1993, founding the British Society of Mystery Entertainers in 2007. I am also a Visiting Professor of Performance Magic at the University of Huddersfield, where I perform and run workshops for drama students. I love performing live shows and I enjoy creating my own effects and routines and collaborating with magicians around the world.

**YOU CALL YOUR WORK 'ACADEMIC MAGIC'. WHAT IS THIS?**

Over the years, my magic has evolved from close up performances to narrative-based magic, communicating big ideas from many different academic disciplines. I brought

my academic work on politics and human rights together with my magic to create the performance persona of The Academic Magician. My shows are crafted to educate, entertain, and baffle all at the same time.

Topics in my performances range from the separation of mind and body to an exploration of social justice through a famous mental asylum in Middlesex. I have my own Magiculum, a physical space with a collection of magical objects and books where like-minded magicians can meet and publish essays on the meaning of magic.



*Todd talking at the Arizona State University conference on human rights, February 2020*



## WHAT IF WE COULD STEP IN THE SHOES OF MIGRANTS AND INHABITANTS ON THE ISLAND OF LAMPEDUSA?

THE ITALIAN ISLAND OF LAMPEDUSA HAS BECOME A MAJOR TRANSIT POINT FOR MIGRANTS SEEKING TO ENTER EUROPE. WITH THOUSANDS ARRIVING, AND MANY DYING ON ROUTE, MIGRATION IS PORTRAYED AS A HUMANITARIAN AND POLITICAL CRISIS. DR ALESSANDRO CORSO, BASED AT THE UNIVERSITY OF OXFORD IN THE UK, IS WORKING TOWARDS CREATING A PLATFORM FOR MIGRANTS AND LOCALS ON LAMPEDUSA TO SHARE THEIR EXPERIENCES. THE HOPE IS TO DISMANTLE THE LANGUAGE OF FEAR AND CREATE A MORE POSITIVE VIEW OF MIGRATION

*'It is night-time in Lampedusa when the coast guard boat approaches land, and the dazed faces of the migrants appear more distinctly from the darkness. As the boat moves closer to the pier, the beams from the spotlights on land illuminate them. "They have been at sea for two days," the coast guard captain tells me. The first migrants to touch land almost fall to the ground. They are weak after so many hours at sea... As they land, the migrants, mostly male, are pushed quite roughly towards the medical check-up area. Their feet are mostly swollen. Some are wearing t-shirts, while others are naked from the waist up.'* (Excerpt from a book manuscript by Alessandro Corso.)

Imagine an island in the Mediterranean Sea, bathed in sunshine and surrounded by crystal clear, blue waters and white, sandy beaches. Now imagine shoes, clothing, books and dead bodies retrieved by local fishermen in their fishing nets, or washing up on to the island's shores. How would you feel if you lived on this island? What would you be thinking if you arrived at these shores, as a migrant, having escaped from terrifying ordeals in your home country and travelled for days over treacherous waters to get here? How would you be received by those who live on this island, the migrant officials who are paid to police it, and

doctors or cultural mediators who are there to offer medical, legal and psychological support?

Lampedusa is an Italian island located to the north of Libya, east of Tunisia and at the southernmost border of Europe. Since the 1990s, it has become a militarised frontier for irregular migration.

Dr Alessandro Corso is starting a project that seeks to provide a safe space for migrants and the inhabitants of Lampedusa to share their experiences, both within the community of Lampedusa and with the rest of the world. Based at the University of Oxford, Alessandro is an anthropologist who wants to dismantle superficial representations of forced migration and build a more engaged and less simplistic narrative - one that is based on lived experiences.

For various reasons, politicians and media outlets in the UK, Europe and the US (as well as other regions around the world), represent migrants as a potential threat. Migration is seen as an ongoing crisis, and borders as sites of inevitable tragedies. This standpoint propagates a language of fear that has grown louder in recent times. We are often confronted with oversimplified and misleading representations of threatening or needy migrants,

heroic rescuers, and angry and frustrated local communities. Rather than unite people, these representations divide people and reinforce ideas of 'us' and 'them'.

"At the borderland of Lampedusa, where migrants land after being rescued at sea by NGOs, fishing vessels or naval ships, the imagined 'us' and 'them' meet," says Alessandro. "Doctors, fishermen, border agents, police officers and migrants share their stories and experiences. Such encounters allow for personal stories to be expressed in such a way that 'fear' often turns into 'mutuality' and 'distance' becomes 'proximity'.

### ENGAGING WITH MIGRATION WORKERS, ARTISTS AND TEACHERS

One of the key aspects of Alessandro's project will be to use workshops, seminars and public events to facilitate an in-depth reflection about how the media and politicians portray the border zone. "The idea behind this project is to allow the inhabitants of Lampedusa to find a communal space where they feel comfortable to freely express themselves. The island is small (about five thousand inhabitants) and it is often difficult to create spaces of aggregation," says Alessandro. "Different groups of people from separate

## ALESSANDRO'S TOP TIPS

- 01** Read, write, watch movies, and engage with your surroundings, whatever these may be. Learn how to value what may appear to be obvious, unimportant or banal at first glance. This will help inform you and develop your knowledge, as well as encourage you to encounter different viewpoints that will aid you personally and professionally.
- 02** Be open: life may offer things you do not expect. Be ready to embrace them, but also accept when they do not take the direction you imagined or hoped for.
- 03** Follow what makes you feel alive and passionate – you should study hard but enjoy life as you do so. Being disciplined is important, but by exploring what fascinates you, it will be easier to work hard.

dimensions (local residents, migration workers, migrants, visitors, researchers) would usually occupy different spaces meaning their views are not shared productively. I believe that by creating a shared space for open discussion and collaboration, these disparate groups will be able to find unexpected elements of communion.”

From previous fieldwork in 2016 and 2017, Alessandro predicts that in light of the widespread sense of neglect and abandonment by the Italian state, the EU, and the law more broadly, there will be a profound need to express personal and shared stories of suffering, abandonment and frustration, but also of hope and love.

### A MUSEUM OF SHARED EXPERIENCES

Tragically, the island of Lampedusa has received the dead bodies of migrants since the 1990s. They were first caught by fisherman in their fishing nets, but are now mainly retrieved by the Navy or coastguard. Such experiences have had a significant impact on individuals and there are stories of fishermen not eating properly for a long time or refusing to go back to sea. However, some local residents have been actively investing their time and energy in collecting migrants' belongings that have washed ashore, such as shoes, clothing and books. As a

result, a museum named Porto M (Harbour M) has been created, offering different perspectives on migration.

“As you enter Porto M and you look up, old shoes once belonging to travelling migrants hang from the roof,” describes Alessandro. “They have been retrieved by the shores of Lampedusa or found at the boat cemetery. This is a remote space now surveilled by the Italian Air Force, where dozens of giant boats have been left in abandonment. Inside these boats, you can still find the belongings of migrants: backpacks, milk boxes, clothes and toothbrushes.”

Importantly, Porto M is not simply a museum of objects. There are performative arts, traditional Sicilian puppet playing and storytelling, music exhibitions, poetry and theatre, all of which tell the stories of colonisation, incarceration, forced migration, abandonment and mutual suffering in new and creative ways.

Alessandro's aim for his ESRC project is to bridge the gap between academia and art. In a similar way to the Porto M project, he hopes to engage with locals' creative responses, interpretations and representations of the hardships of irregular migration, and the complexities of life at the borderlands of Europe in these present times.



*Porto M, a museum of shared experiences.*



### DR ALESSANDRO CORSO

Oxford Department of International Development, University of Oxford, UK

### FIELD OF RESEARCH

Anthropology

### RESEARCH PROJECT

Alessandro is creating a safe space for migrants and locals on the island of Lampedusa to express themselves through art, music and theatre. The ultimate aim is to channel people's energies towards a more productive and positive view of migration that dismantles superficial and false representations of the realities they face.

### FUNDER

Economic and Social Research Council (ESRC)

### ALESSANDRO'S HOPES

“The project is an opportunity for the people who live on Lampedusa to share their difficulties, worries, needs and perplexities,” explains Alessandro. “I want to try and channel their energies into a productive exercise of speech against ongoing superficial and false representations of the reality they have to live with on a daily basis, albeit from very different perspectives, and with greatly diverse consequences.”

Through art, music and theatre, some of us may be able to see beyond the stereotypes perpetuated by politicians and media outlets, and recognise the challenges that irregular migrants around the world face. This recognition will help us understand that so-called ‘people on the move’ (irregular migrants or refugees) are forced into situations that put their well-being and lives at risk. As Alessandro says, “We should be mindful that a real threat for any community comes from superficial representations of ‘otherness’ (i.e. ‘us’ and ‘them’) that go against people's lived experiences.”

# ABOUT ETHNOGRAPHY AND ANTHROPOLOGY

Put simply, anthropology is the study of humanity, while ethnography is the writing of the human condition through fieldwork: an 'immersion' in individual cultures.

Alessandro's research could be defined as a study of sorts, but the people he works with and writes about are the substance and force behind his writing, thinking and analysis. He is not merely studying migrants, nor the Lampedusa inhabitants, but rather attempting to share time and meaningful moments with them as they go about their daily lives. In turn, they have become inspirational voices, companions and friends that represent the realities his work is trying to explain.

## WHY IS IT IMPORTANT TO BUILD A MORE POSITIVE NARRATIVE OF MIGRATION?

The introduction to this article was an excerpt from Alessandro's book manuscript, which is based on his research. This abridged preface from the same manuscript offers a heart-felt explanation as to why it is important to build a more positive narrative around migration:

*"We could pretend to be blind to our own experience, and deaf to our own ears. But can we afford to keep living with indifference? Can we leave reality unquestioned and take it for granted when it seems to concern someone else, or something other than our world, and merely accept it, as if it does not belong to us,*

*whatever? Are the margins of our safe zone as tragic and dangerous as we are told by the media? Are borders as morally unstable as the images broadcasted on TV and social media seem to suggest? The world map signals Lampedusa as a dot drawn between Sicily and Libya. The island reflects a micro-world within a macro-space of global migration, political issues, economic inequalities, illegality, state abandonment and profit. It is an ideal space to address these issues outside the geographical, ethical, academic and imaginative borders. It stands as a frontier of a political imagery which fails when compared with everyday experience. It is a symbol of a tragedy which keeps hidden voices of suffering and pain; a conglomerate of acceptance and abandonment, profit and suffering, indifference and love."*

You can access Alessandro's research thesis, here: [etheses.dur.ac.uk/13403/1/Lives\\_at\\_the\\_Border\\_Thesis\\_A\\_Corso.pdf?DDD5+](https://etheses.dur.ac.uk/13403/1/Lives_at_the_Border_Thesis_A_Corso.pdf?DDD5+)

## WHY IS ILLUSTRATION ANOTHER POWERFUL MEANS OF SHARING ANTHROPOLOGICAL RESEARCH FINDINGS?

Ever since he was a young child, Alessandro has been drawing and painting, which has culminated in some of his artwork being featured in the Illustrating Anthropology exhibition. For him, illustration provides a unique means of studying the subjects at hand. "I believe that giving oneself the freedom to express what one is experiencing in the

field (particularly when fieldwork concerns emotionally and ethically challenging contexts) allows researchers to investigate their research questions from a particularly interesting angle," says Alessandro. "Self-reflection and introspection are fundamental to fieldwork in anthropology and the social sciences, as they are more generally in life. Art is a powerful way to explain the relationship between the world we learn about and ourselves."

## WOULD ALESSANDRO RECOMMEND A CAREER IN ANTHROPOLOGY?

It really depends on what it is that you are interested in and passionate about. Anthropology is a fascinating discipline which dismantles reality, questions certainty, raises doubt and encourages you to learn about yourself. "You might be fascinated by the idea of seeking to understand a particular way of life practised in a remote or nearby geographical areas. You might be interested in religious practices, fascinated by the symbolisms of language, or drawn towards a historical, political or existential interest in violence, pain, suffering, reciprocity or love," says Alessandro. "Ultimately, anthropology revolves around the question of what it means to be human, but humanity may be approached from many perspectives and sub-questions."

## EXPLORE A CAREER IN ETHNOGRAPHY AND ANTHROPOLOGY

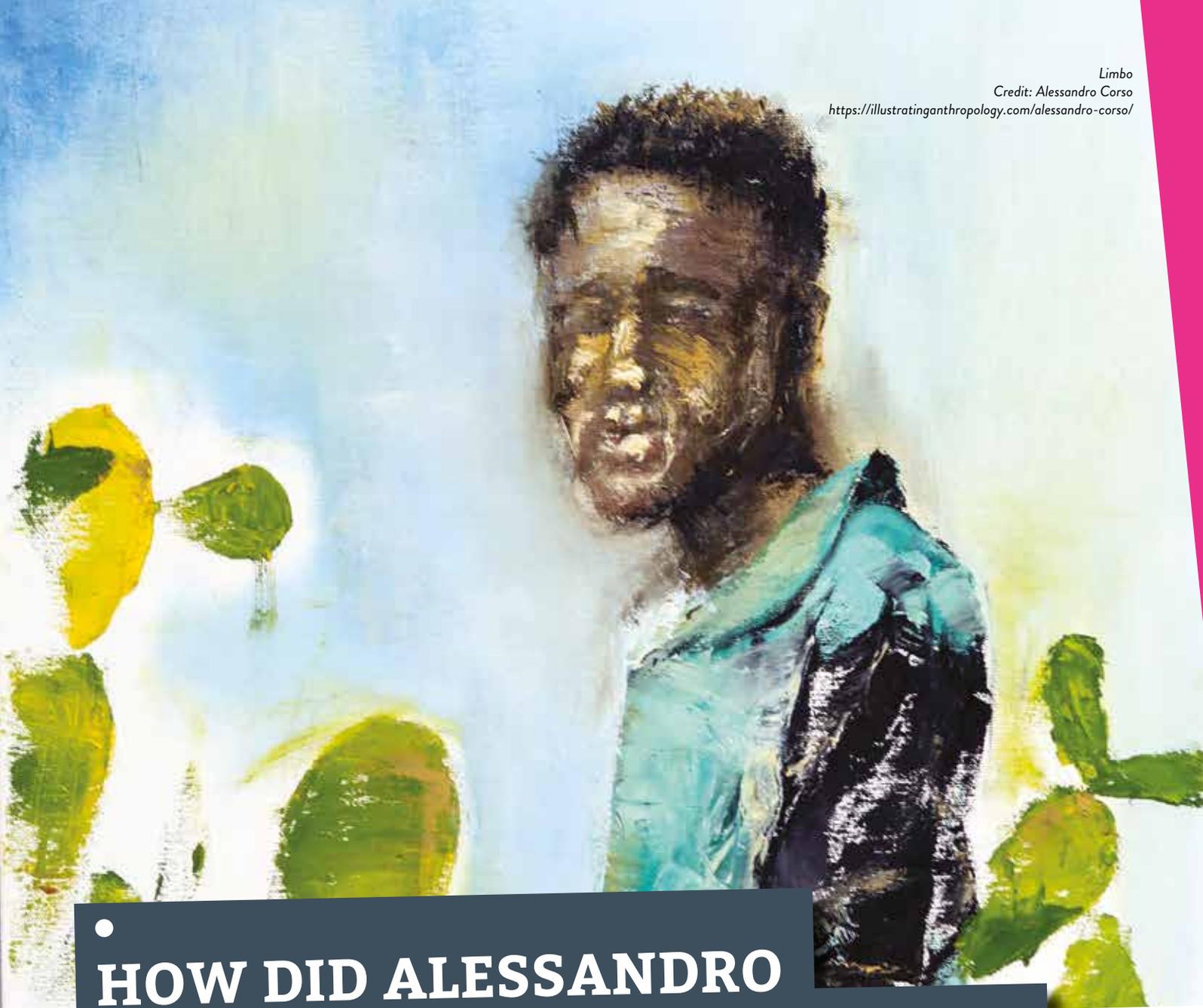
- Prospects provides a wealth of advice on what you can do with an anthropology degree, including the different jobs and routes for further study you might want to embark on: [www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/anthropology](http://www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/anthropology)
- UKRI has put together a useful career guide for anthropologists that may well prove useful to those interested in the field: [esrc.ukri.org/files/public-engagement/social-science-for-schools/careers/careers-in-anthropology-a-guide/](https://esrc.ukri.org/files/public-engagement/social-science-for-schools/careers/careers-in-anthropology-a-guide/)
- The average salary range for an anthropologist is between £36,000 and £64,000, depending on experience.

## PATHWAY FROM SCHOOL TO ANTHROPOLOGY

Alessandro recommends a broad range of subjects that you might consider if you want to get into the field of anthropology.

These include literature, history, philosophy, art, biology and languages (both modern and ancient).

[www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/anthropology](http://www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/anthropology)



## • HOW DID ALESSANDRO BECOME AN ANTHROPOLOGIST?

ARTWORK (ILLUSTRATION, THEATRE, STORYTELLING, WRITING) IS A LARGE FEATURE OF YOUR RESEARCH. DID YOU WANT TO BE AN ARTIST WHEN YOU WERE GROWING UP?

I believe that anthropology, as I understand it (and practise at this very early stage in my academic career), is inevitably linked with art. You may be an artist who works as an anthropologist, or an anthropologist who does art. You may be both. However, I generally believe that once you try to put a label on what you are, things seem to lose their mystery and meaning. Art is a mystery, and it could be argued that anthropology is a mystery, too. Certainly, humanity and life more broadly are the greatest mysteries we come to experience. As such, it shall be left for what it is, and we, as scholars, writers,

intellectuals, artists, should perhaps only and ultimately aim to learn from it.

YOU STUDIED HUMAN SCIENCES AT THE UNIVERSITY OF DURHAM. WHO OR WHAT INSPIRED YOU TO STUDY THIS SUBJECT?

It was by chance! A series of events (my mother's vision, accidental encounters, luck and belief in myself) which led me from Milazzo (Sicily) to Durham in the UK to study a subject I knew nothing about.

WHAT DO YOU LOVE MOST ABOUT THE WORK YOU DO?

I love writing. This job gives you the opportunity not only to write, but to read, dedicate a large time of your life to learning from others, and most of all, it 'forces' you to

be in the field. It requires you to experience part of what you are willing to write about. This 'rigorous' combination of practice and theory allowed me to experience an awareness of the world and myself that I may have never been able to acquire otherwise.

HOW WOULD YOU DESCRIBE YOURSELF AND ARE THESE CHARACTERISTICS USEFUL IN ANTHROPOLOGY?

It is hard to describe oneself – and can only ever be an approximation. I am disciplined and diligent, passionate and idealist, stubborn and determined. Some of these characteristics help and others do not. I always try to find some sort of balance, and it is towards that balancing exercise that we should perhaps aim in anthropology and, more generally, in life.



## MINORITY RELIGIONS IN JAPAN: MARGINALISED OR EMPOWERED?

THE WORLD IS HOME TO A STUNNINGLY DIVERSE ARRAY OF RELIGIONS, AND GLOBALISATION MEANS THAT DIFFERENT GROUPS OF FOLLOWERS ARE MIXING MORE THAN EVER. IN JAPAN, 'MAINSTREAM' AND 'MINORITY' RELIGIONS HAVE DIFFERENT CONNOTATIONS – AND THIS BRINGS WITH IT THE POTENTIAL FOR TENSION. PROFESSOR ERICA BAFFELLI OF THE UNIVERSITY OF MANCHESTER, IN THE UK, IS EXPLORING HOW MINORITY RELIGIONS IN JAPAN ARE PERCEIVED AND PORTRAYED, AND WHAT THIS MEANS FOR THEIR FOLLOWERS

### RELIGIOUS GROUPS IN JAPAN: A BREAKDOWN

**SHINTŌ** – often regarded as Japan's 'native' religion, Shintō is a set of diverse traditions and practices that centre around deities called kami. The 'new' religion Tenrikyō incorporates Shintō beliefs

**BUDDHISM** – a religion originating in ancient India, now the world's fourth-largest religion. There are two main branches, with one branch, Mahāyāna Buddhism, being dominant in Japan. From this main group 'new' movements developed in Japan, such as Sōka Gakkai in the 1930s and Agonshū in the 1950s

**CHRISTIANITY** – first introduced to Japan by Catholic missionaries in the 1500s, about 1.5% of Japanese people follow the teachings of the Bible today

**ISLAM** – most Muslims in Japan are foreign-born migrants and make up a small proportion of the population. Islam is considered an immigrant religion

**IMMIGRANT RELIGIONS** - Other immigrant religions, such as Bahá'í, Judaism, Hinduism, Sikhism and Jainism, are represented by small numbers of people in Japan

"Broadly speaking, the main religious tradition in Japan is a combination of Shintō practices and Buddhism – in particular Mahāyāna Buddhism," says Erica Baffelli, a Professor in Japanese Studies at The University of Manchester. Rather than ascribing exclusively to Shintō or Buddhism, many Japanese people will follow elements of each in their lives. Japan has a long history of tradition and ceremony, and many Japanese people will visit Buddhist

temples for memorial rituals and funerals, and Shintō shrines for prayers at New Year. "It is important to note that while participation at these rituals is quite high, most Japanese do not define themselves as 'religious'" says Erica. "They would more often talk of 'tradition' and 'culture' than religious affiliation."

This status quo sets an interesting stage for the integration of other religions or beliefs into

Japanese society. Erica is part of a research network investigating the roles and experiences of religious minorities within Japan. "Our research group includes researchers from the UK and Japan, who work across several different disciplines, such as sociology, religious studies, anthropology and Japanese studies," says Erica. This diverse range of expertise means that the group can collectively grasp a broader picture of new and minority religions in Japan, rather than focusing on any one narrow aspect.

### NEW, MINORITY AND IMMIGRANT RELIGIONS

In the 19th century, Japan started a process of modernisation from a predominantly rural society to an urban one. This also led to the emergence of different religious organisations, which were collectively termed 'new' religions, to distinguish them from Shintō and Buddhism which are seen as the mainstream. This label still exists even though some of the religions have been present for well over a hundred years. "In the Japanese context, 'new' does not mean a religion that has recently formed but is rather a contrast to the more 'established' religions," says Erica. "This means that



organisations such as Tenrikyō, which have been around since the 19th century, are still classified as ‘new’.”

As well as new beliefs arising in Japan, the country also saw the arrival of people from other parts of the world, who brought their religions with them. “Immigrant religions encompass a very diverse range of religious groups, including Christians, Muslims and many Buddhists,” Erica continues. “Some groups are considered ethnic religious minorities, such as Korean Christians. And yet, religious minorities make up a significant part of Japan’s population.”

These so-called new and immigrant religions may break away from Japanese cultural norms, which leads to potential for marginalisation: exclusion of a particular group from wider society. They are often classified as ‘minority’ religions, even though some movements, such as Sōka Gakkai, have many millions of members. This perception of ‘minority’ can exacerbate marginalisation by implying that these groups are not a significant part of the Japanese cultural landscape.

### CONNOTATIONS

New religions that emerge in Japan often incorporate some traditional practices, but have faced negative associations, especially in recent decades. In 1995, a new religion named Aum Shinrikyō staged a deadly terrorist attack on the Tokyo subway with sarin gas, killing 14 and injuring hundreds. “This incident meant that new religions began to be portrayed more negatively by the media, and often became depicted as cults, a word which carries connotations of indoctrination or violence,” says Erica.

Smaller religious groups that have migrated from other parts of the world, such as Islam, may have different experiences. “There have been few cases of Islamophobia in Japan to date, but this may be simply because there aren’t many Muslims in Japan,” says Erica. Muslims are monitored by the state as a possible terrorist threat, a form of discrimination that has the potential to filter into wider society.

### MEDIA AND POLITICS

“While the media can be an important source of information about new religions, they can also spread misleading or dangerous messages,” says Erica. For instance, the media may misrepresent new religions as dangerous or against Japanese values. “However, media technologies have also been used by religious groups to spread their message and reach a wider audience, and promote their relevance in a modern-day world,” she adds. For instance, the new religion Agonshū pioneered the use of satellite broadcasting in the 1980s as an effective tool for garnering more followers.

In general, the Japanese political system does not interfere with religion. Japan has a strict separation between religion and state, though there have been political debates over how to define religion – given the grey areas between religion, culture and tradition. Such discussions are important for defining the role of state officials in participating in religious rituals, for example. Furthermore, the 1995 sarin gas attack raised discussions about how religious organizations could or should be monitored to prevent possible violent incidents.

### DISCRIMINATION OR EMPOWERMENT

“Some members of new religions do not



## PROFESSOR ERICA BAFFELLI

The University of Manchester, UK

### FIELD OF RESEARCH

Japanese Studies

### RESEARCH PROJECT

Understanding the roles of marginalisation and empowerment on minority religions in Japan

### FUNDERS

*This research is part of a collaborative project between The University of Manchester (PI: Professor Erica Baffelli) and Toyo University (CI: Professor Norihito Takahashi), funded by UKRI (ESRC/ AHRC UK-Japan SSH Connections Grant “Religion and Minority: Lived Religion, Migration and Marginalities in Secular Societies” ES/S013482/1).*

publicly disclose their membership, for fear of judgement,” says Erica. “At the same time, participation in these groups may help them feel empowered. Being part of a special group that claims to have the ‘truth’ can lead to strong internal cohesion, even if they face increasing marginalisation from wider society.” Religious communities can also provide important forms of support, such as information about access to education and welfare, which minority groups might otherwise lack.

Erica’s research will dig deeper into this paradox, to uncover to what extent these communities feel marginalised or empowered, or both. Her work will be integrated alongside that of her colleagues within the research network, and together they will produce an authoritative exploration of the experiences of minority religions in Japan, how they are perceived and represented, and any lessons for a rapidly changing society.

# ABOUT THE HUMANITIES AND JAPANESE STUDIES

Though sometimes portrayed as less valuable than science, both science and humanities are essential for understanding and improving the world around us. Erica explains more, drawing on her own experience.

**It is important to have experts in history, languages, media, and religion,** especially given the uncertainty and challenges surrounding society's future. A degree in the humanities will make you a good communicator, a quick and flexible learner, and a knowledgeable person.

**I think the COVID-19 pandemic has highlighted why we need training in the arts and humanities.** Though of course we needed scientists to develop treatments and

vaccines, we also needed historians to draw on experiences of past pandemics to address this one, language and culture experts to understand human responses to lifestyle restrictions, and social scientists to explain the societal and economic impacts of the pandemic. We also need empathetic thinkers to assist with mental wellbeing through lockdowns, and to help people deal with loss and trauma.

**This goes for other societal challenges, too.** Addressing climate change, for instance, relies upon humanities experts to understand how society and individual human beings can respond to these challenges, and implications for life in the future.

**I believe that studying a language is crucial to understand a culture.** However, language itself is not enough for an in-depth understanding of society. Language degrees such as Japanese Studies combine intensive language training with in-depth study of cultural aspects and how to research them effectively.

As it states on the *The University of Manchester's website*: "Japanese Studies at Manchester gives students the opportunity to examine contemporary Japan through its language and culture while developing an understanding of the historical forces and cultural and social dynamics that have shaped the country."

## EXPLORE A CAREER IN THE HUMANITIES

- There are a very wide variety of potential careers resulting from studying a humanities subject, including Japanese Studies. Careers in research, languages, law, marketing, and consulting are all possibilities. Find out more: [www.brightnetwork.co.uk/graduate-career-advice/no-idea-what-to-do/what-to-do-with-degree/what-can-you-do-humanities-degree/](http://www.brightnetwork.co.uk/graduate-career-advice/no-idea-what-to-do/what-to-do-with-degree/what-can-you-do-humanities-degree/)
- Manchester's Faculty of Humanities, where Erica works, has a rich variety of outreach activities for high schools and young people: [www.humanities.manchester.ac.uk/connect/schools-colleges/](http://www.humanities.manchester.ac.uk/connect/schools-colleges/)
  - Manchester's School of Arts, Languages and Cultures has a wide range of subject-specific outreach activities: [www.alc.manchester.ac.uk/connect/schools/outreach/](http://www.alc.manchester.ac.uk/connect/schools/outreach/)
- The 2019 Complete University Guide rated The University of Manchester 3rd in the UK for East and South Asian Studies.

## PATHWAY FROM SCHOOL TO JAPANESE STUDIES

Many universities in the UK and abroad offer courses in Japanese Studies, from a first degree to a master's and PhD. Erica recommends studying a foreign language as an important skill. English Language is also useful as well as other humanities subjects such as history, sociology, anthropology or religion.

## ERICA'S TOP TIP

Whatever degree you do, look for scholarships or schemes that will allow you to spend a term or year in another country. Living abroad is challenging but can be a positive life-changing experience. Having a broad perspective on different ways of life is highly valued by employers



# ● HOW DID ERICA BECOME A PROFESSOR IN JAPANESE STUDIES

## WHAT LED YOU TO STUDY JAPANESE STUDIES AT UNIVERSITY?

I must confess the choice was initially quite random, and I didn't know much about Japan when I enrolled. In high school I was interested in languages and philosophy, though the philosophy I was taught focused on European traditions and I was curious to learn about differences in other parts of the world. My degree offered the chance to combine language training with specialisation in a cultural area.

## WHAT IS IT ABOUT JAPAN THAT FASCINATES YOU?

I grew up in Italy, where few regularly go to church, although many people say they are Catholics. In contrast, in Japan, most people describe themselves as non-religious, but participation in rituals and religious festivals is very high. This difference fascinated me and

made me want to know more about the role of religion in Japanese society. These days, Japan is a very familiar place to me, a place where I feel at home.

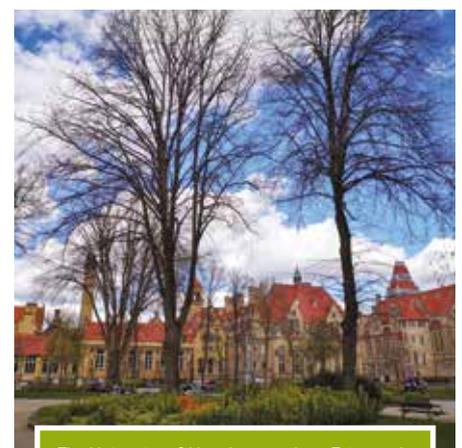
## WHERE DID YOUR CAREER TAKE YOU AFTER YOUR PHD?

My first academic job was in Otago, New Zealand. I was very inexperienced, but I was lucky to have a supportive environment that taught me how to be a good teacher and a good colleague. It was a crucial experience for my career.

## WHAT DO YOU ENJOY MOST ABOUT BEING A RESEARCHER?

I love listening to people's stories, especially when their ideas, values and life experiences are different from mine. Then, I like to read widely about a topic and try to grasp it. I also like the

idea of constantly feeling that there is so much more that I can read and study, that there is always something new to learn.



*The University of Manchester, where Erica works*



# WHAT DOES ADOLESCENCE LOOK LIKE FOR TEENAGERS IN ENGLAND AND JAPAN?

OUR WORLD MAY BE HOME TO MANY DIFFERENT CULTURES, BUT NO MATTER WHERE WE ARE RAISED, THE TIME WE SPEND TRANSITIONING FROM CHILDREN INTO ADULTS IS ONE OF THE MOST IMPORTANT STAGES OF OUR LIVES. DR EMILY EMMOTT AT UNIVERSITY COLLEGE LONDON IN THE UK AND DR MASAHITO MORITA AT THE UNIVERSITY OF TOKYO IN JAPAN ARE LOOKING AT WHAT IS IMPORTANT TO TEENAGERS IN DIFFERENT CULTURES AS THEY GO THROUGH ADOLESCENCE. BY ASKING TEENAGERS IN ENGLAND AND JAPAN TO PHOTOGRAPH THEIR EVERYDAY LIVES FOR A WEEK, THE TEAM HAS LEARNED MORE ABOUT THE SOCIAL LIVES OF TEENAGERS, AND HOW THEIR EXPERIENCE OF ADOLESCENCE IS SHAPED BY THEIR CULTURE

## TALK LIKE A BIOLOGICAL ANTHROPOLOGIST

**ADOLESCENCE** – a transition period between childhood and adulthood, associated with puberty, as well as changes to our roles and responsibilities

**CULTURE** – the customs, beliefs, habits, arts and social behaviour of a particular group of people

**SOCIALITY** – our ability as individuals to associate with other people in our communities

**EVOLUTION** – changes in the characteristics of living organisms over many generations, which help species to adapt to their surrounding environments

Adolescence is one of the most important periods of our lives. As we grow out of childhood, we are constantly surrounded with changes – to our bodies, to our roles and responsibilities, and even to the people we choose to spend time with. At the same time,

changes in our brains make us suddenly very sensitive to what other people think about us, shaping our behaviour and development as we grow into adults. Yet even today, biologists are not completely sure why adolescence evolved in the first place!

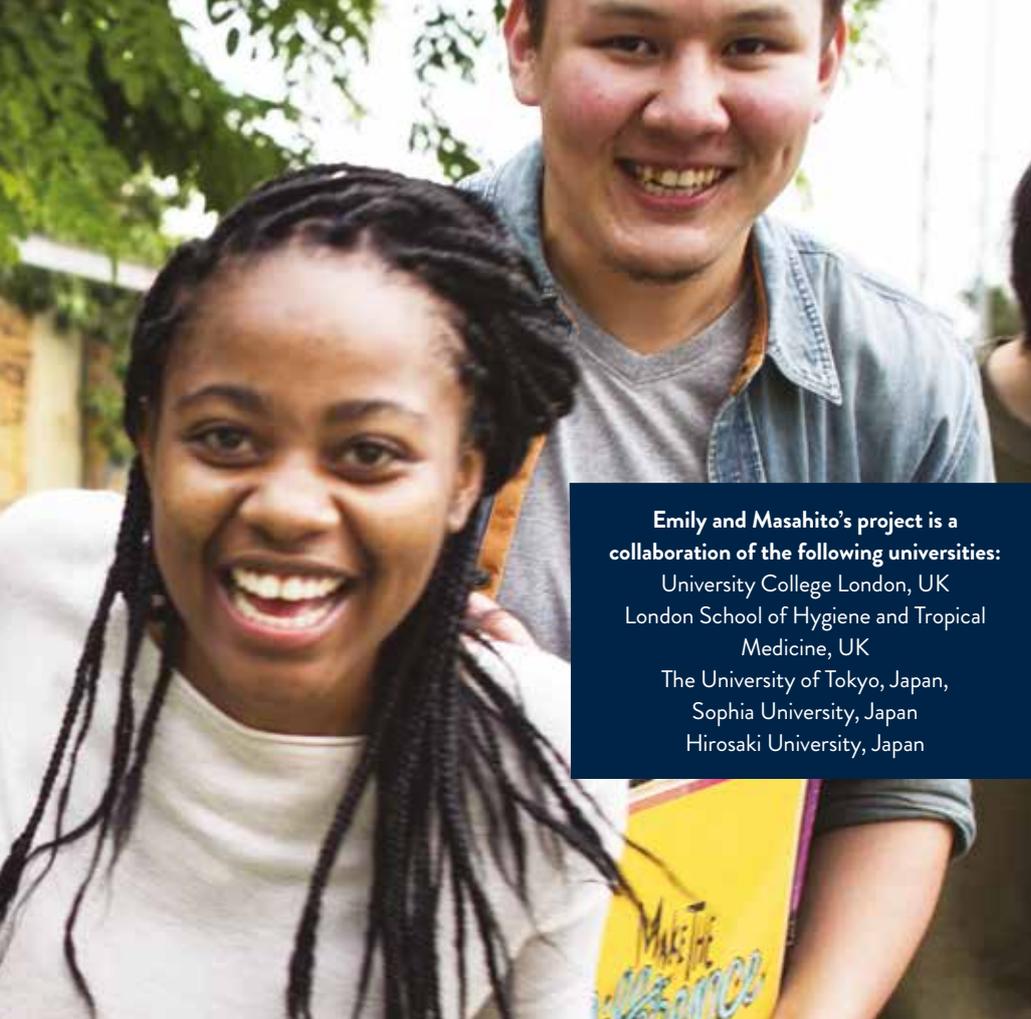
The adolescent experience is not completely unique to humans; in nature, biologists have discovered similar stages in the lives of many animals. Because of this, some biological anthropologists think that adolescence has a key evolutionary advantage, which provides us with the crucial skills needed to survive and thrive as adults. In their research, biological anthropologists Dr Emily Emmott, from University College London, and Dr Masahito Morita, from the University of Tokyo, are studying this idea by exploring similarities and differences between the adolescence experienced by teenagers in England and Japan.

## WHAT CAN WE LEARN FROM STUDYING ADOLESCENCE IN DIFFERENT CULTURES?

Across the world, humans have developed an array of different cultures. Although the

culture we grow up in can have a strong influence over how we think and feel, we are all still human beings – and so there are many aspects of our behaviour, especially in adolescence, that are similar no matter where we are raised. “Every society has some kind of adolescence,” Emily says. “Common characteristics include interest in potential mates (girlfriends and boyfriends), exploring new things, developing new skills, and spending more time with friends instead of family.”

Emily proposes that by comparing the experience of adolescence between different cultures, biological anthropologists could learn more about how such an important stage of our lives first evolved, and how it impacts our future development. While any two cultures would be interesting to compare in this way, Emily chose to work with teenagers in England and Japan in particular. This is because she is half English and half Japanese, knows many people in both countries and understands both cultures very well. Working in collaboration, Emily and Masahito are now leading a fascinating study into what adolescence really means to teenagers in both countries.



**Emily and Masahito's project is a collaboration of the following universities:**  
 University College London, UK  
 London School of Hygiene and Tropical Medicine, UK  
 The University of Tokyo, Japan,  
 Sophia University, Japan  
 Hirosaki University, Japan

**HOW DID THE TEAM COLLECT DATA?**

The key questions that Emily and Masahito wanted to ask were centred on the social lives of teenagers – such as who they hang out with, who they speak to, who supports them, and who they like and dislike. To collect this information, there are no people better qualified than teenagers themselves, and no better way to gather the data than taking photos of things important to them, which many teenagers already do every day. In their study, Emily, Masahito and their colleagues asked students from different schools in England and Japan to capture their everyday lives on camera, over the course of a whole week.

“We asked students between 13 and 15-years-old to take photographs of important things, people and places in their lives,” Emily says. “Teenagers are experts of their own lives, so it was very important that we as researchers did not make assumptions about what’s important to teenagers.”

**WHAT DISCOVERIES HAS THE TEAM MADE SO FAR?**

Emily and Masahito’s team gained a lot of new information from the data. By studying the photographs, the team attained a fuller view of the social lives of teenagers in both countries – with common subjects including friends and family, pets, hobbies and nature. As studies have revealed in the past, the data suggest that adolescence in both England and

Japan is crucial for gaining an identity and developing skills, and also for strengthening connections with our families, friends and wider communities.

At the same time, the team also noticed differences between the photos of teenagers in the two countries which they did not expect when the study started. “In England, many students communicated the importance of nature, and their pets were very important members of their family,” Emily says. “In Japan, students seemed to think more about their past and future, not just the important things in the present.” As it draws conclusions from the similarities and differences they have found between the experience of adolescence in England and Japan, the team will soon present its discoveries to the wider research community. Yet, even when the research has been published, there will still be much more for the team to learn through future research.

**HOW COULD THE RESEARCH BE EXPANDED IN THE FUTURE?**

Already, the team is carrying out further studies to explore more specific aspects of adolescence in England and Japan. “My research student at UCL is investigating what 16 to 18-year-olds in London think about ‘femininity,’ and a PhD student at the University of Tokyo is investigating how peers and schools might impact girls’ sports participation,” Emily says.



**DR EMILY EMMOTT**  
 University College London, UK

**FIELD OF RESEARCH**

Biological Anthropology

**FUNDERS**

Economic and Social Research Council,  
 Arts and Humanities Research Council  
 (Grant ref: ES/S013733/1)



**DR MASAHITO MORITA**  
 The University of Tokyo, Japan

**FIELDS OF RESEARCH**

Evolutionary Anthropology,  
 Human Behavioural Ecology

**FUNDER**

Japanese Ministry of Education, Culture,  
 Sports, Science and Technology  
 (Grant ref: JP17H06381)

Ultimately, the cultures of England and Japan are just a tiny fraction of all of the cultures we can find worldwide. In the future, Emily and Masahito’s team hopes to branch out to study how teenagers experience adolescence in other countries. By expanding the project further, the team could soon gain a more complete picture of how humans as a whole transition into adults, and perhaps even solve the evolutionary mystery of why adolescence emerged in the first place.

# ABOUT BIOLOGICAL ANTHROPOLOGY

As a whole, anthropology is the study of everything that makes us human. Within this incredibly diverse field, biological anthropology studies the bodies, behaviours and evolution of human beings, our now-extinct hominin cousins, and other living primates, which are closely related to us on the evolutionary tree of life. Biological anthropologists draw from many different biological concepts in their research: from Charles Darwin's theory of natural selection, to the latest advances in psychology.

The field is split into many different branches: from bioarchaeology, which studies prehistoric human bones taken from archaeological digs; to evolutionary psychology, which explores how our minds have been shaped by the laws of natural selection. Biological anthropology is also an important part of human biology, which explores how our minds and bodies are shaped by aspects including anatomy, biochemistry and genetics.

## WHAT IS REWARDING ABOUT THE FIELD?

Because biological anthropology is such a diverse area of research, Emily says that it can be really exciting to study. She could

be reading about the hunting practices of ancient hunter-gatherers one day, brain development in children and adolescents the next day, and the lives of marmoset monkeys the day after that!

Such a wide range of different topics means that biological anthropologists are rarely confined to one specific area of research. Instead, they use their knowledge of a broad range of subjects, combined with problem-solving skills and collaboration with other scientists, to make new discoveries. In addition, biological anthropology is one of the best-suited fields for working with people from all around the world, representing a hugely diverse range of cultures.

## WHAT CHALLENGES FACE THE NEXT GENERATION OF BIOLOGICAL ANTHROPOLOGISTS?

The huge diversity of biological anthropology also means that researchers from many different fields, who will not be hugely knowledgeable about each other's main area of research, will often need to work closely together. Because of this, it can be very challenging to coordinate experiments to gain the best possible results.

It is essential for anyone who hopes to become a biological anthropologist to be highly open-minded to unfamiliar differences between cultures; willing to learn from researchers who are more specialised than them in certain areas; and able to thrive when working as part of a larger, often international team. Emily also says that, so far, most biological anthropologists have worked exclusively with other scientists, but because history and culture are such important aspects of anthropology, there is now a growing demand for them to collaborate with researchers in the arts and humanities. It could be up to future generations of researchers to find new ways to extend the reach of biological anthropology beyond the scientific community.

## PATHWAY FROM SCHOOL TO BIOLOGICAL ANTHROPOLOGY

Although biological anthropology is a diverse field, Emily says that its foundations are based in biology, so that is the most useful subject for students to take at school. At university, some anthropology degrees offer biological anthropology as an option. You could also take broad-based science degrees like human sciences or arts and sciences.

Emily also says that it is important to understand human society, which subjects like geography, sociology and psychology are useful for. Since biological anthropologists often carry out their research all over the world, it might also be beneficial to study extra languages in school.

## HOW TO BECOME A BIOLOGICAL ANTHROPOLOGIST

- UCL Anthropology runs events, activities, and summer schools for students through the AnthroSchools programme: [www.ucl.ac.uk/anthropology/anthroschools](http://www.ucl.ac.uk/anthropology/anthroschools)
- Find out more about a career in biological anthropology through the UCL Anthropology website: [www.ucl.ac.uk/anthropology/about/biological-anthropology](http://www.ucl.ac.uk/anthropology/about/biological-anthropology)
- In Japan, the Human Behavior & Evolution Society of Japan ([www.hbesj.org](http://www.hbesj.org)) and Anthropological Society of Nippon ([anthropology.jp](http://anthropology.jp)) provide lots of useful information.

# HOW DID EMILY BECOME A BIOLOGICAL ANTHROPOLOGIST?

I loved art and being creative throughout my childhood and adolescence, but I also loved finding out how the world works. I never thought I would become a biological anthropologist – but it makes sense, as in my job I need to combine science with creative thinking.

I never thought I would become a scientist! I just kept doing what I loved, and one day I'd become a lecturer and researcher at a university. I'm very lucky to have been able to pursue my interests as my job.

Investing in collaborations and working well with people have made me much more

productive. Supporting and being supported by your team means you all work much better.

It's important not to take things too personally when things go wrong. It helps me to talk things through with people, and have a good break. It also helps to take my dogs for a walk!

It's hard to pick a single proudest moment, as my achievements have been a series of small steps, supported by other people, that have all built up to now. One thing I am very proud of is the course I designed and teach at UCL Anthropology, called Biosocial Approaches to Childrearing. It's based on my research to

understand the different ways in which people look after children and adolescents across cultures, and how that impacts development.

## EMILY'S TOP TIPS

- 01 Find your interest. To be a researcher, you need to keep learning new things all the time – so make sure you enjoy what you are learning.
- 02 Don't worry about failing or making mistakes. The important thing is to think about what you could do better next time, so you can improve.
- 03 Things often go wrong in research, and that's very normal – but the important thing is to reflect on the issues, so you keep making improvements.

# HOW DID MASAHITO BECOME AN EVOLUTIONARY ANTHROPOLOGIST?

In my first biology class in my high school (I was 15 years old), the teacher introduced a book entitled *The Selfish Gene* by Richard Dawkins. I was really impressed with the simple idea that a variety of animal behaviours can be understood in terms of survival and reproduction. This excitement made me interested in biology and has remained in my mind since that day.

Completing several processes in research (making a research plan, collecting data, analysing the data, discussing the results, writing and revising a paper, and publishing the final outcome) is sometimes really tough, but also lots of fun. Like the adolescent sociality project, conducting research with many colleagues and collaborators is exciting.

I have explored human behaviour from an evolutionary perspective for more than ten

years. What most left an impression was my first research as an undergraduate, where I observed people at a train station. I couldn't collect data at all in the beginning, but I gradually got used to it, and then I thought that I could understand 'a piece of nature' of the people and the place.

In studies of (non-human) animal behaviour, researchers often perform field observations in natural settings. In humans, however, such an approach is difficult due to several theoretical and experimental reasons, including ethical problems. So, we aimed to better understand the daily lives and thoughts of teenagers through their photographs.

Many early career researchers have experienced difficult situations, but fortunately I can continue to conduct research activities

thanks to many people. I am proud of it. I have recently begun a few new projects, so I hope to enjoy them in the short-medium term.

## MASAHITO'S TOP TIP

Cherish and explore the exciting things that you face in your life, now and in the future. They will enrich your life!



Masahito, Emily and colleagues in a workshop in Tokyo, by Adolescent Sociality Project, 2019. CC BY-NC 4.0



# WHAT IF WE COULD UNDERSTAND HOW AND WHY LANGUAGES EVOLVE?

THERE ARE OVER 7,000 LANGUAGES SPOKEN ACROSS THE WORLD, BUT HOW AND WHY DID THESE LANGUAGES EVOLVE? TO ANSWER THIS QUESTION, DR JENNY CULBERTSON OF THE UNIVERSITY OF EDINBURGH IN THE UK IS INVESTIGATING OUR CAPACITY TO LEARN ARTIFICIAL LANGUAGES – AND HER FINDINGS COULD HELP UNLOCK THE SECRETS OF THIS UNIQUELY HUMAN ABILITY

## TALK LIKE A LINGUIST

**LINGUISTICS** – the scientific study of language, including how we learn and use sounds, words and phrases to communicate

**CULTURE** – a broad term describing the habits of large groups of people living in the same area, which are passed on to new generations through learning and socialising

**PSYCHOLOGY** – the study of how our minds work, and how processes in our brains and bodies influence our thoughts, feelings and behaviours

**LEARNING BIAS** – in the case of linguistics, a learning bias

describes a preference we have for certain linguistic patterns or behaviours, regardless of our experience with language

**WORD ORDER** – how words in a phrase are ordered, e.g., ‘these two cups’ has the order Demonstrative Numeral Noun

**DEMONSTRATIVE** – a class of words including ‘this’, ‘that’, ‘these’, ‘those’ in English, used to indicate items in space or time

**SIGN LANGUAGES** – languages that use visual means to communicate, including hand gestures and facial expressions, used mainly by people who are Deaf or have hearing impairments

Language – be it spoken or signed – is the most important tool we have for sharing our thoughts, feelings and ideas. As you read this article, for example, you are using your knowledge of the English language to learn more about linguistics! But English is just one of over 7,000 languages spoken all over the world – and among the 8 billion people who speak these 7,000 languages, there is an incredibly diverse range of cultures. Over tens of thousands of years, these disparate groups have developed their own languages to make sense of the world around them.

“In Northern Paiute, an indigenous language of

the western US, words for siblings like ‘brother’ and ‘sister’ have different versions that specify whether they are older or younger,” says Dr Jenny Culbertson, a linguist and Director of the University of Edinburgh’s Centre for Language Evolution. “Languages spoken on islands and atolls, like Marshallese, use words like ‘oceanward’ and ‘lagoonward’ to navigate instead of ‘north’ and ‘south’.”

This linguistic diversity has its roots in cultural diversity: languages evolve from a need for people to express ideas that their particular

culture considers important. However, researchers like Jenny propose that our language is also shaped by how we, as humans, learn, in a way that does not depend on culture.

## CULTURAL EXPERIENCES AND PATTERNS IN THE MIND

To express this idea, linguists use the phrase ‘learning bias’. A learning bias describes a preference we have for certain linguistic patterns or behaviours that does not come from the experience with language that we have had. If our language knowledge came



### DR JENNY CULBERTSON

Director of the University of Edinburgh's Centre for Language Evolution  
The University of Edinburgh, UK

purely from experience, as some psychologists believe, Jenny argues that we would simply mimic the language of the people around us as we grow up, and speak like our parents.

As Jenny explains, this does not capture some of the most important things we know about language. "Even as toddlers, we create new words and sentences we've not heard before," she says. "Many linguists argue that this reveals a learning bias to reuse and recombine sounds and words in systematic ways." In other words, no matter our culture, the language we use reflects certain patterns and behaviours that come from the way our human minds work. Amazingly, we can also see this idea in action in the similar patterns of words found across otherwise very different languages.

#### WHICH TWO BLACK CATS?

By studying similarities and differences in the sentence structures used in different languages, Jenny can explore how learning biases shape language. Take the English phrase, 'these two black cats'. In Thai, the phrase would be 'mæw dā sǎng tǎw nī', or literally 'cats black two these'. In Basque, a language spoken in Spain, it would be 'bi katu beltz hauek', or 'two cats black these'.

Although the words are ordered differently in each case, it turns out that all three languages actually follow a very common pattern: when the adjective, numeral or demonstrative are on the same side of the noun, adjectives come closest to the noun, demonstratives (words such as this, that or those) are farthest away, and numerals fall in between. Word orders that do not follow this pattern, like 'black two these cats', 'cats these two black', or 'black cats these two' are far less likely to be used in a language. According to Jenny, this hints at what she calls 'universal' learning biases: language patterns that all humans prefer, no matter their cultural background.

#### A TRIP TO KENYA

A key part of Jenny's research is to gather

evidence for universal learning biases in controlled experiments. To do this, Jenny and her team travelled to Kenya to work with people who speak Kĩitharaka – a language spoken in a rural area around 100 miles from the Kenyan capital of Nairobi. Today, all children in Kenya must learn English in school. However, many people in their 60s and 70s went to school before this law was passed, and so they are 'monolingual', meaning they only speak one language – in this case, Kĩitharaka. Because of this, they are not familiar with the sentence structures used in other languages.

As Jenny describes, her team's mission was no simple task. "As you can imagine, recruiting monolingual Kĩitharaka-speaking participants is very complicated," she says. "In our study, we worked with a collaborator who is a member of that community and can travel around to visit the Kĩitharaka speakers."

Jenny's collaborators have documented that in Kĩitharaka 'these two black cats' is 'mbaka ino njiru cĩĩĩ', literally 'cats these two black'. This is a rare order where adjectives, instead of being close to the noun, are farthest away, and demonstratives, instead of being farthest from the noun, are closest. Jenny explains, "If we can show that Kĩitharaka speakers, despite experience only with this kind of rare pattern, find it easier to learn a language with a more common pattern, that would be very strong evidence for a universal learning bias."

#### MAKING UP NEW LANGUAGES

In her search for evidence of universal learning biases, Jenny constructs artificial languages, and looks at how they are learned. To create them, she constructs sentences of made-up words using some linguistic rules or patterns, like the ones used in Kĩitharaka, English or Thai. She then recruits people to find out how easy these artificial languages are to learn by speakers of other languages. "I've made artificial languages with words and grammar to describe cute animals, weird insects, aliens, chefs punching burglars and groups of friends

#### FIELD OF RESEARCH

Linguistics

#### RESEARCH PROJECT

Jenny studies the similarities and differences between the linguistic patterns used by languages around the world. Through the use of artificial languages, she is studying whether these patterns emerge because of local cultures or are more influenced by universal properties of the human mind.

#### FUNDERS

UK Research and Innovation  
European Research Council

*This work was supported by the Economic and Social Research Council (grant number ES/N018389/1), and by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 757643).*

eating bananas!" Jenny says. "We try to make it fun for people to learn."

So far, Jenny's research has included working with people who speak English, Thai and Hebrew. Her research on Kĩitharaka is the latest ongoing project. Jenny's aim is to find out how easy it is for them to learn each other's sentence structures when expressed in an artificial language that Jenny's team has made up. In turn, she will uncover whether certain linguistic patterns are learned more easily. "If the patterns we find commonly among the world's 7,000 languages are easy to learn, while very rare patterns are hard, this would provide key evidence that universal learning biases, shared by all humans, shape the evolution of language."

# ABOUT THE EVOLUTION OF LANGUAGE

The society we have built for ourselves today would have been impossible without language. While many animals can talk to each other using noises, movements and even smells, none of their communication systems are nearly as rich or complex as the languages we use. For linguists, this creates two particularly important questions: how did language come to be as rich and complex as it is? And secondly, how did human language evolve from the kinds of communication systems used by other animals?

## WHAT CAN WE LEARN FROM LANGUAGE SYSTEMS CREATED BY DEAF COMMUNITIES?

Some of the most exciting recent discoveries have come from studying newly emerging sign languages. “These are visual languages created by Deaf communities where there is no existing common sign language they can use. In other words, they have to create a language wholesale,” explains Jenny. Her team has

recreated these processes in the lab, by asking hearing people with no previous knowledge of a sign language to make up their own hand gestures for communicating ideas, and then passing them on to a new set of people to learn and use in turn.

## WHAT DID THIS TELL US ABOUT HOW LANGUAGE BECAME SO COMPLEX?

As newly created hand gestures were used and then passed from one ‘generation’ of participants to the next, orderly linguistic patterns emerged that were similar to those developed by Deaf communities. This suggests that both the complexity and the regularities we see in more established sign and spoken languages have developed over many years of people learning from past generations and then using what they have learned to communicate. If these ideas are correct, they could go a long way to explaining how languages have developed over time to become both rich and complex but also learnable.

## WHAT ABOUT THE RELATIONSHIP BETWEEN OUR LANGUAGE AND ANIMAL COMMUNICATIONS?

Like humans, animals can share information with each other about the world around them. For example, many species of monkeys living in the rainforest use a distinct set of ‘alarm calls’ and ‘food calls’. “Monkeys are closely related to us, so it’s very interesting that they have this ability,” says Jenny, “but their repertoire of calls is small, say 15 calls per species, compared to the 10-15,000 words that a typical 10-year-old knows.” Other animal species, like songbirds and dolphins, can learn to copy complex sounds, and even sometimes create new sound combinations. But as far as we know, these sounds do not have specific meanings. “Humans seem to be unique in having both the ability to learn complex sounds, and the ability to use them to share meaningful information about the world around us.”

## EXPLORE A CAREER IN LINGUISTICS

- Jenny recommends checking out The Linguistics Society of America ([www.linguisticsociety.org](http://www.linguisticsociety.org)), which has a section called ‘What is Linguistics?’. Here, you can find information about studying and working in linguistics.
- “Linguistics graduates are well-equipped to undertake careers ranging from marketing and publishing to speech and language therapy,” says Prospects, which lists job options and potential employers: [www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/linguistics](http://www.prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/linguistics)

## PATHWAY FROM SCHOOL TO LINGUISTICS

Jenny recommends studying psychology and foreign languages at school, as they often include elements of linguistics.

Many universities worldwide now offer dedicated courses in linguistics and the psychology of language.

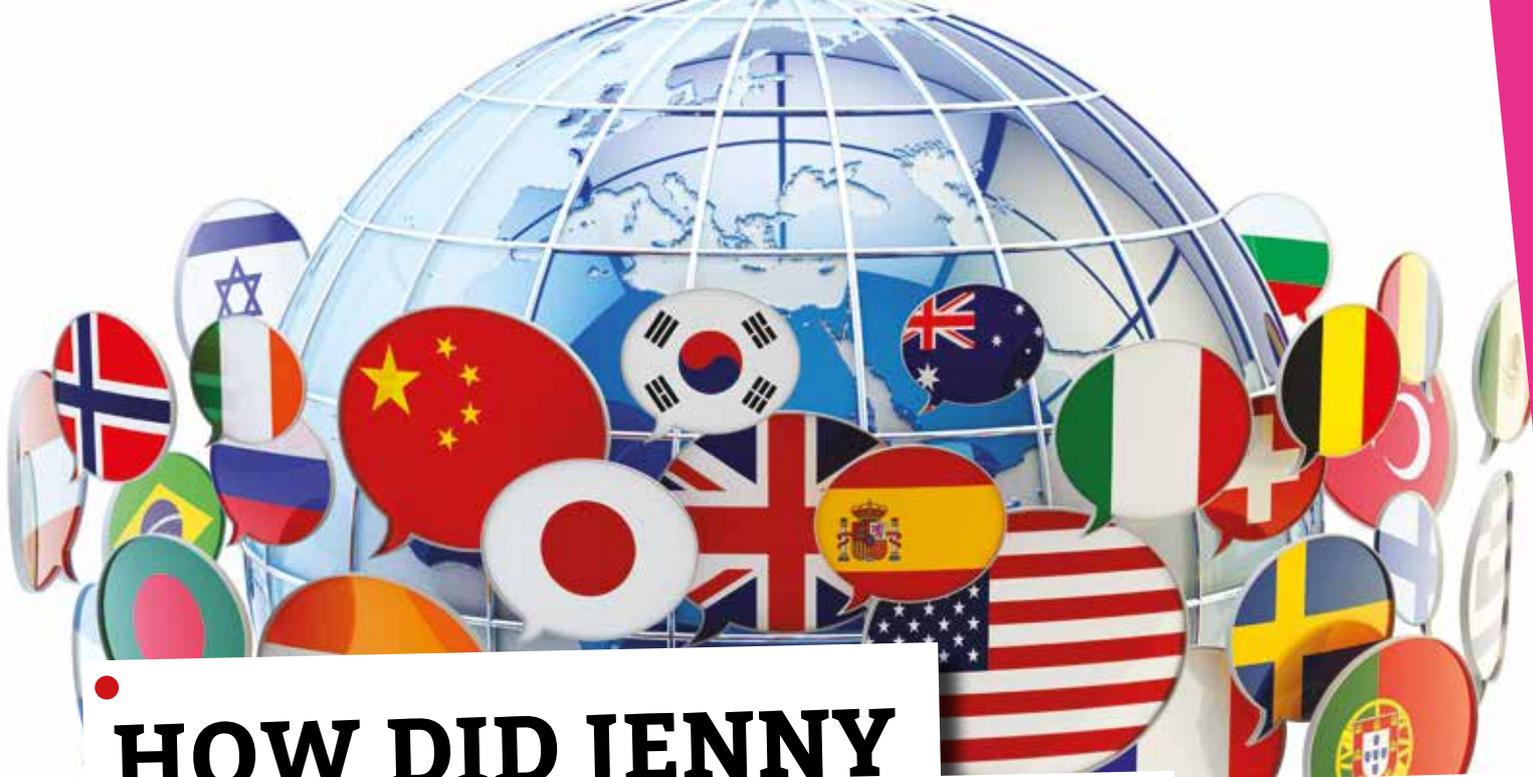
## JENNY’S TOP TIPS

**01** These days, a lot of linguistics involves maths and computer programming. These are great skills to have for almost any career, so start early!

**02** I would also highly recommend seeking out people who work in linguistics in your area to see whether they have any job opportunities available. That’s how I really got into linguistics, by working in a language acquisition lab.



*Jenny and her team travelled to Kenya to work with people who speak Kĩitharaka, a language spoken in a rural area around 100 miles from the Kenyan capital of Nairobi.*



# HOW DID JENNY BECOME A LINGUIST?

## WHAT DID YOU WANT TO BE WHEN YOU WERE YOUNGER?

I've wanted to be an academic for an embarrassingly long time, since early high school!

## WHAT INSPIRED YOU TO STUDY LINGUISTICS?

I was studying Classics (Ancient Greek and Latin) when I first went to university, but I knew it wasn't quite the right thing for me. At some point, I did an independent study class (I was very lucky because it was just me and a professor) on how Latin changed into the Romance languages like French, Spanish and Italian. I was super fascinated, and that led me to linguistics.

## YOU HAVE A BA IN LINGUISTICS AND CLASSICS, AND AN MA AND PHD IN

## COGNITIVE SCIENCE. WHY DID YOU MAKE THE MOVE FROM LINGUISTICS TO COGNITIVE SCIENCE?

I had no idea about cognitive science until I applied to graduate school at Johns Hopkins University in the US. I remember that as soon as I got there and started talking to people, I just thought, yes, this is it! Cognitive science is an interdisciplinary field that is focused on the study of the human mind and how it represents knowledge. That includes perspectives from linguistics, psychology, computer science and philosophy. So, it's much broader, and really lets you see the big picture and think about language as just one (very cool) part of human cognition.

## DO YOU LOVE LEARNING LANGUAGES?

I do love learning languages, but sadly, aside

from English and French, I don't speak any others fluently. That's partly because of my focus on languages like Ancient Greek, Latin and Sanskrit, which aren't spoken anymore, and partly because the type of linguistics I do is focused less on particular languages and more on language, in general. But many linguists are amazing speakers of multiple languages!

## WHAT SHOULD WE ALL KNOW ABOUT LEARNING LANGUAGES?

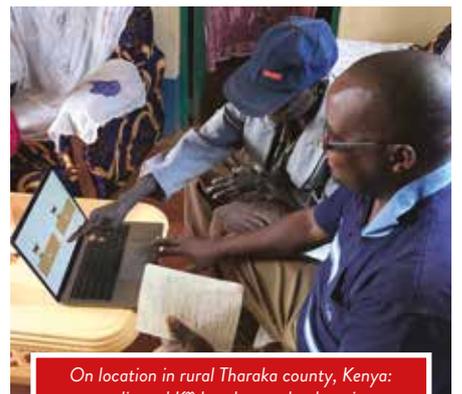
It's hard! And we are much better at it as children. But recent research suggests that the window for native-like language learning might be wider than we thought – up to the age of 20. So, it's not too late to start. Most people in the world speak more than one language.



The team in Kenya (Patrick Kanampiu, Jenny Culbertson, David Adger and Alexander Martin).



Jenny at a Language Evolves! workshop in Edinburgh, Scotland.



On location in rural Tharaka county, Kenya: a monolingual Kiitharaka speaker learning an artificial language.

# WHAT IF WE COULD TRANSLATE DATA INTO SOUND?

THE HUMAN EAR CAN PROCESS INFORMATION FAR BETTER THAN THE EYE, SO WHY ARE DATA ALMOST ALWAYS PRESENTED TO US IN VISUAL FORMS? COMPOSER **GLENN MCCLURE** IS THE PRINCIPAL INVESTIGATOR OF A NATIONAL SCIENCE FOUNDATION PROJECT, WHICH AIMS TO TRANSLATE BIG DATA INTO MUSIC

## GLOSSARY

**ALGORITHM** – a sequence of instructions used by computers to solve complex problems using data

**BIG DATA** – a field of research that develops ways to accurately extract useful information from huge datasets

**SONIFICATION** – the use of non-speech sound to convey information and perceive data

Whether we notice them or not, we are surrounded by sounds at every moment of our waking lives. And when we interpret these sounds, our brains make decisions about what to do next. “Your alarm clock delivers a sound to wake you up. Social media sites have sound alerts when you receive a new message. When you’re about to cross the road, you might hear an ambulance siren before you see it,” says Glenn McClure. He is a composer, co-founder of the Antarctic Artists and Writers Collective (AAWC) and principal investigator of the Music in the Numbers project.

Emerging research shows that the human ear has the capacity to process information far better than the eye and yet, in spite of the importance of sound in so many aspects of our lives, its role in the interpretation of scientific data is fairly limited. Indeed, sound tends to be used for threshold analysis – in other words, alarms that are triggered by certain thresholds. For example, an alarm will go off to alert hospital staff when a patient’s heart rate falls or increases to a dangerous level. But, for Glenn, this barely scratches the surface for the potential use of sound when interpreting data. This is where his Music in the Numbers project comes in.

## INSPIRATION FOR MUSIC IN THE NUMBERS

In 2016, Glenn travelled to Antarctica on a grant from the National Science Foundation’s (NSF) Antarctic Artists and Writers Fellowship. Its mission is to inspire and educate the public about this polar region and the science that goes on there. With a team of scientists from the Scripps Oceanographic Institute in San Diego, Glenn studied data gathered by seismometers placed on the Ross Ice Shelf. By picking up subtle movements in the ice, these seismometers detected vibrations or infragravity waves travelling through the ocean. Since the ice shelf

sits on water, it responds to water movement affected by events around the globe. The data collected by these instruments even registered wave movements from the 2011 Fukushima tsunami in Japan!

Glenn used the seismological data to compose several pieces of choral music, which told a story of our changing planet. “During my time on the ice, I started to realise that the algorithms created for this artistic project may have applications beyond music. Musicians are professional listeners and highly trained in analysing multiple, parallel datasets coming from every instrument of the orchestra. This training allows musicians to listen in ways that the average guy on the street does not. After performing the initial choral pieces, I started researching challenges in data science and found that there is a need for new strategies to analyse big data,” Glenn explains.

## SIMILARITIES BETWEEN DATA AND MUSIC

Think about your favourite piece of music. When you listen to this music, your ears will be presented with deeply intricate soundscapes, with each voice and instrument contributing its own small part to the overall sound. According



**GLENN MCCLURE**

Composer, Co-founder of the Antarctic Artists and Writers Program (AAWP) and Principal Investigator of the Music in the Numbers project, USA

**RESEARCH PROJECT**

Developing computational techniques for expressing large sets of data using music. The Music in the Numbers team advocates the wider use of sound to present and interpret information.

**FUNDER**

National Science Foundation (NSF)

to Glenn, data gathered through scientific experiments – or in other contexts such as in banking – display similarly complex patterns. “Just as we listen to a guitar, bass, keyboard, drums and singers in a rock band, data analysis involves studying many parallel datasets, including the ups and downs and ongoing relationships between multiple sets of numbers,” he says. With this in mind, music could therefore be used to convey complex datasets (see the print of some sonification translation below). Of course, successfully converting raw scientific data into sound is no easy task. To do this, Glenn and his team use advanced mathematical techniques.

**SONIFICATION**

Glenn’s team is developing useful algorithms that are able to instruct computers to ‘sonify’ data. This involves creating a set of rules that determine how data points are plotted on a

musical canvas. When data are plotted on a graph, the relationship between sets of variables is shown with lines, bars and dots. With music, however, data need to be presented as notes, with varying sounds, pitches and volume.

Not only that, but the sonified data have to be tailored to different users. “For those cultures that widely use the seven-note Do Re Mi scale, we will translate the data points into musical pitches that fit that scale. For cultures that use microtones and other musical systems, other algorithms work better,” Glenn explains.

Handling large datasets and allowing users to tailor the music to their desired settings were a challenge for the team, but a working prototype known as ‘Music in the Numbers’ has been developed. Excitingly, Music in the Numbers can sonify datasets and generate musical melodies,

which can be played using a wide range of instruments and even in different musical genres, from jazz to rock or classical music.

**WIDER IMPACT**

Technology plays a part in so many aspects of our daily lives. Many careers, from scientific research to finance and city planning, require people – or computers – to accurately interpret vast amounts of incoming information. With Music in the Numbers, Glenn’s team is introducing an entirely new way for us to experience these data. Indeed, work environments could become more productive, and even less stressful.

“Music in the Numbers will allow users to customise these sounds to make their experience both useful and fun,” says Glenn. “This product will provide a screen-free data tool that allows users to track data away from a computer screen, perhaps while they’re jogging, driving, making coffee for their co-workers, etc. This will open up a new avenue for productivity, mitigate current problems with eye strain over too much screen use, and engage a new part of our brain in data analysis – our audio cortex!”

But that is not all. Music in the Numbers will be a new tool for visually impaired scientists. Like visual analysis, braille representations of data have their limitations. Music in the Numbers will put visually impaired scientists on equal footing with their seeing counterparts.

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-0.2571341	0.07540349	1.82742997	F1	01	B1	01	01	F#
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0.4481488	-1.9099118	1.7406448	0.74954134	0.6465213	01	01	01	01

A print of some sonification translation.

# ABOUT THE ANTARCTIC ARTISTS AND WRITERS COLLECTIVE

The Antarctic Artists and Writers Collective (AAWC) is a gathering of creators that have participated in the National Science Foundation Artists and Writers Fellowship, which provides travel grants to artists of all kinds. With this funding, artists team up with scientific research teams in the Antarctic and tell their stories in imaginative ways. "The project recognises the long heritage of artists that have told these stories since the earliest days of Antarctic exploration," says Glenn.

The Collective now has over 70 members, all of whom communicate their work to the public with regular exhibitions and presentations – both online and in person.

## WHY IS AAWC'S WORK SIGNIFICANT?

Firstly, while the public might understand what scientists study closer to home, it is more difficult to engage the public in the study of Antarctica. AAWC artists have played a vital role in not only informing but also inspiring the public with artistic stories of the vital science done by courageous scientists at the bottom of the planet.

Secondly, misinformation spread by anti-science groups threatens several aspects of our lives,

from health to the economy and climate change. AAWC is taking innovative steps to combat this problem. Through paintings, poems, music, photography and other media, AAWC is drawing attention towards scientific research in ways that may not have been possible just a few years ago. Members strongly believe that the integration of art and science will be key to ensuring a widespread understanding of science among the public.

## WHY IS IT IMPORTANT FOR SCIENTISTS AND ARTISTS TO COLLABORATE?

Glenn argues that our current educational system forces a divide between students of art and science that really should not exist. In reality, the arts and sciences are strongly interlinked: for example, the physics of sound waves, and the biological mechanisms used to convert them into brain signals, are key to understanding how we play music and how it moves us emotionally.

In order for scientists to effectively communicate their ideas, especially about pressing issues such as climate change and public health, a strong collaboration between art and science has never been more important. "Scientists and artistic creators have a great deal in common,"

says Glenn. "They both try to understand the world around them, study intensely to gain the necessary skills and the proficiencies, and present to audiences with the hope to move them to understanding, compassion and action."

## DOES MUSIC REALLY HAVE A PLACE IN SCIENCE?

From ancient Greece (think of Pythagorus) to Renaissance-era Italy (think of Galileo), many of the greatest thinkers in history believed that science and music were intricately linked. In contrast, our modern culture tends to separate both fields entirely – and, as a student, you might have been made to believe that you must choose one over the other, i.e. the sciences over the arts. Glenn proposes that both science and society could benefit greatly if we shifted back to the attitudes of ancient thinkers towards music.

Music in the Numbers certainly presents an ideal opportunity to do this. "As we increase our understanding of the brain, we are learning that our audio capacity of processing data is equal to or greater than our visual capacity," Glenn says. "Sonification offers an opportunity to confront the biggest scientific and economic questions of our time."

*Recording the sounds of Adélie Penguins, Cape Royds, Antarctica*



# MEET GLENN

## WHAT DID YOU WANT TO BE WHEN YOU WERE YOUNGER?

I always wanted to be a musician. I was born a severe stutterer. At age 11, I learned a skill to control the disability. Before learning this control, the only time I could open my mouth without the physical and emotional distress of stuttering, was when I sang. Music circumnavigates the part of the brain affected by stuttering. When I sang, it was the only time I could freely communicate what was inside of me. Music had a scientifically measurable effect on my disability, which is why I seek to find hidden voices in the silence of data: the ice, space and students with disabilities.

## DURING YOUR NSF FELLOWSHIP IN ANTARCTICA, YUKI TAKHASHI SHOWED YOU AN IONISATION DETECTOR AND CHALLENGED YOU TO LISTEN FOR SOUNDS HE COULD NOT HEAR. HAVE YOU ALWAYS HAD AN ABILITY FOR THE DEEP LISTENING YOU USE IN CONCERT HALLS OR A RECORDING STUDIO, OR IS IT SOMETHING THAT COMES WITH PRACTISE?

It has come with both nature and nurture. On the nature side, stutterers feel the visceral link between the sounds of words and the complicated mechanism that produces them. Some studies suggest that hypersensitive hearing is linked to stuttering, and I have been diagnosed. On the nurture side, a musician

learns to listen deeply and, among other things, be able to imitate the professionals they emulate. I listened and learned to imitate many of the musicians in my upbringing. I studied sophisticated audio analysis techniques as a musician.

## WHO OR WHAT HAS BEEN YOUR INSPIRATION?

My grandfather Charlie McClure was a Vaudeville revival performer in the 1930s. He always had songs to sing and stories to tell, and also used his music to help people in his small, rural New York State town. My oldest brother's rock and roll band practised every Wednesday night in my living room. I fell asleep listening to songs from the Beatles, the Rolling Stones and Wilson Pickett. My parents were medical volunteers for the seasonal communities of migrant farmworkers. As they were doing medical check-ups, I would wander over to any informal music events, hearing Mexican, Puerto Rican and Southern Black Music. Music was never isolated in my life, it was always part of something bigger.

## YOU CALL YOURSELF A MUSICAL ACTIVIST. HOW HAVE YOU USED MUSIC AS A FORM OF PROTEST?

Music not only serves as a voice of protest for the individual musician but also has the power to draw together diverse constituencies toward a common goal. My career was launched when I joined a local environmental group that was

protesting a proposal to fill the empty cavities of our local rock salt mine with incinerated garbage ash. Scientists, political consultants and volunteers were all doing great work, but all this hard work wore them down. I found that a series of concerts that celebrated the good work of these people, and articulated our goals, played an important role in sustaining the protest until the proposal was rejected by our state government. I went on to perform with folksinger Pete Seeger and many others in support of this issue. My musical career has always held on to science and the environment in big and small ways.

## WHY IS IT SO IMPORTANT TO END THE DIVIDE BETWEEN SCIENTISTS AND ARTISTS IN SCHOOLS?

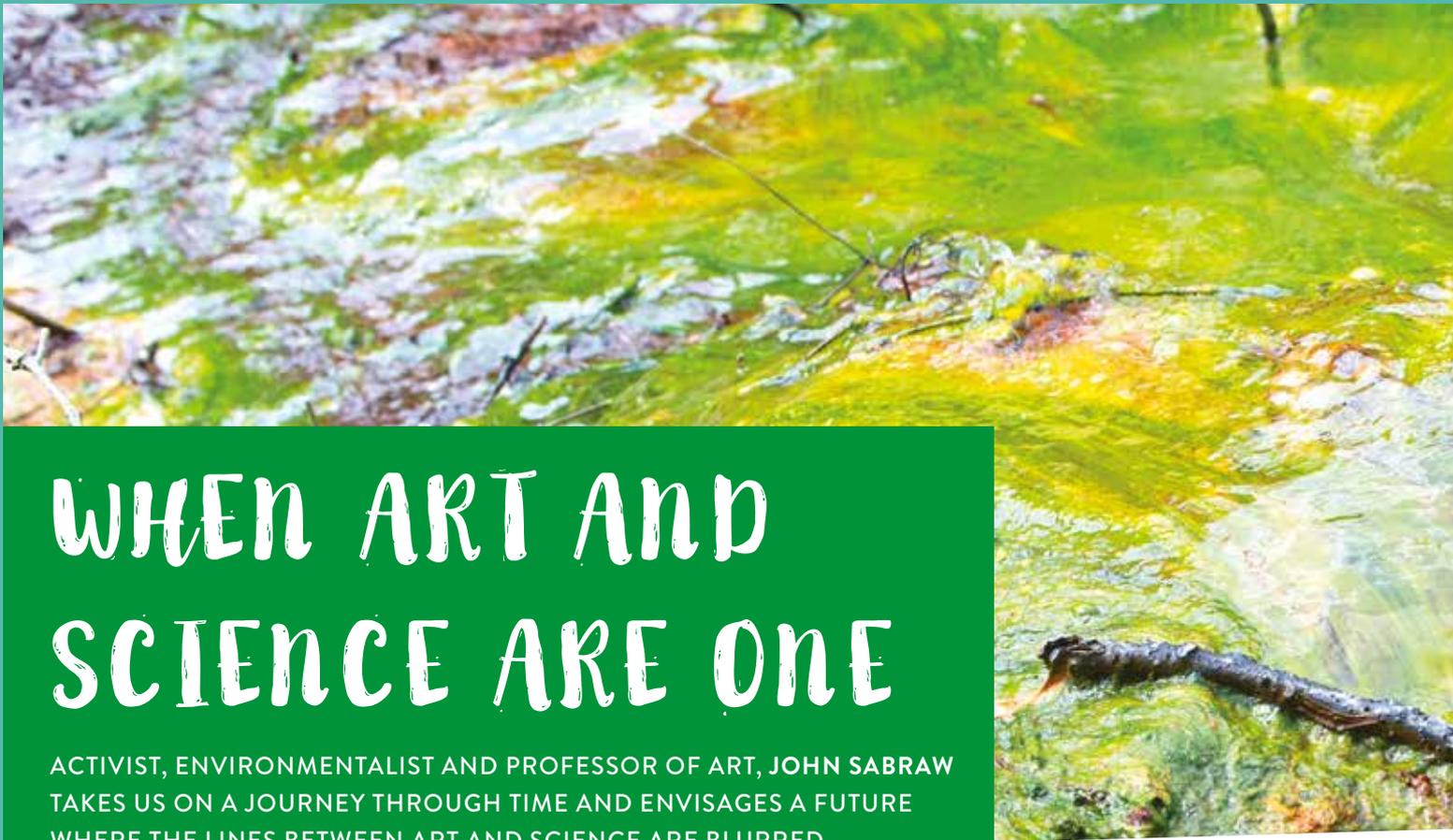
In the US, our current educational culture is still based upon a 19th century industrial model that was originally designed to help young farm kids learn how to work in an urban factory, because the factory was the driver of their future employment. Our schools mimic the industrial model of dividing tasks and separating math, science, English, music and art. Today, the drivers of future employment are connectivity, innovation, effective communication and leadership. Our school systems need the inspiration of countless musicians and scientists to reimagine how to prepare students for the world unfolding in front of us, rather than the world of 150 years ago.

## GLENN'S TOP TIPS

- 01** We all feel the burdens of information overload these days and no doubt you'll feel it more than anyone else. We are constantly asking ourselves, "Is this important or can I scroll to something else?" "Is this going to be on the test or can I just ignore it?" Don't wait for a teacher to tell you what is important or not. **EVERYTHING MATTERS.**
- 02** You should always be looking for ways that your studies of science or music connect to other things. You should always be curious, willing to try something that looks difficult, something totally out of your comfort zone. You should be joyfully willing to fail, then laugh, then try again.
- 03** Our lives are already integrated with learning, beauty, risk, success, mystery, failure and wonder. Embrace it all and watch where it takes you. As a high school student, I never put together a plan to get to Antarctica. I never imagined it. But I did good work and followed the advice of good people.



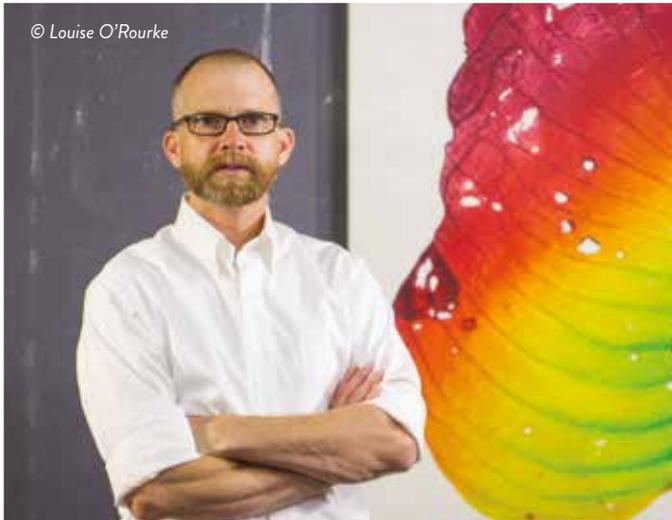
Glenn in concert. Rochester Oratorio Society, Director Eric Townell. Photo by Francesca McClure.



# WHEN ART AND SCIENCE ARE ONE

ACTIVIST, ENVIRONMENTALIST AND PROFESSOR OF ART, JOHN SABRAW TAKES US ON A JOURNEY THROUGH TIME AND ENVISAGES A FUTURE WHERE THE LINES BETWEEN ART AND SCIENCE ARE BLURRED

© Louise O'Rourke



**What comes to mind when you think of coal? Do you see it as a geological miracle? How about a piece of art? Or is coal something to be vilified: one of the causes of climate change and, therefore, a threat to our very existence?**

John Sabraw is a professor of art at Ohio University in the US. He is also an activist and environmentalist, using paintings, drawings and collaborative installations to highlight the many metaphysical dilemmas we face. Take coal, for example. It is a finite resource, formed many millions of years ago, when Earth was covered in swamps and giant trees, ferns, reeds and mosses. Today, John is embedding pieces of coal in resin and screwing other pieces onto canvas to make striking works of art in his studio in Ohio.

“All of the media coverage and conversations about coal, coal-fired power plants, electricity and renewables present coal as this big bad

thing when, actually, it’s really beautiful stuff,” says John. “In each chunk, you can see the tree. You can see fibres growing through it. I love knowing that this chunk of coal was a tree that fell into a swamp 300 million years ago, and because bacteria hadn’t evolved to eat it yet, it became condensed carbon. Once we’ve used up all the coal, we’re not making any more, that’s it. I want to make sure we aren’t turning coal into an evil object but, instead, giving it its due and seeing it as the magical formulation that it is.”

John collaborates with scientists. With numerous art projects on the go, his ultimate aim is to create opportunities for public interactions with art, science and all the questions we, as humans on planet Earth, need to be asking ourselves. “Artists and scientists have this tremendous responsibility right now to bring the public back into the discussion,” he says. “Not merely to show them something and go, ‘Hey look at this, do you like it?’, but saying to people, ‘Come and work on this with us, come out and see what the wildlife is doing, see what your waterways are doing, visit your local powerplant, understand the science so that you know how these things connect to you as an individual and your choices’. All of those discussions are a lot more fun when art and science are doing it at the same time, and with the public.”

## WHEN ART AND SCIENCE WERE ONE

**Leonardo da Vinci (1452-1519)** was an Italian painter, draughtsman, engineer, scientist, theorist, sculptor and architect. Interested in topographic anatomy, among many other subjects, he studied and drew the human skeleton, muscles, tendons and other visible anatomical features, and was the first to define atherosclerosis and liver cirrhosis.

**Johann Wolfgang von Goethe (1749-1832)** was a poet, playwright, novelist, theatre director and statesman. He was also a German scientist interested in the natural sciences – in particular, the form and structure of organisms (morphology).

Acid mine drainage with algae growth near Carbondale, Ohio. Photo by John Sabraw



"Vein" Appalachian coal and 24k gold leaf on jute, by John Sabraw. Photo courtesy of the artist.



"Axioma X" Mixed media on wood panel. Painting by John Sabraw. Photo courtesy of the artist.

**Alexander von Humboldt (1769-1859)** was a German polymath, meaning his knowledge spanned a substantial number of subjects. His main interests, though, were in geography, the natural sciences, exploration and philosophy.

Art and science have not always been viewed as separate entities. Rather, art and science were seen as a vital and inseparable means of understanding and describing the world. Towards the end of the 19th Century, however, and far into the 20th Century, the two began to separate. "When we had Goethe, Alexander von Humboldt and Leonardo, people understood that it was all connected. But then we made art and science irrelevant to the everyday lives of citizens," says John. "In academia, specifically, we did a great job of making sure that art and science were removed from the public. We did a fantastic job of specialising, specialising and specialising. Towards the end of the

20th century, though, artists and scientists started to recognise that it's not about making art or doing science in ivory towers."

#### ART AND SCIENCE IN THE 20TH CENTURY

**Agnes Denes (1931-)** is a Hungarian-born American conceptual artist. Based in New York in the US, she is known for her works in a wide range of mediums, covering science, philosophy, linguistics, psychology, history and music. In 1982, Agnes planted a two-acre wheatfield on a landfill site in lower Manhattan. She wanted visitors to do more than simply observe her art; she wanted them to experience it. The wheat was harvested, sent to 28 cities around the world in an exhibition called International Art Show for the end of World Hunger, and the seeds handed out to people to plant. In an interview, Agnes said "Wheatfield



*"Cortex S1 7" Mixed media on wood panel. Painting by John Sabraw. Photo courtesy of the artist.*

*"Chroma S4 Dragon" Mixed media on aluminum panel. Painting by John Sabraw. Photo courtesy of the artist.*

– A Confrontation represented food, energy, commerce, world trade, economics. It referred to mismanagement, waste, world hunger and ecological concerns.”

**Mel Chin (1951-)** is another American conceptual artist motivated by political, cultural and social circumstances. Mel started investigating the use of hyperaccumulator plants – plants that are able to extract heavy metals like cadmium, zinc and nickel from contaminated soil – and, in 1991, began an ongoing project with Dr Rufus Chaney, a senior research agronomist at the US Department of Agriculture. Based at the former Pig’s Eye Landfill in Minnesota, Revival Field is a 60 x 60-foot square, with a circle delineated inside that has been divided into 96 plots. Pig’s Eye was a hazardous waste site classified as toxic to humans and the environment by the Environmental Protection Agency. Mel’s idea was to test the efficacy of different hyperaccumulator plants in removing heavy metals from this site. Through this project and others, Mel has been instrumental in redefining the concept of art and its role in society.

“From around the 70s, artists like Robert Smithson were doing art about environmental degradation, but even though the dialogue was

there, little of it was directly involved with scientists,” says John. “They weren’t citizen science projects that people could interact with. When you get to the early 80s, Agnes and Mel started doing this work. This is when you begin to see a shift in terms of inspiring artists and scientists to collab in this way.”

### ART AND SCIENCE IN THE FUTURE

Periscopic calls itself a ‘socially conscious data visualisation firm’ and its motto is ‘Do Good With Data’. Periscopic is driven by artists (or artisans, as they call themselves) and their aim is to help organisations promote data transparency and public awareness. Their work spans all manner of societal issues, such as helping people empathise with children living in urban poverty, revealing the overwhelming magnitude of loss from US gun deaths, or raising awareness about breast cancer risk in the workplace. Periscopic is an example of an organisation that’s blurring the lines between what we would normally define as art or science.

“What I’m seeing now gives me great hope for the near future,” says John. “It’s not just about two disciplines working side by side in a space, it’s about people creating something new from collaborations.



I'm seeing it in terms of people who are dealing with gender issues, racial issues and inequality, as well as environmental issues. I'm seeing scientists, anthropologists, sociologists and psychologists working with artists to start addressing issues in a more public way. And I'm seeing a lot of cool artists who are crossing over into coding, processing, Unity and things like that. They're visualising data in ways that mathematicians or scientists can't and they're making new discoveries. Now we're asking: What is design, what is art, what is data, what is science, and what is the public outreach? It's all becoming a little blurry and I like it."

In these current times, there is still a tendency to separate the arts and sciences and to see ourselves as either an artist or scientist. Is this really the right way to be looking at the world around us and solving the challenges that need to be solved? Or should we be drawing on our collective creativity and knowledge, and working together to safeguard the natural wonders of our planet?

## ABOUT JOHN

John was born in St Ives, Cornwall in the UK, before moving to Southern Idaho in the US as a young boy when his father was reassigned to Mountain Home Airforce Base. Much of John's childhood was spent outdoors, exploring the canyons and desert landscapes, camping next to lakes where grizzlies roamed, and catching trout to cook over open fires. John loved drawing, and was good at it, but he didn't know he could embark on a career as an artist. He also loved science, but not as a school subject. He liked catching grasshoppers, reading books about prospecting for precious metals, and making explosives. Eventually, his explosives got him into trouble, and he was offered counselling or the justice system. John chose counselling. Interestingly, he was sent to a chemistry professor, Carl Bricker, who opened John's world to chemistry and more. "It became less about chemistry and more about the cosmos and how it works and what our place is in it," says John. "And that is the core of who I am today, without question."

[www.johnsabraw.com](http://www.johnsabraw.com)

## JOHN'S TOP TIP

"Whoever you are, whatever you're doing at any point in your life, it's good enough. All those things you desire, which might come to you someday but aren't in your life at the moment, those things can make you feel like you're not good enough. You are, without question, good enough. No matter how young you are, if you have something you're skilled at – coding, artwork, design, outreach – find someone who's doing something that speaks to you, reach out to them, email them, text them. They might not get back to you, but sometimes they will, and they'll be really happy to have someone thinking about what they're doing. Don't wait until you get that high school degree, or that one thing you think you need. If you want to do it, start right now, and you're going to get so good so fast."

## JOHN'S WORK

John has many collaborations with scientists on the go. One such project involves cleaning up waterways in Ohio that have been ravaged by coal mining. He and his team collect toxic sludge from polluted streams (take a look at the background images in this article), extract iron oxide from the sludge, and turn it into iron oxide pigment, which is then used to make paint.

You can read more about the project here:

[www.johnsabraw.com/research](http://www.johnsabraw.com/research)

Another example is a project with Draper Lab and MIT (Massachusetts Institute of Technology). "They're figuring out ways to take Monterey pine, which is an endangered species in California, and grow wood fibres in the lab so that you don't have to cut down trees to make paper," explains John. The team at Draper Lab and MIT are sending wood fibres to John, who will turn them into artwork that will inspire the public to learn more and get involved.



# TAKE A DEEP BREATH: INVESTIGATING AIR QUALITY

THE AIR IS FULL OF AEROSOLISED MICROSCOPIC MATTER THAT ENTER OUR LUNGS WITH EVERY BREATH. THE BIOAIRNET TEAM IS INVESTIGATING AEROSOLS OF BIOLOGICAL ORIGIN, WHAT THEY MEAN FOR OUR HEALTH, AND HOW WE CAN IMPROVE THE AIR QUALITY OF THE PLACES WE SPEND TIME IN

## AIR QUALITY TERMINOLOGY

**AEROSOLS** – particles suspended in the air

**AIR POLLUTION** – the presence of substances in the air that have harmful effects

**BIOAEROSOL** – aerosol of biological origin

**BIOAIRNET** – Indoor/Outdoor Bioaerosols Interface and Relationships Network

**BIOPM** – biological particulate matter; another term for bioaerosols

**HVAC SYSTEMS** – heating, ventilation and air conditioning systems

team. “It is estimated that between 28,000 – 36,000 deaths a year in the UK can be attributed to long-term exposure to particulate pollution.” Smoke and exhaust fumes are the most common suspects for these deaths, but less well-understood are the effects of biological particulate matter (known as BioPM). This is what the BioAirNet team is focused on finding out.

The BioAirNet team also hopes to remedy a common stumbling block when tackling large-scale challenges such as air pollution. “A lack of cohesion between communities of researchers and users can limit research and innovation, and this can affect the application of new science within policy,” says Dr Zaheer Nasar, Academic Fellow in Atmospheric Aerosols at the Centre for Environment and Agricultural Informatics, Cranfield University. “To ensure this is not the case with our project, BioAirNet is highly interdisciplinary.”

### WHAT ARE BIOAEROSOLS?

There are lots of different particles floating about in the air, most of which we cannot see. The collective term used for them is aerosols. The BioAirNet team works on a particular type of aerosol known as bioaerosols – any aerosol

from a biological origin. This can include single-celled organisms such as bacteria and viruses, and cells from larger organisms such as pollen, fungal spores or shed skin cells.

Bioaerosols enter the air from a wide variety of sources. They can come from natural origins – wind blowing over soil, rain falling on water or decomposition of organic matter, for instance. They can also come from industry, such as animal farming facilities, ventilation systems, food processing and sewage treatment. Household items such as carpets, pets, houseplants or heating systems can also produce bioaerosols.

Bioaerosols fulfil a number of useful purposes. They have a role to play in regulating the climate, such as through contributing to the creation of clouds, which absorb and scatter sunlight. Some also have an important biological function, like plants using airborne pollen or fungi using spores to reproduce.

However, bioaerosols also have the potential to harm human health. Some bioaerosols, such as pollen, fungal spores and cells from pets, can provoke allergic reactions. But most significantly, many disease-causing microbes,

“Air pollution is a major risk to public health in the UK,” says Frederic Coulon, Professor of Environmental Chemistry and Microbiology at the Cranfield Water Science Institute, and Principal Investigator of the BioAirNet

**“MICRO-ORGANISMS ARE FOUND EVERYWHERE – IN WATER, SOIL, AIR, AND IN AND ON PLANTS AND ANIMALS, INCLUDING HUMANS,”** says Frederic. While most of these are harmless or even beneficial, some can lead to illness and infection.

or pathogens, have a potential to be dispersed via the air.

### BIOAEROSOLS INDOORS

“Micro-organisms can enter indoor environments through various routes,” says Zaheer. “Doors and windows, HVAC systems, and our shoes and clothes are common entry points.” Once inside, microbes can get established if they find a suitable environment. “For instance, damp conditions can help microbes grow and multiply, leading to high levels of bioaerosols indoors,” explains Zaheer. “These can be harmful for human health, such as increasing the risk of respiratory disease.”

Indoor environments are of special interest to the BioAirNet team. “We spend a lot of time indoors, so we are more likely to have a high exposure to bioaerosols in these environments,” says Frederic. “Our exposure may also be changing over time. It is possible that more energy-efficient buildings, with increased insulation, may have reduced ventilation, which results in higher concentrations of air pollutants.” Those most vulnerable to harmful bioaerosols, such as the ill or elderly, also typically spend more of their time indoors.

### BIOAEROSOLS IN TODAY’S WORLD

“Today we are facing unprecedented levels of airborne biological threats,” says Zaheer. “Globalisation, urbanisation, and changes to the environment and climate mean that disease transmission cycles are changing significantly.” This was exemplified by the COVID-19 pandemic, where an airborne disease was rapidly spread around the world by international travellers.

Built environments have a major role to play in managing bioaerosols. “For instance, outbreaks of Legionnaires’ disease arise from contaminated water systems and air conditioning units within buildings,” says Frederic. “People are infected by breathing in airborne water droplets containing the pathogen.” Hospitals provide another example, especially given that they contain high numbers of both infected and vulnerable people. There

is a need for hospitals to be designed or maintained to ensure airborne micro-organisms are flushed from the building as effectively as possible.

### BIOAIRNET

“BioAirNet has been set up to tackle emerging air pollution challenges and associated health risks,” says Frederic. “This includes exploring human behavioural changes and technology interventions that can improve air quality.” The network encompasses professionals with many different areas of expertise, to make sure that all bases are covered.

BioAirNet has four interconnected themes:

1. Investigating the range of BioPM sources in different indoor/outdoor environments and identifying where research is needed.
2. BioPM sampling, to characterise different microbial systems.
3. Exploring effects of exposure to BioPM on human health, and how to prevent this.
4. Policy and public engagement, communicating about how to create healthy environments.

### BIOAIRNET AIMS

The project understands that quality and impactful research involves many minds coming together. “We will promote discovery science to answer the pressing questions we have on bioaerosols, facilitating cross-fertilisation of knowledge and interdisciplinary collaboration,” says Zaheer. “We also aim to attract the next generation of academic leaders, by providing leadership opportunities and helping early-career researchers engage with community stakeholders.”

BioAirNet does not just focus on research, but also includes outreach – an essential part of science to ensure that research findings are actually used in society in a meaningful way. “We will foster interactions between academics, businesses and other community-based stakeholders,” says Frederic. “We will also communicate our findings to the wider public.”

Ultimately, outcomes will influence the deployment of the UK’s Clean Air Strategy,



### PROF FREDERIC COULON

Principal Investigator, BioAirNet  
Professor of Environmental Chemistry  
and Microbiology  
Cranfield University, UK



### DR ZAHEER AHMAD NASAR

Co-Investigator and BioAirNet Manager  
Academic Fellow in Atmospheric  
Aerosols, Cranfield University, UK



### BIOAIRNET

Tackling air pollution through the Indoor/  
Outdoor Bioaerosols Interface and  
Relationships Network (BioAirNet) is  
one of six networks tackling air pollution.

BioAirNet brings together experts  
from a range of fields, and focuses on  
bioaerosols.



### FUNDER

Natural Environment Research Council  
(NE/V002171/1)

helping to make real-world positive changes for UK communities. Additionally, the findings from BioAirNet will be shared with other countries, who can share findings of their own with the UK. The project will also inform the UK’s foreign aid spending, helping to make positive changes to regions suffering from poor air quality. “BioAirNet aims to be the leading voice for the UK BioPM science community,” says Zaheer.

# THE UK'S CLEAN AIR STRATEGY

In 2019, the UK Government published its plans for tackling all forms of air pollution, to benefit human health, the environment and the economy. The conclusions of BioAirNet will influence how this strategy is carried out.

Previous legislation has focused on tackling concentrated sources of air pollution – factories, power stations and vehicle exhaust fumes, in particular. Since these major sources have decreased, now the focus is on more spread-out sources of pollution, such as smaller industrial sites, cleaning/maintenance products, open fires in homes and spreading manure on farms.

The Strategy can be broken down into several key parts:

- **Understanding the problem:** using research and analysis to build a picture of current air quality and the likely impacts of different policies.
- **Protecting health** – cutting public exposure to air pollution through public engagement and targeted action.
- **Protecting the environment** – focusing on nitrogen deposition, monitoring and addressing impacts on natural habitats.

- **Clean growth and innovation** – promoting the development of cleaner technologies through funding and legislation.

- **Reducing emissions from transport, at home, from farming, and from industry** – setting out policies for each area for targeted reductions.

- **Leadership** – enabling local action on air pollution and working with international partners.

- **Progress** – tracking how well the UK is doing in meeting the above targets.

## IMPROVING THE AIR QUALITY OF YOUR HOME

At the personal level, hygiene is the most effective way to reduce bioaerosols, especially indoors. The COVID-19 pandemic has reinforced these measures for many. Keeping surfaces and hands clean, covering your mouth when coughing, and wearing a mask when ill are effective ways of reducing potentially harmful bioaerosols.

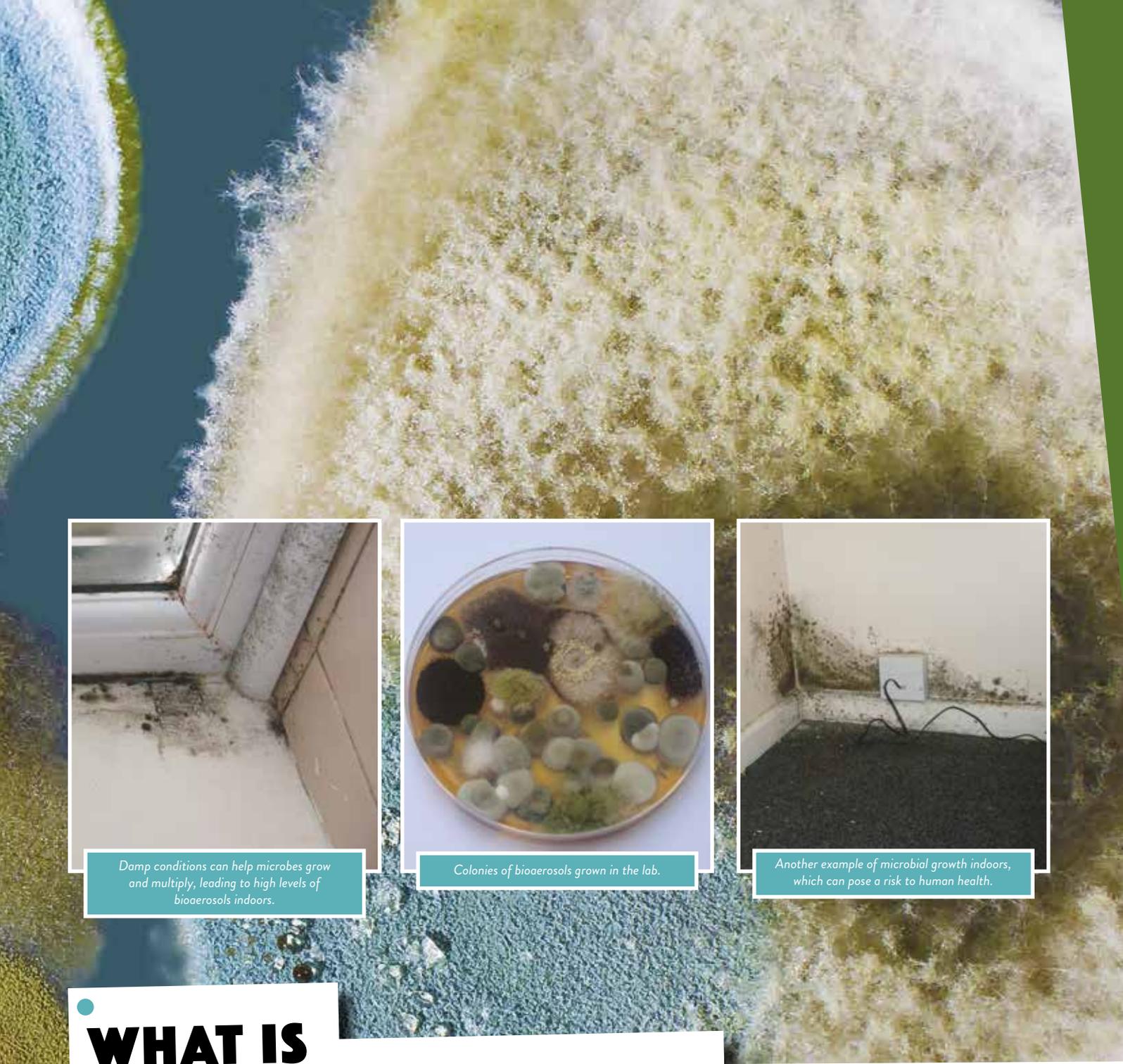
For maintaining indoor air quality more generally, here are some simple steps from the Clean Air Hub:

- Open windows regularly to prevent the build-up of air pollutants.
- Use fragrance-free or milder cleaning products.
- If you have an open fire or stove, use it only when essential, and opt for dry wood or smokeless fuel.
- Use extractor fans and open windows when cooking, cleaning or decorating.

## EXPLORE A CAREER IN AIR QUALITY RESEARCH

The BioAirNet team is highly interdisciplinary and its researchers come from a range of different scientific backgrounds. Below are some of the possible routes into a career studying air quality.

- **Chemistry** courses can include modules on air quality.
- **Microbiology** involves the study of micro-organisms, including airborne pathogens.
- **Epidemiology** involves modelling how diseases spread, such as through the air.
- **Environmental science** can include the study of how natural or man-made environments interact with air quality.
- **Chemical engineering** can include the study of industrial processes and how they affect air quality.
- **Social sciences** can explore sociological reasons for differences in air quality across society, and their impacts on communities.
- **Medicine** involves studying how aerosols impact individuals' health.



*Damp conditions can help microbes grow and multiply, leading to high levels of bioaerosols indoors.*



*Colonies of bioaerosols grown in the lab.*



*Another example of microbial growth indoors, which can pose a risk to human health.*

# WHAT IS INTERDISCIPLINARITY?

Scientists tend to specialise on a certain topic. This is to be expected, since it is very hard to be an 'expert' at many different things, given how much time and effort goes into building expertise. This means that it is impossible for one expert, or a group of experts in the same field, to fully understand, research and provide recommendations for any particular societal issue. Each can only hope to understand the part of the issue that relates to their expertise.

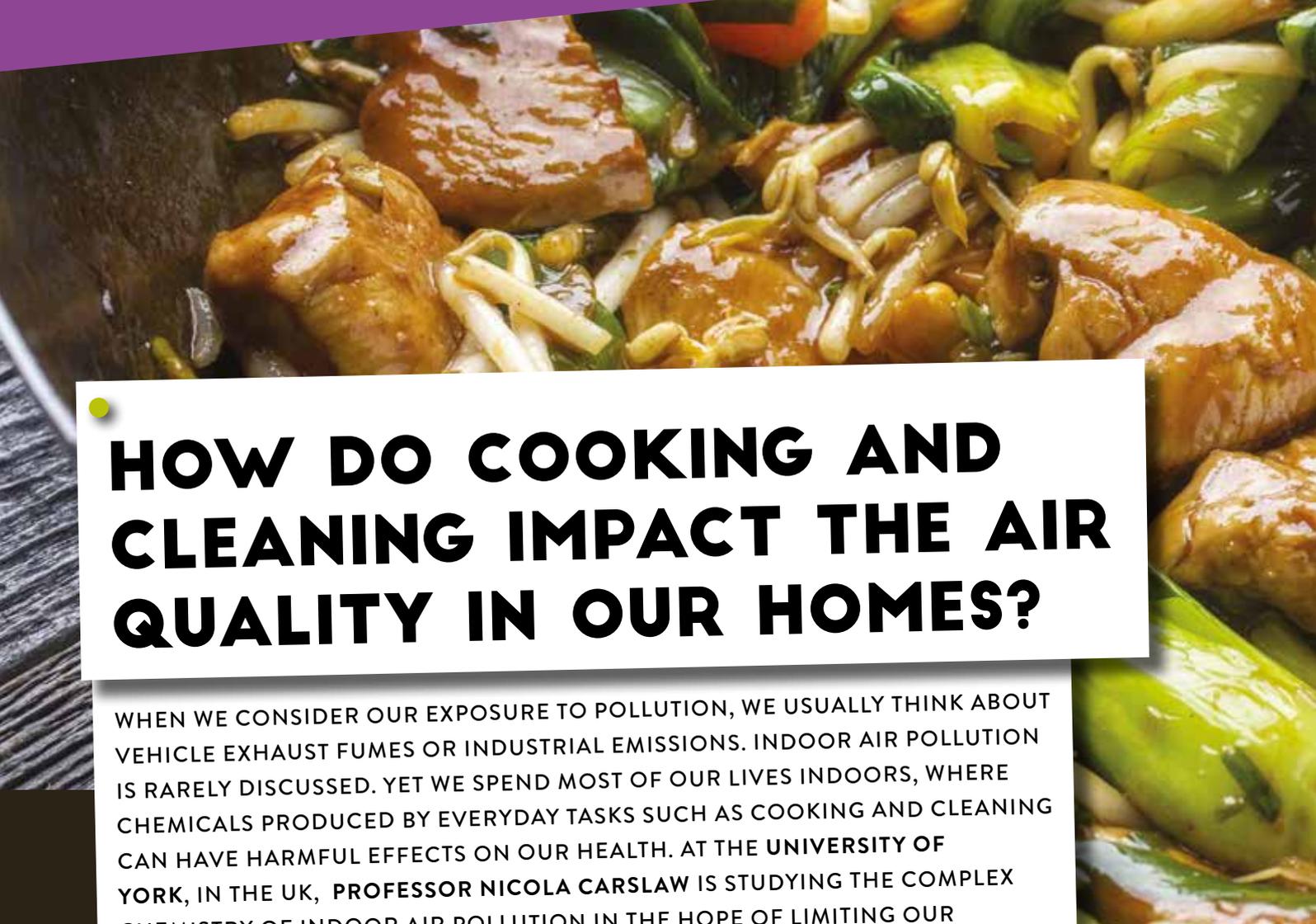
Working with scientists from other disciplines

solves this problem. By combining different skillsets, scientists can work together to tackle the issue, each contributing their own expertise to collectively build up the whole picture.

While this can be sufficient for effective research, there are more skills needed to ensure the outcomes of this research are put to good use. At this point, scientists can join forces with people from other professions – policy makers, businesses and communicators,

to name a few. This ensures that the research outcomes are applied in the real world, for the benefit of wider society.

BioAirNet is an example of interdisciplinarity, with experts from different fields coming together to tackle air pollution (with a focus on bioaerosols) and the associated health risks.



# HOW DO COOKING AND CLEANING IMPACT THE AIR QUALITY IN OUR HOMES?

WHEN WE CONSIDER OUR EXPOSURE TO POLLUTION, WE USUALLY THINK ABOUT VEHICLE EXHAUST FUMES OR INDUSTRIAL EMISSIONS. INDOOR AIR POLLUTION IS RARELY DISCUSSED. YET WE SPEND MOST OF OUR LIVES INDOORS, WHERE CHEMICALS PRODUCED BY EVERYDAY TASKS SUCH AS COOKING AND CLEANING CAN HAVE HARMFUL EFFECTS ON OUR HEALTH. AT THE UNIVERSITY OF YORK, IN THE UK, PROFESSOR NICOLA CARSLAW IS STUDYING THE COMPLEX CHEMISTRY OF INDOOR AIR POLLUTION IN THE HOPE OF LIMITING OUR EXPOSURE TO POLLUTION INSIDE OUR HOMES, SCHOOLS AND WORKSPACES

## TALK LIKE AN AIR CHEMIST

**AIR POLLUTANT** – a substance in the atmosphere that is harmful to the health of humans, other animals, plants, materials or the climate

**CARCINOGENIC** – a substance that has the ability to cause cancer

**COMBUSTION REACTION** – a chemical reaction caused by burning

**INDOOR AIR CHEMISTRY** – the study of chemical reactions that occur indoors

**PHOTOLYSIS REACTION** – a reaction in which chemical bonds are broken down by exposure to sunlight

**SECONDARY POLLUTANT** – a new pollutant produced by the chemical reaction of other pollutants

**SICK BUILDING SYNDROME** – a recurring illness with symptoms including a sore throat, wheezing and coughing while indoors. Symptoms are alleviated when the occupant leaves the building

## WHAT ARE THE SOURCES OF INDOOR AIR POLLUTION?

Pollutants are released from items or during tasks that we encounter daily. Cleaning products, air fresheners, paints and building materials, smoking and even pets all release chemicals and particles into the air of our homes, schools and workplaces. Many harmful pollutants are also created during combustion reactions. These include outdoor sources of pollution produced by vehicle emissions and industrial processes that enter buildings through windows or ventilation pipes. And indoors, combustion reactions occur when gas cookers, candles or wood stoves are used.

Not only are some of these pollutants directly harmful to our health, but even the non-toxic ones may undergo chemical reactions to produce harmful secondary pollutants. As Nic explains, “Many cleaning products contain limonene, a harmless chemical at typical indoor concentrations that creates a citrus scent. But when limonene is released indoors, the molecules go through a series of complex chemical reactions and eventually form formaldehyde, a toxic and carcinogenic secondary pollutant.”

We all understand that we are exposed to air pollution if we walk next to a busy road full of vehicles pumping out exhaust fumes, but we rarely think that pollution is an issue when we are inside. However, indoor air pollution can be a significant problem. And as we spend around 90% of our lives indoors, most of our exposure to air pollutants will occur when we are inside. So, it is important to understand what these are and how they act.

Professor Nicola Carslaw is an indoor air chemist at the University of York. She leads the IMPeCCABLE project (IMPacts of Cooking and Cleaning on indoor Air quality: towards healthy Buildings for the future), designed to investigate the sources of pollution emissions and the chemical reactions that occur following their release, with the aim of improving building design to reduce our exposure to indoor air pollution.



## PROFESSOR NICOLA CARSLAW

University of York, UK



### FIELD OF RESEARCH

Indoor Air Chemistry



### RESEARCH PROJECT

Studying the pollutants and reactive chemicals released indoors by everyday cooking and cleaning tasks



### FUNDER

Engineering and Physical Sciences Research Council (EPSRC)

### HOW DO POLLUTANTS REACT DIFFERENTLY INDOORS?

Pollutants produced outdoors do not stay in the air in the air forever. Reactive chemicals can be removed by wind, rain or sunlight, but this is not the case indoors. Inside, there is less ventilation and no rainfall, and photolysis reactions occur much more slowly. This means that pollutants indoors have much less chance of dispersing than they do outdoors.

Indoors, there are also different types of surfaces that pollutants may react with. "Surface interactions are more important indoors and they have a large impact on the resultant chemistry," says Nic. "This even includes the surfaces of people, as ozone can react with components of skin oil to produce secondary pollutants."

### WHAT IS OUR EXPOSURE TO AIR POLLUTION?

Our exposure to pollution will vary throughout the day. It is lowest when we are asleep, while travelling to and from school along busy roads will see a spike in exposure. Burning a scented candle for an hour can increase the concentration of nitrogen dioxide (NO<sub>2</sub>) to the World Health Organisation's recommended limit. But your greatest exposure to pollutants will occur during cooking. Preparing an evening meal could increase the NO<sub>2</sub> concentration to seven times the level of when you are asleep. This will depend on your cooking appliance (gas cookers release pollutants from combustion, electric cookers do not), your method of cooking (frying food releases far more particles than steaming) and the food itself (frying bacon is worse than frying vegetables!).

### DOES INDOOR AIR POLLUTION IMPACT OUR HEALTH?

"There is evidence that occupational cleaners are more likely to develop asthma than workers with other occupations<sup>1</sup>," says Nic. "Research has also been conducted into 'sick building syndrome', an illness that causes itchy

eyes, wheezing and sore throats as a result of exposure to indoor pollutants, but it is not known which of the many chemicals indoors cause this. Studies have also shown that lower ventilation rates in buildings are associated with inflammation, respiratory infections, asthma symptoms and short-term sick leave increases<sup>2</sup>."

### THE IMPECCABLE PROJECT

To investigate indoor pollution emissions and their chemical reactions, Nic and her collaborators have set up a series of cooking and cleaning experiments. "Experiments will be carried out on increasing spatial scales, with each set informing the design and interpretation of the next," explains Nic. Each test will involve using kitchen cleaning products and cooking meals such as chicken stir-fry, with each series of experiments increasing in complexity.

"We will start by studying cooking and cleaning in a controlled environment," explains Nic. "We will cook and clean within a small chamber at the University of Chester and follow the evolution of the chemistry." The team will then scale up their experiments in a larger chamber at the University of Nottingham, modelled to contain a kitchen. "This adds another layer of complexity," says Nic, "such as through surface interactions (e.g. kitchen countertops and a lino floor) that were absent in the initial chamber." The final stage will scale the experiments up to building-scale, using a test-house facility at the University of Chester. The cooking and cleaning activities will be repeated at house-scale, providing a complex, realistic environment where chemicals and processes can interact with each other.

### FROM RESULTS TO APPLICATION

Nic will model the chemistry at each stage, introducing more surface interactions to make results more realistic. "We are aware that we need to make our conditions as relevant as possible, which is why we are moving from

simple chambers through to more realistic environments like the test-house," she says.

The results from these studies will be scaled up even further to inform best practices for building design and product manufacture. To ensure her results are relevant to the real world, Nic is working with a number of stakeholders including architects, catering managers, cleaning manufacturers and local government. Hopefully results from the IMPeCCABLE project will produce future policies that reduce our exposure to indoor air pollution in our homes and other buildings.

### HOW CAN YOU REDUCE YOUR EXPOSURE TO INDOOR AIR POLLUTION?

"The best thing to do is avoid sources of air pollution in the first place," says Nic. Cut down on the use of fragrances and cleaning products or replace sprays with roll-on deodorant and cream cleaners. Increase ventilation by opening windows and always use extractor fans when cooking and showering. Ultimately, you can change the air quality in your home or school by the actions you choose to take.

1. [pubmed.ncbi.nlm.nih.gov/14586047](https://pubmed.ncbi.nlm.nih.gov/14586047)
2. [pubmed.ncbi.nlm.nih.gov/21204989](https://pubmed.ncbi.nlm.nih.gov/21204989)

# ABOUT INDOOR AIR CHEMISTRY

Many everyday tasks release chemicals into the air in our homes. Nitrogen dioxide ( $\text{NO}_2$ ), nitrous acid ( $\text{HNO}_2$ ) and polycyclic aromatic hydrocarbons are released from combustion appliances when cooking or heating your home. Nitrogen oxides ( $\text{NO}_x$ ) and particulate matter are produced by vehicles and then enter buildings through windows and doors. Ozone ( $\text{O}_3$ ) is produced by chemical reactions outdoors and can also enter buildings through windows and doors. Cleaning products release ammonia, chlorinated volatile organic compounds (VOCs), acetic acid and limonene. Printers and photocopiers produce ozone. Mould and bacteria create microbial particles. And even humans emit chemicals through our skin and breath, such as unsaturated fatty acids, isoprene and squalene, not including those that we spray on ourselves in the form of deodorants, perfumes or hairsprays.

We do not think about these chemicals as we lead our daily lives, so Nic's research is important to highlight the emissions and

chemicals that we are exposed to indoors. Her experiments will help scientists understand what chemicals are released when we undertake everyday tasks such as cooking and cleaning. This will hopefully lead to changes in product manufacture, to reduce the pollutants emitted by cooking appliances and cleaning products, and also to changes in building design, to limit our exposure to any harmful chemicals.

## WHAT DOES NIC FIND MOST REWARDING ABOUT RESEARCH IN HER FIELD?

"Studying indoor air pollution gives me a chance to apply my knowledge of chemistry to a real-world problem," she explains. At university, Nic studied for a joint honours degree in chemistry with environmental science. She knew she did not want to do a pure chemistry degree as she was, "never interested in spending days in the lab synthesising minute quantities of chemicals." Instead, she wanted her studies to be relevant to the environment or human

health. Now a professor, Nic gets immense satisfaction from her job, not just from her research, but also from teaching her students. She hopes she can inspire some of them to take up jobs in air quality in the future.

## WHAT ISSUES ARE FACING THE NEXT GENERATION OF INDOOR AIR CHEMISTS?

A key issue facing scientists in all fields is the need to generate, analyse and curate large quantities of data. Nic thinks we need more data management skills taught at schools and universities. "I am glad to see that coding is now making its way onto school curricula as this is another important skill that chemists need," she says. Nic also highlights that future chemists need curiosity and the ability to work with people from other disciplines. "We need the next generation to come along and question things and to be willing to work at and across the boundaries of disciplines."

## EXPLORE A CAREER IN INDOOR AIR CHEMISTRY

- Keep abreast of the latest work in the field. The Indoor Air journal is the best place to read about the most recent research: [onlinelibrary.wiley.com/journal/16000668](http://onlinelibrary.wiley.com/journal/16000668)
- Follow the leading scientists on Twitter – Cath Noakes (@CathNoakes), Linsey Marr (@linseymarr), Shelly Miller (@ShellyMBoulder) and Jose Jimenez (@jjcolorado) have provided valuable information during the pandemic on COVID transmission indoors.
- The IndoorChem website is a valuable community tool ([www.indoorchem.org](http://www.indoorchem.org)). Check out their YouTube channel: [www.youtube.com/c/indoorchem](http://www.youtube.com/c/indoorchem)
- Nic regularly delivers public lectures and is always happy to hear from people who want to learn more about the work she and her team conducts.

Find her contact details and more about her work at: [www.york.ac.uk/environment/our-staff/nicola-carslaw](http://www.york.ac.uk/environment/our-staff/nicola-carslaw)

## PATHWAY FROM SCHOOL TO INDOOR AIR CHEMIST

Nic recommends taking science subjects at school. "Maths, chemistry and physics is a good combination that keeps options open for many careers," she says. "Then a science degree is always worthwhile." You could follow this with a master's degree in air quality or atmospheric science if you want to specialise in air pollution.



IMPcCABLE team members Ellen, Catherine and Archit, ready to cook and clean in the test facility at the University of Chester. Photo credit: Terry Dillon.



## HOW DID NIC BECOME AN INDOOR AIR CHEMIST?

### WHAT WERE YOUR INTERESTS WHEN YOU WERE YOUNGER?

I was very much a girly swot at school and look back on my school days with great fondness. I always loved learning and continue to do so. I was, and still am, an avid reader and I also loved camping.

### WHO OR WHAT INSPIRED YOU TO BECOME A SCIENTIST?

I had amazing chemistry and maths teachers at school. Both of them inspired a love of their topics and therefore pushed me towards studying science at A-level. It was chemistry that really interested me enough to make me want to study it further. I wanted to apply it to the environment, and this made me engage with atmospheric science, before specialising in indoor air chemistry.

### WHAT ATTRIBUTES HAVE MADE YOU SUCCESSFUL AS A SCIENTIST?

I think the most important attributes are to be willing to work hard, to continue to be open to learning and to try and be resilient against failure. Grant applications are very competitive now and good ideas often fail to receive funding. You need to pick yourself up from numerous rejections and try again, and don't take rejection too personally.

### WHAT DO YOU ENJOY DOING OUTSIDE OF WORK?

Ironically given my topic, I like being outdoors. I go running, cycling and also love gardening.

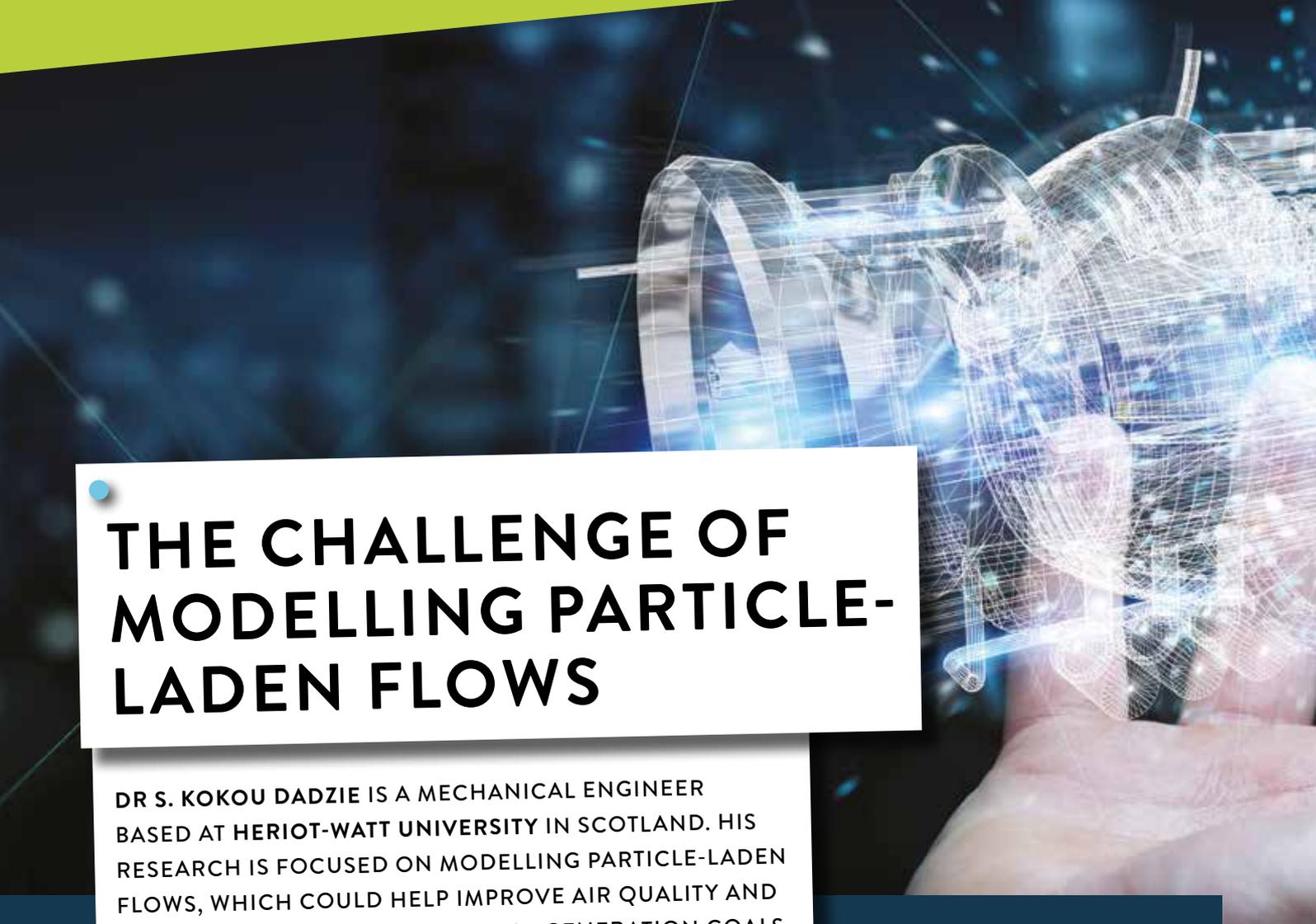
### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS SO FAR?

It's always good to get a grant application

funded or to publish a paper, but I think the most important moments for me are when one of my PhD students passes their viva. Or when one of the undergraduate or master's students I teach decides to take up air quality as a career as a result of enjoying my lectures.

### NIC'S TOP TIP

Work hard and follow your passions. If you end up working in an area you feel passionate about, it doesn't feel like working.



# THE CHALLENGE OF MODELLING PARTICLE-LADEN FLOWS

DR S. KOKOU DADZIE IS A MECHANICAL ENGINEER BASED AT HERIOT-WATT UNIVERSITY IN SCOTLAND. HIS RESEARCH IS FOCUSED ON MODELLING PARTICLE-LADEN FLOWS, WHICH COULD HELP IMPROVE AIR QUALITY AND HELP SOCIETY MEET CLEAN ENERGY GENERATION GOALS

## TALK LIKE A MECHANICAL ENGINEER

**NON-CONTINUUM FLOWS** – where there are not enough discrete fluid material elements, i.e. particles or molecules, for a fluid element to be assumed continuous and indefinitely divisible

**PARTICLE-LADEN FLOWS** – a class of two-phase fluid flow, in which one of the phases is continuously connected (referred to as the continuous or carrier phase) and the other phase is made up of small, immiscible and typically dilute particles

**RAREFIED GAS DYNAMICS** – concerned with flows at such low density that the molecular mean free path is not negligible. Under

these conditions, the gas no longer behaves as a continuum

**KINETIC THEORY** – the body of theory which explains the physical properties of matter in terms of the motions of its constituent particles

**HYDRODYNAMICS** – a branch of physics that deals with the motion of fluids and the forces acting on solid bodies immersed in fluids and in motion relative to them

**PHYSICS OF FLUIDS** – the study of the mechanical and flow properties of fluids, especially as they apply to practical engineering

Put simply, particle-laden flows are multiphase flows that are composed of a mixture of solid particles and a liquid or gas phase. This flowing mixture involves a number of interactions between the solid particles and the carrier fluid, which are of interest to researchers for a variety of reasons.

Particle-laden flows are abundant in nature, such as in blood flow, dust storms, geophysical flows and rain formation in clouds. However, they are also used in a range of engineering and industrial processes, such as fluidised-bed reactors, which are used to operate power

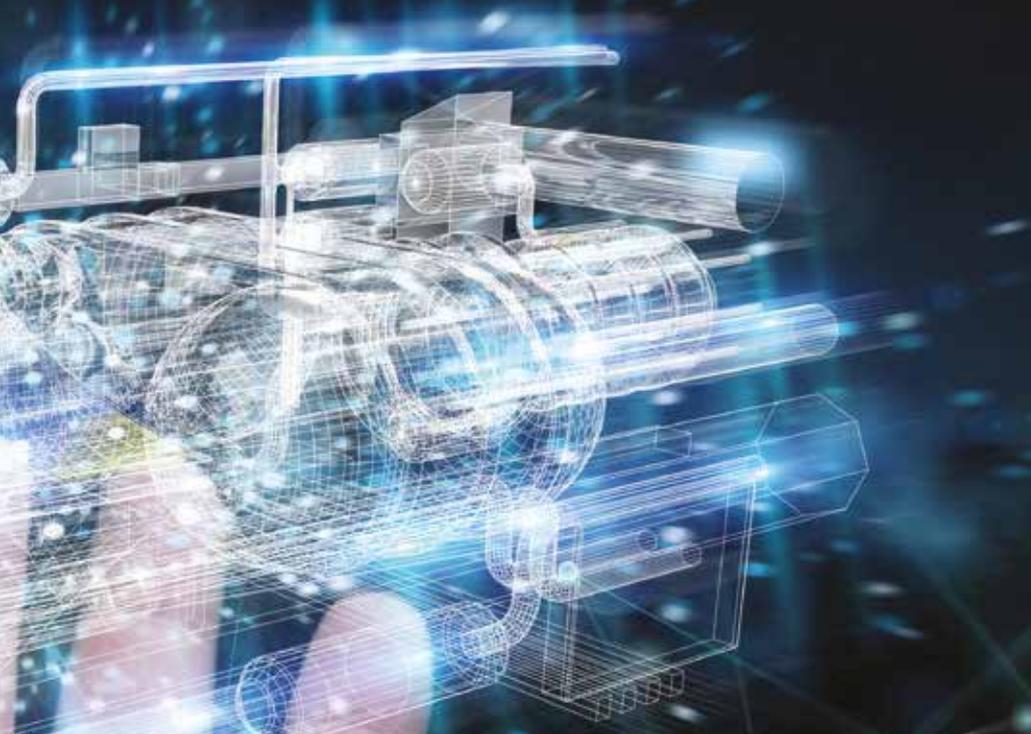
plants in generating electricity. The importance of fluidised-bed reactors can hardly be overstated because, as we begin to generate clean electricity to combat the impacts of global warming and climate change, fluidised-bed reactors are one of the technologies that will enable industry to generate clean electricity from coal, i.e. generating electricity whilst emitting much less CO<sub>2</sub>, particularly in coal-dependent countries such as China.

In more general terms, particle-laden flow technologies are essential if we are to work towards controlling the air pollution in cities

around the world; they are required in the design of air purification systems. Given the importance of particle-laden flow technologies, Dr S. Kokou Dadzie is working on a means of modelling particle-laden flows, in the hope that his findings will enable the development of new technologies that serve the requirements of the future.

## WHY IS THE MODELLING OF PARTICLE-LADEN FLOWS SO CHALLENGING?

Based within the Institute of Mechanical, Process and Energy Engineering at Heriot-



Watt University in Scotland, Kokou leads a team studying particle-laden flows, with the aim of understanding the interactions between the solid particles and the carrier fluid. However, to achieve this modelling, a number of assumptions have to be made. “If the solid particles have density similar to that of the liquid or the gas, then the mixture may be considered a single phase. In a single-phase fluid, Newton’s laws of motion translate into the fluid flow equations that is the Navier-Stokes equation. But in a mixture such as particle-laden flows, the fluid dynamics are more complex,” explains Kokou. “Therefore, new tools such as those used in kinetic theory of gases (which describes the motion of a gas by almost following the motion of individual particles) have to be used. Generally speaking, in particle laden-flows a number of flow phenomena occur that need to be replicated in the modelling process.”

#### WHAT HAS MOTIVATED KOKOU TO TACKLE THIS CHALLENGE?

This current project is a progression from Kokou’s previous research – he worked in rarefied gas dynamics during his PhD and post-doctoral research fellowship. Rarefied gas dynamics relate to the motion of a gas where the separation distance between molecules is large. To study this, the molecular structure of a given gas needs to be considered – which is something that can be ignored in other fields of study, such as modelling water flowing in a river, for instance. “Rarefied gas flows involve non-equilibrium effects that we do not see when dealing with air flowing over a car or air flowing in a room. I developed models in rarefied gas that are capable of handling some of these complex non-equilibrium phenomena,” says Kokou. “As particle-laden flows share some similarity with rarefied gas, it was therefore the ideal candidate to translate my work in rarefied gas dynamics into particle-laden flows.”

#### HOW WILL KOKOU DEVELOP A MORE SOPHISTICATED MODEL OF PARTICLE-LADEN FLOWS?

Traditional models follow some traditional fluid modelling processes, such as replicating Newton’s laws of motion. The problem is that there are observations that those models do not describe. For example, in particle-laden flows, particles can arrange themselves in some form of structures. It is therefore necessary to develop mathematical models that are capable of capturing or reproducing these structures in experiments. Because the physics of fluids is not strictly restricted to the laws of motion as they relate to solid objects, Kokou is looking for new laws of motion that work better in fluids.

The experiments all start with existing models and examining where they have failed. From there, the team seek to find improvements. “In constructing our new models, we start with some basic principles, then formulate the mathematical models. Once constructed, they must be compared to existing models, then tested and, if they do not work, we start again,” explains Kokou. “The project team members all contribute to this in various ways. It takes time, lots of reading and practice to come up with the ideas that work. We then meet up to share our developments and ideas to make progress.”

#### WHAT ARE THE APPLICATIONS OF THIS STUDY?

The research will help us to understand – and therefore predict – natural phenomena, such as volcanic ash disruptions. Armed with this knowledge, industry will be better positioned to design systems that can combat issues relating to these particle-laden flows. As mentioned earlier, there is also the expected outcome that cities around the world will be better able to meet clean energy goals and improve air quality for residents.



#### DR S. KOKOU DADZIE

Associate Professor, Institute of Mechanical, Process and Energy Engineering, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, Scotland, UK

#### FIELD OF RESEARCH

Mechanical Engineering

#### RESEARCH PROJECT

From Kinetic Theory to Hydrodynamics: re-imagining two fluid models of particle-laden flows’ – modelling particle-laden flows in order to improve air quality and help society meet clean energy goals

#### FUNDER

Engineering and Physical Sciences Research Council (EPSRC)

#### WHAT ARE THE NEXT STEPS?

The team has already had some notable successes which have involved identifying the challenges in the modelling process. There are several steps involved in the project, such as the development of mathematical methods for the gas phase and then the particle phase, followed by numerical implementation and testing. The team has made good progress on the gas phase and its numerical implications. It is currently investigating different forms for the particle phase and expects some progress in the near future.

However, the particle-laden flow project is just one aspect of Kokou’s wider research interests. “My ultimate ambition is to take fluid mechanics to another level and there are a number of issues in the field that need to be resolved,” says Kokou. “At the moment, I am looking into other projects that will enable me to work on those other issues. In many ways, fluid mechanics involves reinventing physics, but I am hopeful I can succeed in doing this!”

# ABOUT MECHANICAL ENGINEERING

As Kokou's research makes clear, mechanical engineering involves many different scientific principles, such as physics, engineering, mathematics and material science. In addition to the maths and physics involved in modelling aspects such as particle-laden flows, there is also the wider need to translate findings into real-world applications (which Kokou's research will hopefully eventually lead to). These aspects lean heavily on engineering and materials science.

Mechanical engineering came to prominence in the 19th century, when the Industrial Revolution was sweeping across the UK and Europe. It would be impossible to list all of the achievements and inventions that owe themselves to mechanical engineering in this period of time, but the steam engine, petrol engine, typewriter, metal detector, telephone, underground railways, man-made plastic, solar power, transatlantic cable, dishwasher, fuel cell, battery and fax machine are all products of mechanical engineering in the 19th century to differing extents.

Since then, we have seen man land on the moon and Futurum publish articles on the world wide web – both achievements enabled by mechanical engineering. Given what has been achieved in a relatively short space of time in the field of mechanical engineering, it is extremely exciting to consider what the next few decades have in store for humanity – but the field holds promise for overcoming many of the challenges involved in reducing greenhouse gas emissions and creating new technologies that are 'cleaner' than those currently in use.

## WHAT DOES KOKOU LOVE ABOUT MECHANICAL ENGINEERING?

Kokou says that one of the aspects he finds most rewarding in his work is discovering new models and methods that are capable of providing accurate predictions that could change the field. We have already touched on his ambition to take fluid mechanics to another level and this is in keeping with the most appealing aspects of mechanical engineering. He also enjoys seeing his PhD

students and Research Associates develop their skills and knowledge under his tutelage.

## WHAT ISSUES WILL BE FACING THE NEXT GENERATION OF MECHANICAL ENGINEERS?

Of course, if we are not careful, then the environmental challenges the world is currently facing will be even more pressing for the next generation (although the hope is that we will have made significant progress by then). For Kokou, there are many potential difficulties in the future. "Developing and promoting green engineering might be challenging, as it can be difficult to make people change what they are used to," says Kokou. "There is also the issue of developing cutting-edge technologies to maintain the demand of an ever-burgeoning global population."

If you think you are up to these challenges, why not embark on a career in mechanical engineering? Maybe you will help take our understanding of the field to 'another level'.

## EXPLORE A CAREER IN MECHANICAL ENGINEERING

- There is plenty of useful information out there, including how to become an engineer through the *Institution of Mechanical Engineers*:  
[www.imeche.org/careers-education/careers-information](http://www.imeche.org/careers-education/careers-information)  
and *Tomorrow's Engineers*:  
[www.tomorrowsengineers.org.uk/](http://www.tomorrowsengineers.org.uk/)
- Kokou suggests you broaden your horizons by watching, listening and reading a variety of different engineering-related topics. There are many engineering documentaries out there, as well as ways to keep up to date with new technologies. Explore professional bodies in the UK and beyond too – there are so many out there!
- Visit Heriot-Watt University's Engineering and Physical Sciences webpage:  
[www.hw.ac.uk/uk/schools/engineering-physical-sciences.htm](http://www.hw.ac.uk/uk/schools/engineering-physical-sciences.htm)

## PATHWAY FROM SCHOOL TO MECHANICAL ENGINEERING

Kokou is a passionate advocate for the benefits of maths and physics – which are fundamental requirements for mechanical engineering. "It is important to be good in all subjects, including maths and physics, but there are other subjects that will stand you in good stead in the future," explains Kokou. "When it comes to submitting research grant applications or presenting your findings, you need to have excellent writing and communication skills, so certainly consider studies in that area too."

You can do a degree in a variety of subjects to become a mechanical engineer, including mechanical engineering, electromechanical engineering, mechatronics and engineering manufacturing. Some courses include a year working in industry, which could be useful when you start applying for jobs after finishing your course.

[nationalcareers.service.gov.uk/job-profiles/mechanical-engineer](http://nationalcareers.service.gov.uk/job-profiles/mechanical-engineer)

## KOKOU'S TOP TIPS

- 01** Never be afraid to be different – difference is the very thing that makes you stand out from the rest in a good way.
- 02** If you enjoy doing something, then do it, but do it the best you can. Half the battle has already been won if you embark on a career that involves something you are passionate about.
- 03** Follow your dreams! It is a cliché to say this, but in my case, it is what I did and it has worked out. There is no reason why the same can't be true for you.



# HOW DID KOKOU BECOME A MECHANICAL ENGINEER?

## WHAT WERE YOUR INTERESTS WHEN YOU WERE GROWING UP?

As a youngster, I was a bit boring socially! I was very good at maths and physics, and compared to my peers, I didn't need to put a lot of effort in to attain high grades. From there, I realised I was a little different, in terms of not sharing the same interests as my classmates. I began to develop my interest in wanting to become a scientist – ideally at a western university. To me, it looked like science was one of the few professions where you have the freedom to invent or create things that will still be there after you are gone.

## WHO OR WHAT INSPIRED YOU TO BECOME A SCIENTIST?

At school, I was always fascinated with new

theorems and associated them with the name of the scientist who worked on them. I still remember the moment I learned about the Pythagorean theorem for the first time. There have been others too – Hilbert and the Hilbert Space, Cauchy integral theorem, D'Alembert's principle, Lagrange, etc.

## WHAT ATTRIBUTES HAVE MADE YOU SUCCESSFUL AS A SCIENTIST?

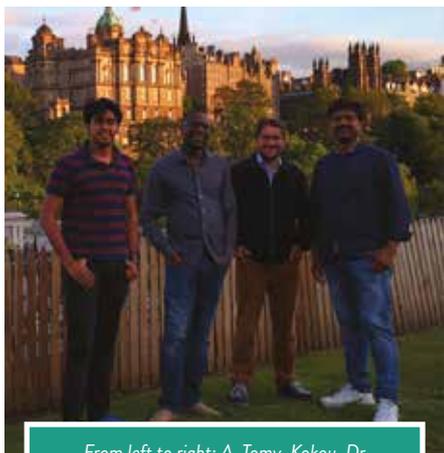
Having the freedom to think how you want is less an attribute and more a circumstance, but it has been crucial to my career. I consider my viewpoints to hold a certain uniqueness and I have embraced my differences. The willingness to forge my own path and not being bound by convention has also helped enormously.

## HOW DO YOU SWITCH OFF FROM YOUR WORK?

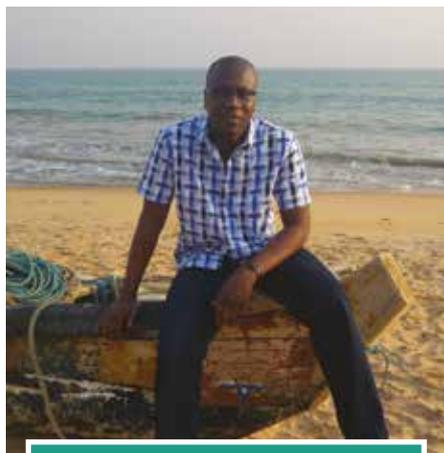
I always try to take some personal time, when I can, to relax and remember what is important in life. I enjoy meditating from time to time and feel this helps me switch off from my studies.

## WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS SO FAR?

Having developed some original theoretical models to deal with gas flows with colleagues. I think they are unique as they do not follow ordinary principles. I hope people adopt them either to model fluid motion or adapt them to model other flow phenomena in the future. I think these models are great mathematical inventions!



From left to right: A. Tomy, Kokou, Dr Stamatiou, Dr Reddy.



Kokou on a beach in West Africa.



Kokou (right) with project partners: Professor Wang (left) and Professor Ocone (centre).



# HOW CAN HYDROGEN BECOME A METAL?

HIGH-ENERGY-DENSITY PHYSICS DESCRIBES SOME OF THE MOST EXTREME ENVIRONMENTS IN OUR UNIVERSE, LIKE THE CORES OF STARS. DR VALENTIN KARASIEV AND DR SUXING HU OF THE LABORATORY FOR LASER ENERGETICS AT THE UNIVERSITY OF ROCHESTER IN THE US ARE CREATING NEW MODELS TO DESCRIBE THESE EXOTIC PROCESSES

## TALK LIKE A PHYSICIST

**THEORETICAL/COMPUTATIONAL MODEL** – a series of equations that describe and can predict the behaviour of a system. These are often very complex so are carried out on a computer rather than doing them by hand

**HIGH-PERFORMANCE COMPUTING** – using large, very powerful computers to run simulations

**NUCLEAR FUSION** – when two or more atoms are joined together to form a new element

**ELECTRONS** – negatively charged particles that are part of atoms

**PLASMA** – another state of matter like solids, liquids and gases. Plasmas are usually very hot clouds with electrons that may behave very differently to other phases of matter

At very high temperatures and pressures, physics as we know it starts to change. The study of such environments is known as high-energy-density physics. These extreme environments are found at the hearts of our sun, and in the interior of giant planets and various types of stars. While they might seem far away, these environments could hold the secret for understanding processes like nuclear fusion which could be an incredibly important source of energy in the future if we could find a way to control the process on Earth.

Dr Valentin Karasiev and his colleague, Dr Suxing Hu, of the Laboratory for Laser Energetics at the University of Rochester are experts in developing theoretical and computational models to describe high-energy-density processes. One of the big challenges they face in their research is that many models which describe the physics of materials at zero to near-room temperatures stop working under such extreme conditions. To overcome this, they need not only to create new models, but to implement the models in a computer code and find ways to run them efficiently using high-performance computing.

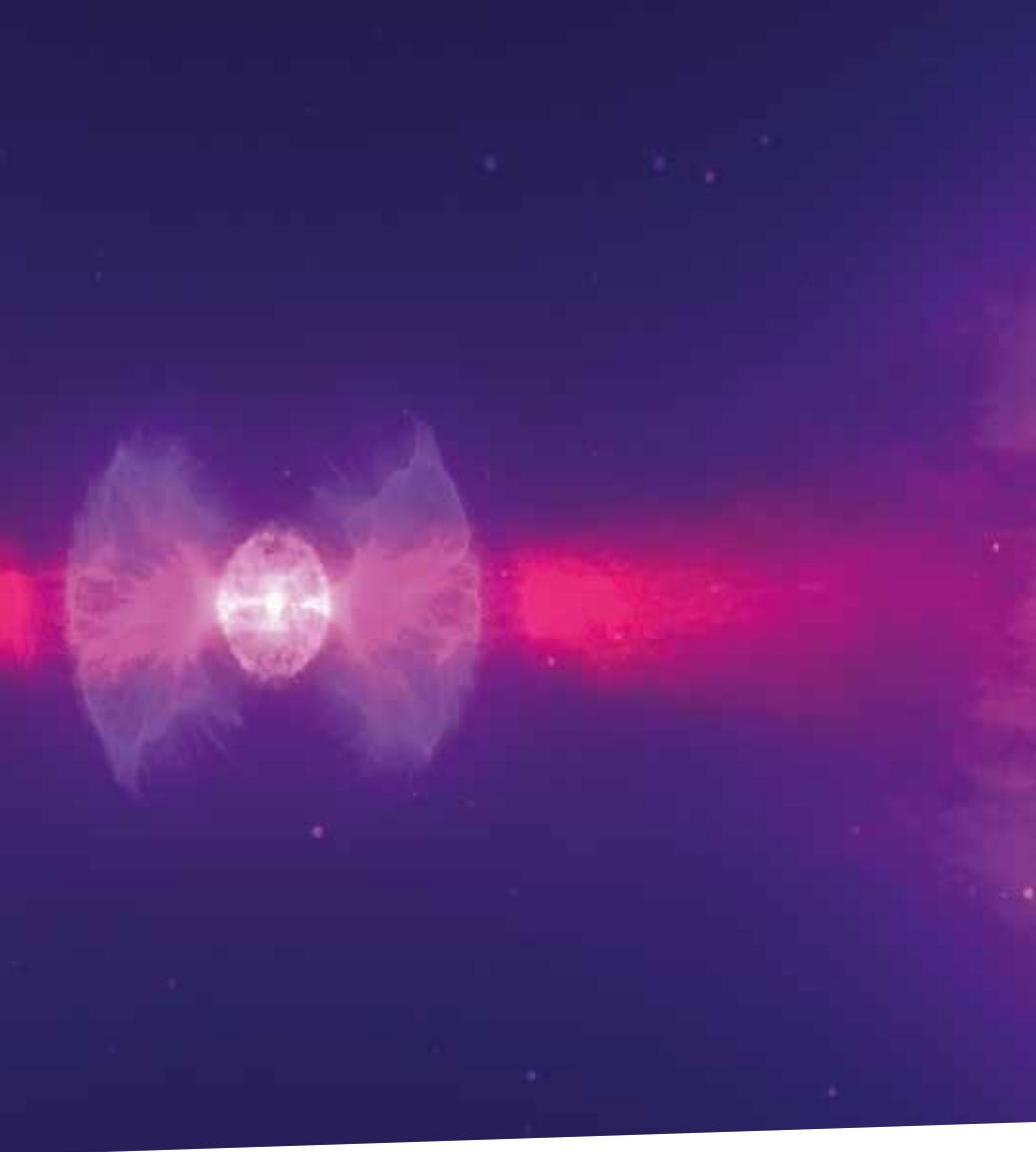
While Valentin only works using theoretical

approaches, he emphasises how important both experiments and calculations are in this area of physics. “Comparisons with experiments can validate theoretical methods used for predictions.” However, having very good theoretical predictions can do more than just match experiments. Valentin says, “Theoretical predictions, which are easier and faster to produce compared to experimental measurements, can be used to guide experiments.”

But how can we study the physics of extreme environments on Earth? Valentin says, “To create high pressures, scientists can perform diamond anvil cell experiments, when a small sample is compressed between two diamond tips or perform gas-gun experiments when a high-velocity projectile impacts a target to create high pressure. For high pressures and temperatures, powerful laser beams are used to heat and compress a target.”

## STRANGE METALS

One of the projects Valentin and Suxing have been working on involves looking at hydrogen. Hydrogen, as we know it on Earth, is a colourless, light gas. It is also the gas that acts as a fuel for nuclear fusion in stars that keeps



them burning and forming heavier chemical elements. However, crank the pressure up enough and hydrogen can start to behave like a metal.

We usually think of metals as hard, shiny materials but what really defines a metal is how the electrons in the material behave. Insulating materials, like wood and gaseous hydrogen, do not conduct electricity. This is because the electrons in the material are bound and do not start to move and flow when the material becomes part of a circuit.

In metallic hydrogen, the electrons are shared between different hydrogen sites and can flow freely through the network of atoms. This means the hydrogen has become a conductor, and scientists hint that this may have some exciting implications where, “under high pressure hydrogen and/or some hydrogen rich materials may become room temperature superconductors.”

A superconductor is a material that lets electrons move with no resistance. For most normal conducting metals, an electron experiences some resistance to its movement and so generates heat as it moves. This means energy is constantly being wasted and is part

of why some electronic devices get hot when in use.

In a superconductor, this heating does not happen and so no energy is wasted. If a perfect superconducting device was made, the device could be on nearly forever, without ever depleting the battery. Recently, Suxing’s and Valentin’s colleagues, the experimental group of Professor Ranga Dias, discovered room temperature superconductivity in carbonaceous sulphur hydride (CSH) systems and from Suxing’s calculations they were able to identify which structures would be the most stable room-temperature superconductors under high pressures.

### DEVELOPING METHODS

One of the biggest challenges in doing these types of calculations for Valentin is that he often needs to develop the methods so they can be applied to model extreme environments. Many of the practical methods using quantum mechanics have not been developed to account for the high temperatures of these extreme environments.

Valentin has made several key developments in the advancement of density functional theory-based methods for high-energy-



## DR VALENTIN KARASIEV

Scientist  
Laboratory for Laser Energetics  
University of Rochester, USA



### FIELD OF RESEARCH

High-Energy-Density Physics



### RESEARCH PROJECT

Developing methods for modelling processes and physics that occur in extreme environments



### FUNDERS

*This work was supported by U.S. National Science Foundation PHY Grant No. 1802964, the Department of Energy National Nuclear Security Administration under Award No DE-NA0003856, the University of Rochester, the New York State Energy Research and Development Authority, and the National Energy Research Scientific Computing Center, a DOE Office of Science User Facility supported by the Office of Science of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.*

density environments to make them efficient enough and usable to describe systems such as warm dense hydrogen. As well as leading these developments he has applied them to problems such as warm dense silicon plasmas and finding a way to describe how unusual interactions between atoms can arise, with unusual behaviour of electrons, in extreme environments.

In the future, Valentin and Suxing will be looking to develop more reliable and faster ways to describe the behaviour of materials for nuclear fusion experiments and mixtures of elements important for astrophysics and chemistry under high pressures. They consider this an exciting time to be in high-energy-density physics as it becomes increasingly involved with many other areas of science. As computers become faster, this will also make it possible to describe even more complex and exciting systems and to really understand the wealth of physics going on in the hearts of our stars.

# ABOUT HIGH-ENERGY-DENSITY PHYSICS

High-energy-density physics is an exciting and rapidly developing field all about trying to understand the physics of what happens at extreme conditions and very high energy densities. Many people working in this area are researchers across different sub-disciplines. In high-energy-density physics, some people specialise in laser experiments to use very powerful laser beams to generate extreme conditions in materials. Other people specialise in plasmas and understanding how they form and interact with lasers, and how the electrons behave.

All of these are very exotic and unusual types of physics that we do not encounter in our everyday lives. However, we do use plasmas to help make circuit boards for electronics and we rely on our stars performing nuclear fusion to act as a source of heat and light. Once, it was these nuclear fusion processes that formed the heavier elements that we find on Earth, such as iron.

Working in high-energy-density physics is a specialised area of physics. Generally, people like Valentin and Suxing start with a more general degree in physics and become

more specialised over time. There is lots of international activity in the field, with new experiments being developed all the time to recreate these extreme conditions on Earth and explore all of the new physics to be discovered there.

## WHAT MOTIVATES YOU TO DO THE WORK YOU DO?

“My motivation is a passion for science as it provides a basis for understanding and discovering unknown, unusual and often counterintuitive properties of matter,” says Valentin. “I also like to develop theory and new methods, I like to write codes and run simulations and really enjoy my work. Getting to mentor graduate students and completing and publishing research projects are also very rewarding parts of the job.”

## WHAT TYPES OF COLLABORATION DOES YOUR WORK INVOLVE?

“We collaborate with theory groups at other research institutions. Modern science is complicated, and sometimes the efforts of several collaborators are required to make key advances. We also frequently collaborate with experimental groups as the measurements

the experimentalists make allows for cross-validation of theoretical predictions.”

## WHAT CHALLENGES DO YOU THINK THE NEXT GENERATION OF PHYSICISTS WILL BE FACING?

“In my opinion, the increasing multidisciplinary character of physics is one of the biggest challenges. This is especially true for materials-related research. For example, nowadays one may be an expert in materials science and have just some knowledge of computational science, perhaps just enough to run simulation packages and sometimes only with a general knowledge of theory/methods behind implementations in these packages. However, with the increasing importance of computer simulations and development of faster and more powerful supercomputers, even specialists in materials-related topics will need to become experts with deep knowledge in computer science and mathematics. While challenging, all of these developments may change the paradigm of how research is conducted drastically, increasing the leading role of theoretical modelling and predictive simulations.”

## EXPLORE A CAREER IN HIGH-ENERGY-DENSITY PHYSICS

- There are roles for both experimentalists and theoreticians in high-energy-density physics. In both cases, a strong general physics background is essential and good mathematical skills will also help.
- National laboratories and universities are where the majority of research in high-energy-density physics is and there are a large number of sub-topics and disciplines that can be specialised in.
- The Laboratory for Laser Energetics – where Valentin and Suxing are based – runs a Summer Research Program for High School Juniors. Find out more:

[www.lle.rochester.edu/index.php/education/summer-research-program-for-high-school-juniors/](http://www.lle.rochester.edu/index.php/education/summer-research-program-for-high-school-juniors/)

- Salaries range with experience, research institution and country, but start around \$40,000 and, with experience, can be in excess of \$80,000.

## PATHWAY FROM SCHOOL TO HIGH-ENERGY-DENSITY PHYSICIST

Valentin recommends studying chemistry, physics and calculus/mathematics at school. At university, study physics or maths and take classes in quantum chemistry and quantum mechanics.

For theoretical physics job and many experimental ones, knowledge of computer programming languages and coding experience will also be beneficial. Much of Valentin's research involves implementing new theoretical developments in new or existing codes and optimising them for high-performance computing set-ups.

Nearly all physicists will have a bachelor's degree in physics or maths. In some areas of physics, a degree in engineering or chemistry may also be suitable. For a research position in a university, like Valentin and Suxing, a relevant master's and PhD is also important. If you want to specialise in high-energy-density physics, this will usually be done at master's or PhD level.

## HOW DID VALENTIN BECOME A HIGH-ENERGY-DENSITY PHYSICIST?

### WHO OR WHAT INSPIRED YOU TO BECOME A SCIENTIST?

“My high school physics teacher, as well as my older brother, who is also physicist. I have had a strong passion for math and physics since high school and, from 5th grade, I was interested in radio-electronics.”

### WHAT ATTRIBUTES HAVE MADE YOU SUCCESSFUL?

“The key attributes for being a successful scientist include being good at abstract

thinking, as well as learning how to perform a sequence of logical deductions. This involves starting with assumptions and established work and seeing what can be deduced to lead to conclusions about a problem. It takes a kind of courage and imagination to put forward new or non-standard hypotheses.”

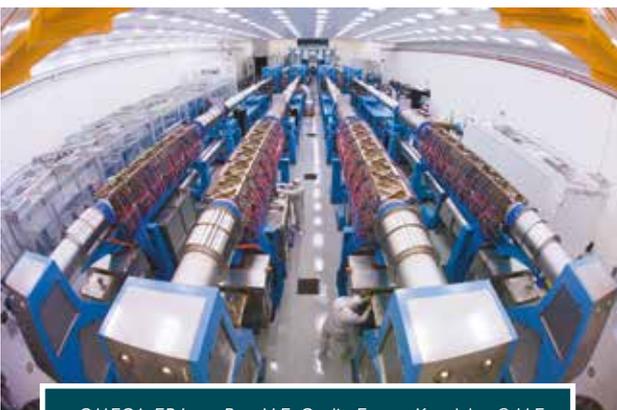
### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS?

“One of my proudest career moments was my move to my current laboratory,

the Laboratory for Laser Energetics at the University of Rochester, three and a half years ago. I have moved several times in my career, from Russia to Venezuela to the USA, and each step has presented new opportunities to learn and new challenges to overcome.”

## VALENTIN'S TOP TIPS

- 01** Persistence is crucial to overcome many obstacles. With years of experience, I have come to realise that almost any problem can be resolved if one persists.
- 02** Follow what you are passionate about.



OMEGA-EP Laser Bay, LLE. Credit: Eugene Kowaluk - © LLE



# POLAR STAR: TEACHING SCIENCE AS A WHOLE

THE POLAR STAR PROJECT IS DESIGNED TO HELP TEACHERS SUCCESSFULLY INTRODUCE STEAM IN THEIR CLASSES. IT COMBINES STATE-OF-THE-ART PEDAGOGIES AND EXCITING ACTIVITIES TO TEACH 'SCIENCE AS A WHOLE' AND HELP TEACHERS ANSWER THE "WHY DO WE HAVE TO LEARN THIS?" QUESTION

Imagine a world where your students never even consider asking why they need to learn something. A world where course materials and methodology imbue each student with a genuine understanding of why they are learning what they are learning and a real desire to learn more. To some, this might sound like a teaching utopia that exists beyond the realm of reality. Despite teachers' efforts, teaching and learning can be confined to a prescriptive curriculum and exam or assessment content, and the "Why do we have to learn this?" question becomes increasingly difficult to answer.

The POLAR STAR project is designed to help teachers by providing the methodology and tools to enable them to answer student questions effectively. The central methodology behind the project is to help teachers re-orientate their teaching and work within a student-centred interdisciplinary framework, one that focuses on students' interests and helps them make tangible links between what is taught in schools and everyday life. POLAR STAR enables teachers to collaborate, innovate and facilitate personalised and active learning.

## POLAR STAR'S MOTIVATION

In most countries, school science education follows a format in which science disciplines are fully separate. This compartmentalised approach may serve certain needs, but it can deprive students of the opportunity to understand that all science disciplines are connected and are about one and the same thing – our world. The team behind POLAR STAR wants to offer teachers an advanced cross-disciplinary methodology that goes beyond the traditional organisation of science curricula and allows teachers and students to make connections between science disciplines, discover underlying connections between phenomena and work on transdisciplinary projects in which the added value of each concept is highlighted.

To achieve this, the team has created a holistic approach that deals with the content taught in classrooms, as well as the way in which this content is taught to students. This has resulted in the creation of a set of core interdisciplinary fundamental concepts as a reference system which students can keep coming back to every time they learn something new. This reference system can facilitate the consolidation of new

knowledge and make it more permanent by explicitly connecting it to past knowledge already built around that set of core concepts.

## A 'CURRICULUM-PROOF' METHODOLOGY

The methodology is divided into two main strands. The 'Science as a whole' strand focuses on the content, i.e. what is taught, while the 'STEAM education' strand focuses on how science is taught to students. The 'curriculum-proof' aspect comes from the fact that the project encompasses all the basic science ideas that students are taught over their school years, but is organised in an interdisciplinary way – the backbone structure is immune to curriculum changes and can be used with students of all ages and in schools of countries with different approaches to science education.

## CORE IDEAS

All of us, to varying extents, have experienced the phenomena of forgetting much of what we learned in school, with only a few scattered pieces of information being retained. A key question is, "When all other knowledge fades away, what are the very basic science concepts



every educated person should know about?" It is a question that the POLAR STAR team seeks to answer through the methodology it has developed. Ultimately, the idea is to replace the scattered pieces of information with a set of core science concepts – the ‘Big Ideas of Science’ – that help explain the world around us.

The team began working on the ‘Big Ideas of Science’ back in 2014, when it looked at the report, ‘Principles and Big Ideas of Science Education’, edited by Wynne Harlen in 2010. The team reviewed several similar sets of core ideas of science or separate science disciplines and, based on that review, developed its own set. Next, it conducted 19 workshops in different European countries, engaging 352 teachers in total to review and validate the set. It also asked 18 stakeholders (curriculum developers, academics, heads of teacher training centres and others) from 18 different countries around the world to review the set. POLAR STAR’s final concept of ‘Big Ideas for Science’ is the end product of an amazing collaboration.

The Big Ideas give students the key knowledge they need, and how these ideas are communicated in class is informed through the methodology. POLAR STAR’s methodology offers tools and materials that allow teachers to deploy a transdisciplinary STEAM approach that develops students’ 21st century skills, increases knowledge retention and boosts students’ appreciation of science.

#### KNOWLEDGE FOR LIFE

Increasing knowledge retention is a key part of the team’s methodology. It offers tools and

guidance to teachers to increase knowledge retention by a) focusing on keeping the bigger picture in mind, b) presenting each concept within different contexts, c) making interdisciplinary connections to other science concepts and d) personalised learning. In the training workshops, the team presents the rationale of the methodology in detail and fully trains teachers to use it in class by deploying simple tools and techniques.

#### THE NEXT STEPS

POLAR STAR has 18 more months to go and from now until then, the team is focusing on training teachers and doing in-class implementation. The team currently designs innovative activities of in-class implementation around Arctic Research (POLAR kit) and Space Exploration (STAR kit) aiming to bring the project’s methodology in schools through contemporary science achievements and

topics that are appealing to all students. Due to the pandemic, the team has decided to run its 2021 summer school for teachers online. The summer school will run from 5th to 9th July 2021 and the team is offering an open invitation to all teachers to participate.

Looking ahead, there are also plans for smaller events in the participating countries, as well as further online training courses for teachers who are unable to attend future face-to-face workshops.

This truly is an exciting project and one that could revolutionise how STEAM is taught to students around the world. The benefits of achieving that will extend far beyond the students and teachers – it will improve many areas of life across the four corners of the globe.

### POLAR STAR Pilots Schools

Join us and  
implement  
POLAR STAR  
in your school!

Register



# MEET MEMBERS OF THE POLAR STAR COMMUNITY



**NAME:** IOANNA KASAMPA  
**ROLE:** PRIMARY SCHOOL TEACHER  
**SCHOOL/ESTABLISHMENT:** 2ND PRIMARY SCHOOL OF CHIOS  
**SUBJECTS:** MATHS, PHYSICS, GREEK LANGUAGE  
**TEACHING AGE RANGE:** 9-12 YEARS OLD

**Our collaboration with POLAR STAR is great!** I have worked with the POLAR STAR team on many projects in the past, such as SPACE AWARENESS, GO-LAB and ISLANDS DIVERSITY, which has helped us work across many different types of methodology and concepts based on science

and STEAM philosophy. I really do enjoy being part of this wonderful team!

**There have been so many amazing workshops in the past that highlighting one memorable moment above any other seems unfair!**

The recent covid-19 pandemic issues have brought into sharp focus just how enjoyable the collaborations have been and no doubt will be again in the future.

**I really enjoy learning new things and methods** – but the greatest part of these projects is that we have been working together for years, so we are a bonded team that tries to give our best to contribute to the development of the projects. My participation in these projects always provides me with great experience, in and out of class, and gives me innovative knowledge that is extremely useful in my profession.

**I like the teaching approach of the project that combines innovative learning techniques, like inquiry learning and the**

**design thinking approach**, which is very helpful for students to develop strong skills for their future life. The most exciting part is that in the POLAR STAR methodology we study ‘Science as a whole’, but, at the same time, we personalise the teaching and learning experience to meet each student’s needs.

**Of course, the application of the POLAR STAR methodology in class provides students with many learning opportunities**, but I think that the most crucial aspect is approaching science in a joyful way that fosters a love of science in the students. As far as the concepts are concerned, they are very interesting, because astronomy and space exploration have always been breath-taking subjects and a rich source of excitement.

**I would definitely encourage other teachers to participate in POLAR STAR.** I would tell them to be open to new horizons in education – the implementation of the POLAR STAR project will give them and their students a wonderful experience!



**NAME:** IVO JOKIN  
**ROLE:** DIRECTOR AND STEAM TEACHER  
**SCHOOL/ESTABLISHMENT:** MUNICIPAL CENTER FOR EXTRACURRICULAR ACTIVITIES, SOFIA, BULGARIA  
**SUBJECTS:** STEAM  
**TEACHING AGE RANGE:** 10-18 YEARS OLD

**I got involved in the POLAR STAR Advisors team, Star Kit.** I am the organiser of the National Astro Party, which is included in the National Calendar for extracurricular activities of the Ministry of Education and Science. In 2020, because of the coronavirus pandemic,

it was held online with over 220 teachers and students. I presented in the official programme of the POLAR STAR project.

In February 2014, together with the Regional Department of Education Pleven, Ms Katya Trifonova, who is a Senior Science Expert, a seminar was held with 28 science teachers from Pleven where I introduced colleagues to the objectives of the project and the work of some of the online laboratories. I also presented the project activities at the 42nd National Conference on Physics Education, September 8-11 in Stara Zagora.

**What has been a memorable moment for me?** A module is included in the educational programme of the Municipal Center for Extracurricular Activities called GO-LAB, which uses ‘Guidelines for design of Go-Lab inquiry Learning Spaces’ – that was a particular highlight.

**What I find most rewarding and enjoyable about POLAR STAR** is the opportunity to

learn new, modern and innovative approaches and methods of teaching science.

**The POLAR STAR approach which embraces science as a whole, with a focus on personalised, student-centred learning, is very appealing to me.** I work in the field of non-formal education, so I find this aspect crucial to my teaching – I will be including it in modular curriculum activities, for sure.

**Directing the educational process to the students themselves** – placing them in the role of young researchers by provoking their curiosity and development of cognitive interest – is an essential need that POLAR STAR allows me to meet. The project also facilitates the change from a teacher as a leader to a teacher-mentor, which is really valuable.

**The POLAR STAR methodology presupposes an interdisciplinary approach.** The proposed concept and methodology of the project – ‘Science as a whole’ – encourages the

participation of teachers from different subjects so that students can acquire a complete and comprehensive picture of the world around us. That can only foster improved collaboration.

**I believe that research-based learning is very important** and through the resources and methodology of the POLAR STAR project, I will develop my competencies in this area further.

**I would be happy to invite other teachers to participate in POLAR STAR!** I think that working with geography teachers (who can be neglected in STEM projects), for example, will prove very successful and useful.



**NAME:** MARINA MOLLA  
**ROLE:** HEADMISTRESS  
**SCHOOL/ESTABLISHMENT:** 9TH PRIMARY SCHOOL OF KOMOTINI, GREECE  
**SUBJECTS:** PRIMARY SCHOOL CURRICULUM  
**TEACHING AGE RANGE:** 6-11 YEARS OLD

**If I had to choose a memorable moment of collaborating with the team, it would be the POLAR STAR Summer School,** for three reasons. Firstly, we had the time to interact with each other and further discuss the POLAR STAR approach. Secondly, I had the honour of being one of the speakers – my presentation was about how I have been teaching interdisciplinarity with the Big Ideas of Science and the feedback I got from the POLAR STAR team and participants was very

positive and useful. Thirdly, I implemented the activities we were asked to do during the workshop with my children and their friends and they were enthused by them.

**The biggest reward of participating in innovative projects like POLAR STAR for me lies in the eyes of my students.** After implementing school projects and activities that follow a fully developed modern and effective didactic methodology and philosophy like PLATON (one of the team's previous projects) and POLAR STAR, you can see curiosity, excitement and motivation glow in their eyes.

**Every single POLAR STAR element is exciting, useful and effective,** but my goal will be to combine all of them, to implement 'Science as a whole'.

**Recently, I became the Headmistress of my School,** the 9th Primary School of Komotini, Greece. My school is a multicultural and multilingual school. Many of our students come from vulnerable social groups. We face inadequate school attendance and school dropout. We need to attract our students back to school and, at the same time, enhance their self-esteem and personalise their learning.

Teaching with the POLAR STAR approach and kit will intrigue and engage our students and help them 'learn how to learn' by making connections and using their memories, stories and experiences. Thus, we will innovate our school and make a difference to the students' lives.

**If, like me, you have come across students who don't remember concepts they have been taught recently,** then POLAR STAR is your answer and this is its biggest added value. Teaching with the POLAR STAR approach will help your students make connections. They will connect what they learn at school with their everyday life and this will make their learning more meaningful.

**The biggest challenge is to leave your comfort zone and decide to innovate your classroom.** Once you have made that decision, the POLAR STAR approach offers you a fully developed, detailed, useful and effective teaching approach that comes with teaching and learning materials which you can use easily in your daily teaching practice. The POLAR STAR team will always be there to support you. Let's grow the POLAR STAR community!

## THE POLAR STAR TEAM



The POLAR STAR team is composed of several teachers, educators, researchers and advisors who all have a passion for helping people teach science as a whole. Each participant has their own role within the project, although collaboration between and across departments and functions is essential to the success of the wider team.

**Pasi Nurmi:** Project Coordinator, in charge of producing the roadmap of the project

**Eleftheria Tsourlidaki:** 'Science as a whole'

**Yvoni Pavlou and Marios Papaevripidou:** 'STEAM Education'

**Iratxe Menchaca Sierra and Oihane Zarate González:** Assessment toolkit

**Agata Gozdzik:** POLAR kit of activities

**Frances McCarthy:** STAR kit of activities

**Priscila Doran and Rosa Doran:** Pilot implementation

### Meet the team...



Pasi Nurmi



Eleftheria Tsourlidaki



Priscila Doran



Marios Papaevripidou



Yvoni Pavlou



Agata Gozdzik



Iratxe Menchaca Sierra



Oihane Zarate González



Frances McCarthy

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# WHAT IF WE COULD DO PSYCHOLOGY EXPERIMENTS IN VIRTUAL REALITY?

VIRTUAL REALITY IS OPENING NEW DOORS FOR RESEARCH IN PSYCHOLOGY. BASED AT THE UNIVERSITY OF KENT IN THE UK, PROFESSOR MARKUS BINDEMANN AND HIS TEAM BUILD PHOTOREALISTIC, 3D AVATARS IN VIRTUAL REALITY TO STUDY FACE PERCEPTION AND PERSON PERCEPTION

## TALK LIKE A VR PSYCHOLOGIST

**VIRTUAL REALITY (VR)** – A three-dimensional (3D), simulated audio-visual experience or environment, usually accessed using a headset and handheld controllers

**AVATAR** – An image representing a person on the internet or in virtual reality

**FACE PERCEPTION** – The ability to understand human faces, including the ability to distinguish faces from other objects, to recognise familiar faces, and to detect emotional expressions

**PERSON PERCEPTION** – The process

of forming an impression of another person, based on what they look and sound like, how they move, and other factors

**FACE-IDENTITY MATCHING** – The ability to identify a person by comparing their face to a photograph

**SIMILARITY SPACE** – A numerical framework that captures how similar different faces in a set are in appearance to each other, by comparing scores that reflect the visual similarity of all possible combinations of faces

Psychological research into human thinking and behaviour is difficult because so many factors influence the human mind. In a lab experiment, psychologists can isolate the factors they want to study by controlling the research environment – but the results can be unrealistic because participants might behave differently in the lab than in complex real-world situations. In field

studies, psychologists can learn about behaviour in real life, but it is difficult to disentangle all the possible reasons for people's actions. So, how can psychologists combat the issues related to both lab and field studies? Professor Markus Bindemann, of the University of Kent in the UK, has a solution to this dilemma: psychology experiments in virtual reality.

In virtual reality, researchers have complete control over the environment. Because VR simulations can be so realistic, however, study participants behave like they do in real life. Markus uses this powerful advantage to study face-identity matching – the ability of people to match human faces to photographs.

A lab experiment might show participants a plain, cropped headshot and ask them to match the photograph to a person, then use psychological or neuroscientific research tools to study how their brains complete the task. The photographs are standardised and carefully designed to remove any sources of bias or other interfering factors. How does this kind of experiment translate into the real-world environment of, say, a passport control line, where passport controllers are under time pressure, lighting may vary, and there are noises and other distractions? More pertinent for Markus and his team, how can VR offer a useful alternative?

“VR allows for sophisticated measurement of behaviour in complex environments,” explains Markus. “We can look at participants’ accuracy and response times (via button presses on hand-held controllers), movement coordinates



(for example, how close a participant moves to an avatar in a VR world), and eye movements to see what participants are actually looking at (via integrated eye-trackers in VR headsets for research).” As a research tool, VR offers Markus and his team so much more than a cropped headshot!

#### CAN VR EXPERIMENTS TELL US HOW PEOPLE IDENTIFY IMPOSTORS?

To answer this and other questions, Markus and his team built a virtual reality passport control game. They create realistic avatars of real people by using handheld scanners to generate a 3D model of a volunteer’s head. The head is then attached to an avatar body and the body rigged with a skeleton so it can move around in VR. The clothing, body size and other elements of the avatar’s appearance can be varied. Participants in the study then ‘play’ as the passport controller in an airport, checking the faces of avatars against a passport photograph as the avatars file through the control booth.

“This scenario investigates the real-world phenomenon of identity-impostors,” Markus says. “Modern passports are extremely difficult to forge but, for people with criminal intentions, one way of passing through security undetected is to utilise the identity documents of someone with a similar appearance.” The research team can investigate how different factors affect participants’ ability to accurately match faces to photographs by changing the VR scenario a little bit at a time. “We have variations of this task to understand what might impact identification accuracy at airports,” Markus explains. “For example, do agitated crowds (versus orderly queues) of waiting travellers in an airport exert time pressure on the passport controller and increase the failure to detect impostors?”

#### AVATARS AS A RESEARCH TOOL

As with any research method, Markus and his team have had to assess and evaluate the quality of their avatars rigorously. “We have examined how well observers can recognise avatars of people that they know, and the answer is they can recognise these as well as photographs. We have performed computations to measure how similar avatars of different people are to each other – and we found that this produces the same ‘similarity space’ as photos of the same people. And we have compared person identification of avatars in our virtual airport with established laboratory tasks that measure face identification and have found strong correspondence there.”

Developing such high-quality avatars has been challenging but will help to drive on Markus’s research for years to come. “It is complex and sophisticated technology, and we also put it to complex and sophisticated use,” he explains. “I lead a research team which works on this, so much of my role is to coordinate and make key decisions. My research assistants were completely new to this technology at the start of this project, but have learned to scan and build avatars, and to run experiments in VR in the space of a couple of years.”

For Markus and his team, developing avatars has been professionally and academically rewarding. “It has been a really fun journey of discovery,” says Markus. “Making the first 3D scans of people, for example, was hugely exciting. And it continues to be really interesting for us to see how well we can scan different people and convert these into avatars – for example, someone with dreadlocks, long curly hair, a beard or distinctive facial marks.”



#### PROFESSOR MARKUS BINDEMANN

Professor of Cognitive Psychology  
University of Kent, UK

#### FIELD OF RESEARCH

Cognitive Psychology, Neuropsychology  
Visual Perception

#### RESEARCH PROJECT

Investigating face perception and face-identity matching in virtual reality

#### FUNDER

Economic and Social Research Council  
Grant no ES/S010181/1

#### WHAT’S NEXT FOR PSYCHOLOGY IN VR?

Markus’ avatars cannot yet talk, interact, or change their facial expressions. Making the simulations more sophisticated is the team’s immediate goal, with the aim of gaining a better understanding of face and person perception. This has the potential to help people with facial recognition disorders, to improve security systems, and to interpret the reliability of eyewitness testimony in court cases, among many other possible applications.

In the long term, the potential of VR for psychology and neuroscience is enormous and goes far beyond face perception or passport control. “I know psychologists who are using VR for research in forensic settings, in sports science, or in clinical settings,” says Markus. Researchers across the psychological disciplines are now carrying out experiments in VR to study, for example, how people communicate and interact with each other, how people navigate through complex environments, or to provide novel treatments for addictions or anxiety disorders.

# ABOUT COGNITIVE PSYCHOLOGY

## WHAT IS COGNITIVE PSYCHOLOGY?

Cognitive psychology is the study of mental processes like perception, memory, creativity and problem-solving. Cognitive psychologists perform experiments with human participants to study how people think, process information, and mentally represent the outside world.

## WHAT RESEARCH AREAS DOES COGNITIVE PSYCHOLOGY COVER?

Some major research areas in cognitive psychology include: object recognition and

pattern recognition; attention; language learning and language processing; memory formation; different kinds of memory such as autobiographical memory, eyewitness memory, short-term and long-term memory, working memory, and false memory; decision-making and choice; problem-solving; reasoning and logic; knowledge representation; and judgment and categorisation.

## HOW IS COGNITIVE PSYCHOLOGY RESEARCH USED IN PRACTICE?

Findings from cognitive psychology can be useful in clinical psychology to help people with psychological disorders, such as attention deficit hyperactivity disorder (ADHD) or Alzheimer's disease. Cognitive psychology helps define and shape therapeutic practices like cognitive behavioural therapy. Cognitive psychology is also important in the justice system when interpreting eyewitness testimony and recall of events.

## EXPLORE A CAREER IN COGNITIVE PSYCHOLOGY

- The British Psychological Society (BPS) provides excellent information about how to become a psychologist, as well as the latest news from the world of psychology: [www.bps.org.uk/public](http://www.bps.org.uk/public)
- Markus recommends looking at the websites of psychology departments at universities in the UK and beyond. "The best departments will have news about the latest research, websites for their staff including research interests and achievements – and, of course, that is where you can find some of the most famous psychologists in the world. Often these websites will also provide information about the exciting equipment and technologies that we use – such as VR!"
- The NHS Foundation Trust offers undergraduate internships in psychology. HM Prison & Probation Service sometimes offers trainee counselling psychologist placements.
- Graduate psychologists can seek an academic career or work in industry or the public sector in a variety of jobs. Non-academic jobs include counselling and psychotherapy, witness assessment services, occupational psychology, and forensic psychology.
- In the UK, psychologist salaries start at around £37,000 in the NHS and range up to £60,000, or higher for consultants. In the USA, the American Psychological Association reported an average salary of \$90,000 for industrial and organisational psychologists in 2007. A typical salary for a post in psychology at a university is £35,000-£50,000 in the UK or \$62,000 in the USA.

## PATHWAY FROM SCHOOL TO PSYCHOLOGIST

Markus recommends studying maths and biology in school, as well as psychology at university. He adds that psychology is a diverse field – it ranges from clinical practice to animal behaviour research – and it is a good idea to read around and try out a variety of courses to find out what appeals to you personally.

Psychology is available as a subject in GCSEs, A Levels, Scottish Highers, Advanced Placement exams and International Baccalaureate diplomas.

A bachelor's or MSc degree in psychology or a sub-field like developmental psychology or neuropsychology is a solid foundation for a career as a psychologist.

## MARKUS' TOP TIPS

- 01** Follow your own interests and develop them. Read as much as you can and read carefully, so you can grasp content fully and make connections between different sources.
- 02** Take opportunities when they come your way. Don't limit yourself – give things a go. It really is better to have tried and failed than never to have tried at all.
- 03** Appreciate that it takes a long time to become an expert at anything. It will take many years, so make sure you enjoy the journey.



Recording of a passport photograph.



Shape model of a face scan.



Face scan with full skin and hair texture.

## HOW DID MARKUS BECOME A COGNITIVE PSYCHOLOGIST?

### WHAT WERE YOUR INTERESTS AS A YOUNGSTER?

I was into music and sports, nothing out of the ordinary!

### WHAT INSPIRED YOU TO BECOME A COGNITIVE PSYCHOLOGIST?

I decided to study psychology at university without really knowing what the subject was. Many people just connect the subject with clinical psychology, and I was one of those people too. But I had fantastic lecturers at university who introduced me to many exciting areas of psychology – such as comparative psychology and animal behaviour, vision science, and face perception.

### WHAT HAS MADE YOU SUCCESSFUL AS A SCIENTIST?

Scientists work a lot and you need intrinsic motivation to keep going. I didn't realise that

I had this motivation until I reached my 20s – so don't panic if your motivation to study has not peaked yet!

### WHAT DO YOU FIND REWARDING ABOUT WORK IN YOUR FIELD?

Working at the forefront of knowledge is a serious occupation, but it's also fun. As a scientist, my job is to recognise that there is a question that we don't know the answer to yet, that the question is worth asking, and then to find a way to work out the correct answer by using the scientific method. It's a creative and stimulating process. Person identification is also an interesting research field because it's such a big part of what we do in daily life. Understanding how we identify the people around us and interact with others runs through everything we do.

### HOW DO YOU GET THROUGH TOUGH

### SPOTS IN YOUR WORK?

Persistence is key, but so is acceptance that it takes time to figure out complex problems. I find it important to read and write to clarify my thinking and my ideas at points when I get stuck. Another way of overcoming obstacles is to work collaboratively – to pool expertise and intellect to work on a problem together.

### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS?

My proudest achievement has always been to help others succeed. I have taught people from many different walks of life and seen them blossom into competent psychologists. It is particularly rewarding when you work with someone over several years and can see how they develop from an enthusiastic student to an independent researcher, capable of forging their own career.



# CAN ANIMATED STORIES HELP YOU TO BETTER UNDERSTAND YOUR MENTAL HEALTH NEEDS?

WHAT'S UP WITH EVERYONE? IS A CAMPAIGN RUN IN CONJUNCTION WITH AARDMAN, RESEARCH TEAMS FROM VARIOUS UNIVERSITIES AND CLINICAL AND CHARITABLE PARTNERS TO PROVIDE SUPPORT FOR MENTAL HEALTH LITERACY AMONG YOUNG PEOPLE. THEY BELIEVE THAT BY SHARING IDEAS RELATING TO MENTAL HEALTH AND WELL-BEING IN AN ENGAGING AND POPULAR FORMAT, ANIMATIONS CAN MAKE A POSITIVE DIFFERENCE TO THE LIVES OF YOUNG PEOPLE

Talking about mental health and well-being is something that has grabbed the headlines in recent years and with good reason, not least during the coronavirus pandemic, when key reports have found increased levels of depression, anxiety and loneliness among young people<sup>1</sup>. More than half of all students at university reported a worsening in their mental health and well-being since the beginning of the autumn term in September 2020<sup>2</sup>. The Office of National Statistics found that in early 2021, adults aged 16 to 29 years were most likely to experience some form of depression (34%)<sup>3</sup>. A Young Minds survey found that 67% of young people believed that the pandemic will have a long-term negative effect on their mental health<sup>4</sup>.

Clearly, these statistics are concerning, not least because issues relating to mental health and well-being in young people appear to be worsening. It is with these issues in mind that the What's Up With Everyone? campaign has been established. Led by Principal Investigator Professor Paul Crawford at The University of Nottingham's Institute of Mental Health, with Aardman Animations Ltd, and research teams across the UK, the project seeks to provide

young people with the tools, affirmation and empowerment (mental health literacy) to support their mental health needs before they develop into more serious issues.

## WHO IS THE TARGET AUDIENCE FOR THE PROJECT?

This upstream project is composed of a variety of five animated stories that discuss life's challenges and encourage people to realise that these are not unique to them. The target audience is primarily young people aged 17 – 24, who are likely in transition to college, university or the workplace, but it is not limited to this age range. Indeed, the films are available to younger audiences on Aardman's YouTube Channel alongside Shaun the Sheep and other popular characters. Ultimately, by providing an engaging and popular format for the sharing of ideas relating to mental health and well-being, the team hopes to provide relevant support and understanding that can make a positive difference to the lives of young people.

## WHO IS INVOLVED IN THE PRODUCTION OF THE ANIMATIONS?

Such an ambitious project requires input from a range of academic, clinical and creative

industry experts. Of course, Aardman is one of the most famous and popular animation studios in the world, while Professor Paul Crawford is the world's first professor of health humanities. However, given the target audience, young people were directly involved in the production of the animations. Accordingly, 42 young people, aged between 16 and 21 joined as co-creators, five of whom provided the spoken voices for each of the characters in the animations: Tai, Merve, Ashley, Charlie and Alex.

## HOW WERE THE PRODUCERS RECRUITED AND WHAT WAS THEIR ROLE?

The young people involved in the production of the animations were recruited by Aardman with support from the Mental Health Foundation and Leaders Unlocked. This was achieved by contacting organisations that work with young people, universities and colleges across the UK, and through posts on social media. The young people actively contributed to the development of scripts in a co-creative pilot and workshops, and provided feedback on how their ideas had been translated into animated characters. The wider team prepared



the website platform information with feedback from the young people.

#### HOW DID THE PROJECT TEAM DECIDE ON THE MENTAL HEALTH THEMES?

Paul and his colleagues are experts in the area of young people's mental health and are acutely aware of the most commonly known areas of concern, notably perfectionism, loneliness & isolation, independence, social media, and competitiveness. These areas featured prominently in the feedback of nine young people in a co-creative pilot and in response to a mailer to 7,000 students sent out by Aardman.

The workshops that were a formative part of the project included diverse participants who helped in developing potential storylines and characters for the animated films. "The workshops confirmed the salience of the expected themes, and raised additional issues relating to loss of agency or being disempowered in decision-making and losing trust in adult frames for how to live their lives or what they called ticking the 'grown up boxes'," says Paul.

#### WHAT IMPACT HAS THE PROJECT HAD SO FAR?

The project has attracted multiple mainstream media coverage since it was released on 8 February 2021. By 12 March, there had already been substantial media coverage, including Sky

News, ITV News, multiple BBC radio stations, BBC Teach, *Daily Mail*, *Mental Health Today*, *The Psychologist*, and *Child and Adolescent Mental Health*. In addition, key celebrities including Stephen Fry, Dr Alex George and Michael Chakraverty got behind the project, which has significantly expanded reach and increased awareness.

Over 17 million people have been reached across social media channels and through influencer posts, including 5 million young people. The project has built over 4.4k followers, a figure that continues to grow at a steady rate. More than 700k engaged with the content posted from Aardman channels, with 637k views across the channels. Excitingly, *What's Up With Everyone* recently won Best Social Media & Content at the Design Week Awards! Clearly, the campaign is heading in the right direction and it follows that the more people know about it, the greater the positive effect will be.

#### WHAT DOES SUCCESS LOOK LIKE?

Paul is clear in his views of what will make the project successful. "We consider success to be offering visible, accessible resources to support mental health literacy among the largest possible audience in the target population in the UK and beyond," says Paul. "From a research perspective, we wish to determine if animated stories and the website platform advance young people's mental health literacy,



#### PROJECT LEAD AND PRINCIPAL INVESTIGATOR

Professor Paul Crawford  
The University of Nottingham, UK

.....

#### CO-INVESTIGATORS

Professor Mike Wilson, Loughborough University; Dr Thomas Curran, London School of Economics and Politics; Dr Elvira Perez Vallejos, The University of Nottingham; Dr Antonia Liguori, Loughborough University, UK

.....

#### FORMAL PARTNER

Aardman Animations Ltd.

.....

#### APPOINTED RESEARCH FELLOWS

Dr Sachiyo Ito-Jaeger, The University of Nottingham; Dr Mel Warwick, Loughborough University, UK

.....

#### MENTAL HEALTH CONSULTANTS

Dr David Crepez-Keay, Mental Health Foundation, Dr Dominique Thompson, Buzz Consulting, UK

.....

#### FUNDER

Arts and Humanities Research Council

*What's Up With Everyone [originally What's Up With Alex]? Animated Storytelling for Mental Health Literacy Among Young People (Grant number AH/T003804/1)*

and understand the mechanisms of digital storytelling. Preliminary findings show that the films improve young people's knowledge and attitudes towards mental health, increase their willingness to seek help and their confidence in helping others."

<sup>1</sup><https://digital.nhs.uk/data-and-information/publications/statistical/mental-health-of-children-and-young-people-in-england/2020-wave-1-follow-up>

<sup>2</sup><https://www.ons.gov.uk/peoplepopulationandcommunity/educationandchildcare/articles/coronavirusandtheimpactonstudentsinhighereducationinenglandseptembertodecember2020/2020-12-21>

<sup>3</sup><https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/coronavirusanddepressioninadultsgreatbritain/januarytomarch2021>

<sup>4</sup><https://youngminds.org.uk/about-us/reports/coronavirus-impact-on-young-people-with-mental-health-needs/#covid-19-january-2021-survey>

# EXPLORE THE THEMES BEHIND THE PROJECT

Personal, Social, Health and Economic (PSHE) education is now compulsory in schools in the UK, which helps show how far we have come as a society in recognising the importance of providing pupils with the support and education they need to keep themselves healthy, safe and prepared for life.

In addition, the government has published statutory guidance in a document entitled *Relationships, Education, Relationships and Sex Education and Health Education*. Here, we delve deeper into the five themes that form part of the What's Up With Everyone? project: perfectionism, loneliness & isolation, independence, social media, and competitiveness.

Where relevant, we have also presented some of the statutory guidance relating to PSHE.

## PERFECTIONISM

Perfectionism is a personality characteristic that reflects a need to be perfect. This often exists alongside harsh self-criticism and there is evidence to show that perfectionism is on the rise; recent meta-analysis showed that perfectionism is rising rapidly among university-aged young people, with modelling

suggesting that by 2050, almost one in three people will report clinically relevant levels of perfectionism.

## WHY IS PERFECTIONISM POTENTIALLY PROBLEMATIC?

The latest research not only shows that incidence is on the rise, but that it contributes to a litany of serious mental health conditions, such as depression, anxiety, anorexia and suicide ideation.

## LONELINESS & ISOLATION

Loneliness and isolation are issues usually associated with older people. Interestingly, the Loneliness & Isolation section of the What's Up With Everyone? website is one of the most visited. While both loneliness and isolation can be a challenge for many people across their lives, especially older people who may have fewer social connections, young people are also badly affected. Moving to college, university or the workplace may pose a particular challenge to young people, as they navigate this transition. They may experience heightened anxiety about a number of issues, including their identity as they attempt to find their place in a world that puts a lot of emphasis on appearance and popularity, the threat of

managing independently in the big world, forging a career pathway, and finding satisfying and supportive relationships.

The pressure to fit in and the intense focus on social experience can be overwhelming. This may be worse if a young person is already marginalised, without access to the resources of their peers (such as the internet), or when from minority communities, who may be subject to discrimination.

**Statutory Guidance:** *Pupils should be supported to recognise what makes them feel lonely. Self-focused or isolating lifestyle choices can lead to unhappiness and being disconnected from society for those who have greater need for companionship and relationships.*

## INDEPENDENCE

Independence is usually regarded as a positive experience so why has independence been identified as a mental health challenge for young people? Becoming independent can certainly be a positive experience, but it is not without its challenges. Independence is all about making your own way in the world and involves acquiring new skills, taking risks and having the confidence to learn from your

## SEEKING HELP

Research has shown that there are many barriers to young people seeking help. These include:

- Stigma and embarrassment about seeking help
- Confidentiality and trust in relation to the potential source of help
- Difficulty identifying the symptoms of mental illness
- Lack of accessibility
- Preference to rely on themselves rather than seeking external help for their problems
- Concern about the characteristics of the potential provider of help
- Lack of knowledge about mental health services
- Fear about the act of seeking help or the source of help.

**Statutory Guidance:** *Pupils should be taught how to judge when they, or someone they know, needs support and where they can seek help if they have concerns. This should include details on which adults in school and externally can help.*

This is why the What's Up With Everyone website has a 'seeking help' page, which gives students lots of options for finding support for any mental health problem they may have: [www.whatsupwitheveryone.com/help.php](http://www.whatsupwitheveryone.com/help.php)

mistakes. Any challenges associated with living independently can be stressful and cause anxiety – and young people may feel that asking for help and support is a sign of weakness.

It is important to recognise that we all depend on other people to some extent, and others will always depend on us. The trick is to balance the desire for independence with the practicality of seeking and giving support to each other.

.....  
**SOCIAL MEDIA**

Much of the research we see and read about in the media is concerned with screen time and its associations with depression, anxiety and social isolation. However, recent advice to parents is not to just focus on screen time, but rather on the online content young people consume and how actively engaging (as opposed to passive scrolling) and creative engagement can have a positive effect.

**IS THE IDEA OF COMPARING YOURSELF TO OTHERS THE REAL ISSUE HERE?**

Many of the images and lives we are all presented with across social media are unrealistic and unobtainable. There exists a perceived standard that is impossible to live up to. However, there

are also pressures to share opinions, personal information and photographs on an extreme scale – behaviours that are encouraged by persuasive loops of reward, duty, exchange and a need for validation. This need for ‘likes’ and ‘shares’ has decreased the quality of communication and increased social withdrawal, self-neglect, poor diet and family conflict.

Government, industry chiefs and technology designers are now incorporating new policies and guidelines to ensure social media platforms design their online services more responsibly and consider young people’s online rights, needs and developmental milestones.

**Statutory Guidance:** *The internet and social media have important characteristics which young people should be aware of in order to help them use them discriminatingly. Secondary school pupils should know the similarities and differences between the online world and the physical world, and how to identify harmful behaviours online (including bullying, abuse or harassment) and how to report, or find support, if they have been affected by those behaviours.*

.....  
**COMPETITIVENESS**

Competitiveness can certainly be a positive

quality to have and levels of it clearly vary among individuals. However, we should recognise that it can be influenced by external factors, such as the number of competitors and the presence of audiences. Competitiveness can be problematic when someone is hypercompetitive.

Individuals who are hypercompetitive have a very strong urge to compete and win at all costs because winning is a big part of who they are. Hypercompetitiveness is related to low self-esteem, high neuroticism (a personality trait that tends towards anxiety, depression, self-doubt and other negative feelings), and high aggression. Other types of competitiveness can also be a problem if they cause people emotional distress.

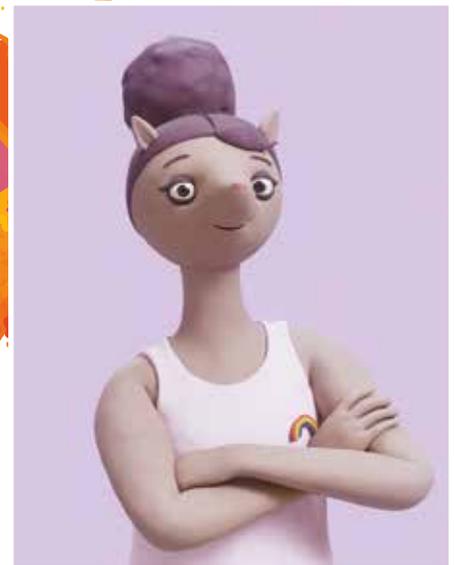
Young people face more competitive environments these days, such as the job market and university admission, which could be related to the increased level of perfectionism seen in recent years. This is concerning because of its association with psychological disorders, such as depression and anxiety.



*“We’re told it’s good to be competitive, right? But I’m starting to think that for me it’s getting a bit out of hand. I feel like whatever I’m doing, I have to be the best at it! If I’m not the best, or the fastest, or the funniest at something it starts to eat me up... I think it’s affecting my friendships, happiness and enjoyment of life. What’s up with me?” - Tai*



*“I know it sounds odd but even when I’m with friends I can feel shy and that I don’t have anything interesting to say... it can be a little scary... I can’t get my words out properly and I feel kind of out of it, not part of the group. I flip between longing to be in the company of others and wanting to hide away. I find it hard responding to the thoughts that rattle around in my head. What’s up with me?” - Merve*



*“I have all these post-it notes stuck to my computer, reminding me to do things I never had to do before. They should all be quite simple on their own, but stacked up with all the other work, I’m finding it overwhelming and hard to cope. Other people seem to manage okay. What’s up with me?” - Ashley*

# YOUR PAIN IS MY PAIN: WHAT MAKES US FEEL EMPATHY?

THE ABILITY TO FEEL WHAT OTHERS ARE FEELING, A PHENOMENON KNOWN AS EMPATHY, IS A KEY PART OF PEOPLE'S SOCIAL BEHAVIOUR. DESPITE US KNOWING HOW EMPATHY FEELS, THE NEURAL PROCESSES BEHIND EMPATHY HAVE LONG REMAINED UNKNOWN. DR VALERIA GAZZOLA AND PROFESSOR CHRISTIAN KEYSERS, OF THE SOCIAL BRAIN LAB BASED IN THE NETHERLANDS INSTITUTE FOR NEUROSCIENCE, EMPLOY THE LATEST TECHNIQUES IN NEUROSCIENCE TO UNCOVER HOW THIS PROCESS PLAYS OUT IN THE BRAIN

## TALK LIKE A NEUROSCIENTIST

**EMPATHY** – sharing and understanding the feelings of another

**fMRI** – functional magnetic resonance imaging – a technique used to measure brain activity

**HAEMOGLOBIN** – the protein in red blood cells that carries oxygen to cells that need it

**NEURONS** – nerve cells, responsible for sensing the world, relaying the information to where it is needed, and sending commands to our muscles

**NEUROSCIENCE** – the study of the structure and function of the brain and nervous system

**PSYCHOPATHY** – a personality disorder marked by antisocial behaviour and lowered or absent emotional responses, such as empathy

**SYNAPSE** – the 'junction' between two nerve cells or between a nerve cell and a muscle cell

Why do we wince when we see someone else stub their toe? Why do we enjoy watching TV shows where actors perform daring stunts or fall in love? How is it that we can feel what others feel? Understanding empathy, and how the brain creates it, is the main mission of The Social Brain Lab at the Netherlands Institute for Neuroscience in Amsterdam. Dr Valeria Gazzola and Professor Christian Keysers, partners in science and in life, run the Social Brain Lab and have unearthed some tantalising secrets of the mind.

## FROM THE OLD TO THE NEW

Not long ago, scientists understood empathy through the 'hamburger model'. "For instance, when I see my friend reach for her empty glass, and I refill it for her, people thought that three separate things happen in the brain," says Valeria. "The first is that my eyes see her reaching for an empty glass and my brain picks this up. The last is that my motor system leads me to refill her glass. In the middle is the 'meaty' part – some sort of abstract thinking and decision-making that led me to conclude that the action of my friend meant she was thirsty, and so refilling her glass was the appropriate response."

However, since Valeria and Christian began working in this area, our understanding of

empathy has changed dramatically. "Mirror neurons are brain cells that allow me to plan and sense my own actions," says Christian. "However, they are not only active when I move or feel with my own body, but also when I watch someone else move." This means that mirror neurons can sense what another body is feeling as if it were happening to one's own. "This led us to conclude that the hamburger model is wrong," says Valeria. "The motor system does not get involved only once the decision to act has been made, but is an integral part of perceiving the experiences of people around you."

## IMAGING BRAINWAVES

The researchers were able to make these conclusions using functional magnetic resonance imaging (fMRI). "When a brain cell becomes active, it requires oxygen, which is brought to it by haemoglobin in the blood," says Christian. "The haemoglobin changes shape once it has released its oxygen, a change which disrupts the magnetic field of the MRI machine. This means we can measure changes in brain activity indirectly by pinpointing where these disruptions take place."

An experiment using fMRI to investigate empathy can look something like this: "We can record brain activity when you experience



pain, such as a pin prick on your finger,” says Valeria. “This allows us to identify the brain regions involved in experiencing pain first-hand. Then, we can show you videos of other people experiencing pain and can see that many of the same brain regions become active again – you feel their pain similarly to how you would feel your own.”

**LAB RATS**

fMRI is a non-invasive technique suitable for humans, but it cannot pinpoint the activity of individual neurons. “For instance, when we witness the pain of others, it may be that although the same brain areas become active as when we experience pain ourselves, it is possible it is not the same neurons that are activated,” says Christian. Rats are often used as a model species in experiments that measure and modify the activity and function of individual neurons, and so can pinpoint which ones are involved in an empathic response.

The Social Brain Lab has used studies on rats to get an understanding of empathy at the cellular level. “We found that if we scared a rat, other rats close by also became scared,” says Valeria. “By measuring the activity of individual neurons, we found that the same neurons became active in the rat when in pain and when witnessing the pain of another. However, if we inhibited these emotional mirror neurons in the observer rats, they no longer became scared.” These studies help the researchers uncover the precise ‘wiring’ behind this kind of empathy, and also show that this empathic response is

not unique to humans but is found within other mammals as well.

**HIGH AND LOW EMPATHY – OR NONE AT ALL?**

The general population shows wildly different levels of empathy, depending on the person and on the situation. “We know that genetic differences influence your level of empathy, but empathy can also be increased by simply being told the person you witness in pain has much in common with you – and, on the flip side, reduced if you are told they are a competitor,” says Valeria. “There is also evidence you can train yourself to become more empathic, and ultimately change your own brain activity. This gives us the flexibility to adapt to our environment and the responsibility to make good social decisions.”

It is commonly believed that psychopathic individuals do not experience empathy, but Christian and Valeria wanted to investigate this belief in more detail. “We showed incarcerated psychopathic individuals and control participants videos of people being hurt and then slapped the participants themselves on the hand,” says Christian. “In both instances, we recorded brain activity using fMRI. We found that psychopathic individuals’ pain regions showed less activity than control participants when watching others in pain, confirming the idea that they have reduced empathy.”

“However,” adds Valeria, “in a follow-up experiment, we explicitly asked them to



**DR VALERIA GAZZOLA AND PROFESSOR CHRISTIAN KEYSERS**

The Social Brain Lab, Netherlands Institute for Neuroscience, Royal Netherlands Academy of Arts and Sciences, Amsterdam, Netherlands

**FIELD OF RESEARCH**

Neuroscience

**JOINT RESEARCH PROJECT**

Researching the neural basis for empathy

**VALERIA’S FUNDERS**

VIDI grant 452-14-015  
ERC-stG 758703

**CHRISTIAN’S FUNDERS**

VICI grant 453-15-009  
ERC-StG 312511  
NARSAD young investigator grant

empathise with the person in the video. Then, they had the same brain activity as the control group. This suggests that psychopathic individuals are not incapable of empathy but, rather, they do not feel it spontaneously.”

**NEXT STEPS**

As neuroscience becomes ever more powerful and precise, Valeria and Christian have no intention of letting up in their work any time soon. “For me, one of the great mysteries I would like to understand is what makes mirror neurons special,” says Christian. “Are they different to other nerve cells? How did they develop in evolution and also in our own lives? Can certain experiences lead to our brains wiring new mirror neurons?”

Valeria agrees that there is still much to be done and understood. “Social behaviour is hugely complex,” she says. “Understanding how the responses of single cells eventually lead to social interaction feels like unravelling a magical process. I will continue to use the most recent technological advances to investigate the complexity of the social brain.”

# ABOUT NEUROSCIENCE

Neuroscience is an increasingly powerful scientific discipline that is progressively uncovering more and more about how our brains work. Valeria and Christian explain more.

## WHAT DO YOU FIND REWARDING ABOUT YOUR FIELD?

Some people argue that science, especially neuroscience, is overly reductionist – the argument goes that if you are fascinated by the beauty of a rose, cutting it into pieces and examining each piece will destroy its beauty. But for us, the great beauty of neuroscience is the discovery that nature uses simple principles to create wonderfully intricate minds.

## WHAT CAN BE CHALLENGING?

Grant applications are an essential part of a successful career in science and they require developing a range of skills, like being able to think big – that is, having an idea that will keep you busy for the next five to ten years! You need to be able to write about your idea in a precise, convincing and, at the same time, easy to understand manner and to present it

in about five to ten minutes in a TEDxTalk-like performance! Of course, like most challenges in science, grant applications can also be very rewarding.

## HOW IMPORTANT IS COLLABORATION IN YOUR WORK?

Neuroscience involves the coming together of many different disciplines. Biology is needed to understand the mechanisms of the brain; psychology to understand what drives behaviour; physics and engineering to understand the high-tech devices we use; computer science to program the software and analyse the data; communication skills to write and talk about your findings in a compelling way. No one person can excel in all these disciplines, so we built a team that covers all these different skillsets.

## HOW DOES WORKING AS A COUPLE AFFECT YOUR WORK?

It can be lonely to be a leader of a team, with nobody telling you what to do and facing obstacles that have never been solved. Working

alongside your partner changes this. You share any pains or frustration and support each other. It also helps you question your own way of thinking and appreciate different approaches. Many scientific breakthroughs have been the result of close collaborations. For us, the privilege of working with a person you love makes every moment more rewarding, and our work more creative.

## WHAT ISSUES WILL THE NEXT GENERATION OF NEUROSCIENTISTS FACE?

It is an exciting time to be a neuroscientist. We now have many powerful tools to peek into the brain and see how its activity relates to our behaviour and our mind. The next great challenge is to master the many skills necessary to use these methods effectively, to have the creativity to invent new impactful experiments, and to have the insight to understand what the resultant data means. Neuroscience can give us the tools to help those with mental disorders and to unravel the mysteries of what makes us who we are.

## EXPLORE A CAREER IN NEUROSCIENCE

- Valeria and Christian suggest finding summer internships or finding a part-time research assistant position to see whether you enjoy working in laboratories. Explore the internship opportunities offered by the Netherlands Institute for Neuroscience: [nin.nl/search/internship/](http://nin.nl/search/internship/)
- Many neuroscience institutions provide outreach initiatives. The Netherlands Institute for Neuroscience has a yearly open day, holds talks in schools during science week and also allows school students to visit at certain times.
- According to PayScale, the average salary in the Netherlands for careers in neuroscience is around €38.5k.

## VALERIA AND CHRISTIAN'S TOP TIP

Be passionate about your choices. If you really love the thrill and purity of fundamental research and do not mind the grind of the daily fight against the unknown, you can make a significant contribution.

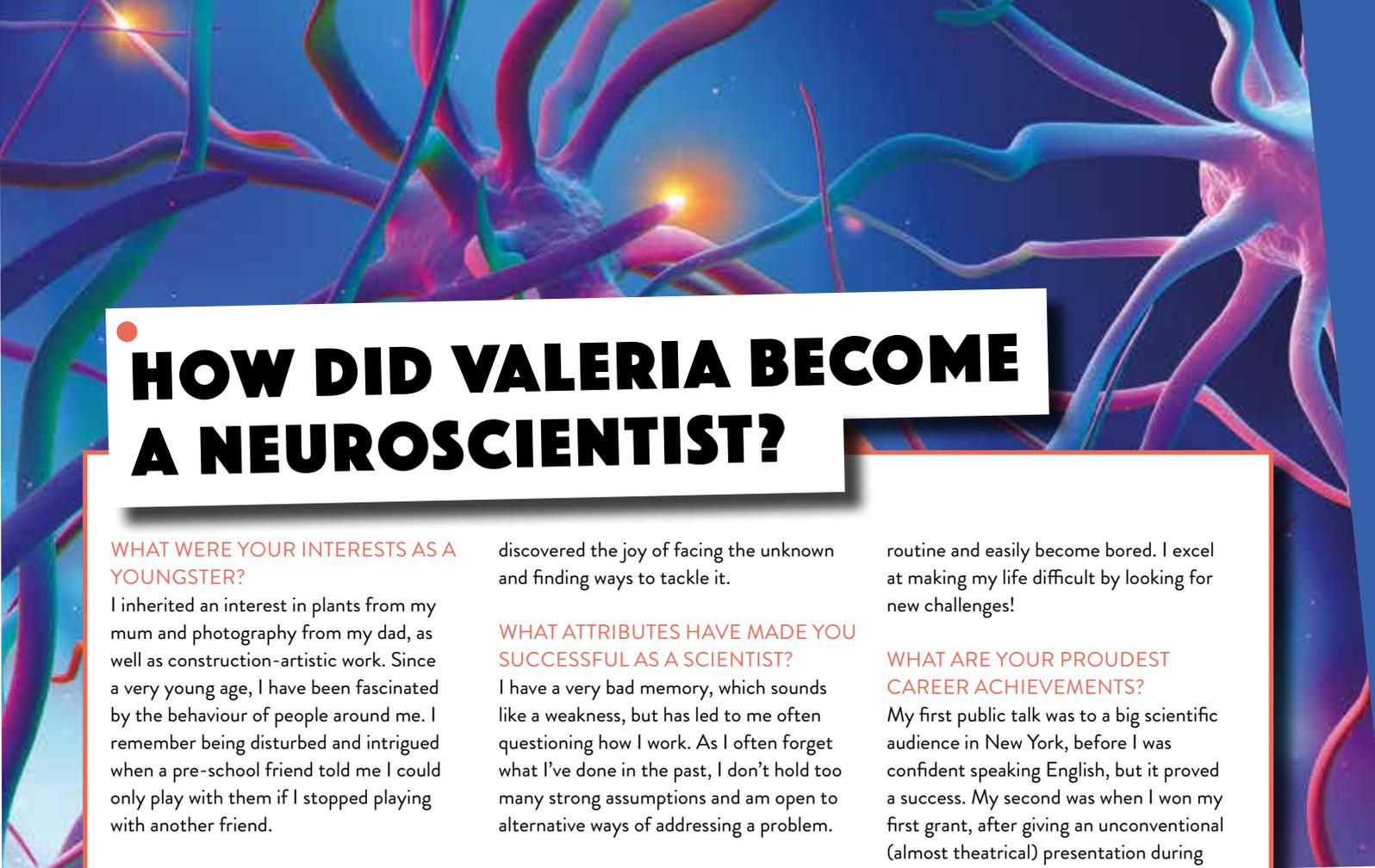
## PATHWAY FROM SCHOOL TO NEUROSCIENCE

Valeria and Christian recommend taking subjects like mathematics, physics, biology and philosophy at school and college, as well as English if it is not your first language.

At university, neuroscience can sometimes be a degree in itself, but there are many different possible approaches – it is a field that can be approached through subjects such as neurobiology, biology and psychology. Courses involving statistics, programming and linear algebra will also prove useful.



As a married couple, Christian and Valeria believe that working with each other is a real privilege and helps them be more creative.



## HOW DID VALERIA BECOME A NEUROSCIENTIST?

### WHAT WERE YOUR INTERESTS AS A YOUNGSTER?

I inherited an interest in plants from my mum and photography from my dad, as well as construction-artistic work. Since a very young age, I have been fascinated by the behaviour of people around me. I remember being disturbed and intrigued when a pre-school friend told me I could only play with them if I stopped playing with another friend.

### WHAT INSPIRED YOU TO BECOME A SCIENTIST?

The interest came progressively, once I started university. At first, I thought I would become a teacher, but over time I

discovered the joy of facing the unknown and finding ways to tackle it.

### WHAT ATTRIBUTES HAVE MADE YOU SUCCESSFUL AS A SCIENTIST?

I have a very bad memory, which sounds like a weakness, but has led to me often questioning how I work. As I often forget what I've done in the past, I don't hold too many strong assumptions and am open to alternative ways of addressing a problem.

### HOW DO YOU OVERCOME OBSTACLES IN YOUR WORK?

Obstacles are motivating, fascinating and eye-opening, and thinking of creative ways to overcome them is the fun part. I dislike

routine and easily become bored. I excel at making my life difficult by looking for new challenges!

### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS?

My first public talk was to a big scientific audience in New York, before I was confident speaking English, but it proved a success. My second was when I won my first grant, after giving an unconventional (almost theatrical) presentation during the selection process, against the advice of some colleagues. This showed me it is good to be daring sometimes.

## HOW DID CHRISTIAN BECOME A NEUROSCIENTIST?

### WHAT WERE YOUR INTERESTS AS A YOUNGSTER?

At school, I was drawn in equal measure to the way that philosophy dissects the big issues of the mind and to the way that science identifies natural laws through clever experimentation. In a way, these interests naturally combined into a passion for neuroscience.

### WHAT INSPIRED YOU TO BECOME A SCIENTIST?

Good teachers at school certainly helped, but my decision to go into neuroscience rather than the humanities came from reading the work of Eric Kandel, which broke down the learning process to the

level of individual synapses. The elegance of these studies showed me that we can indeed understand the mind by studying neurons.

### WHAT ATTRIBUTES HAVE MADE YOU SUCCESSFUL AS A SCIENTIST?

When I don't quite understand something, I home in on the issue relentlessly. This keeps me focused and resilient, and makes science very rewarding for me.

### HOW DO YOU OVERCOME OBSTACLES IN YOUR WORK?

I naturally enjoy the challenge of obstacles. I believe there is no shame in failing, only not trying, and that every failure presents

an opportunity to learn. Working alongside Valeria also helps immensely. It is also important to know when to cut your losses on a challenging problem – too early and you may miss out on a breakthrough, too late and you miss discovering something else.

### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS?

My proudest moments involve securing big grants, because they represent both the ultimate accolade from your peers and the beginning of an exciting new scientific journey.

# “DANCE HAS SHAPED MY PERSONALITY, FORCING ME TO BECOME MORE EXPRESSIVE, SOCIABLE, DISCIPLINED AND FIT.”

**AVO GUEDEKELIAN**, A MEDICAL STUDENT, DANCER, PHOTOGRAPHER AND VIDEOGRAPHER, REMINDS US OF THE VALUE OF BOTH THE SCIENCES AND THE ARTS, AND TO ZOOM IN ON WHAT MAKES US HAPPY AND FEEL FULFILLED



A self-portrait (@photogravoug)

## **YOU ARE THE FIRST IN YOUR FAMILY TO GO TO UNIVERSITY. WHAT CHALLENGES HAVE YOU HAD TO OVERCOME TO GET TO UNIVERSITY AND HOW DID YOU CONQUER THESE?**

I went to school in Lebanon, where university is not as accessible as it is in the United States. The majors you are eligible to choose are contingent on your high school grade average, which makes

the entire process costly and competitive. At that time, I was spending around five hours a day, four to five days a week, at my dance studio, which was affecting my academic studies. I thought university was out of my reach and was trying to find other avenues to find fulfilment.

When I moved to Los Angeles, I not only experienced endless opportunities but was also encouraged to attend university. Though I still loved dance, away from my Lebanese dance academy I had more freedom and decided to give the last two years of high school my best.

High school was administratively complicated for me. My transcripts were not being translated correctly, and I had to make up for a lot of classes I had already taken in Lebanon. I was also thrown into tests such as the SAT college admission test. Without the help of the Boys and Girls Club at my school, I would have not been able to apply to universities on time. It took a room full of volunteers and staff to put me on the right path.

## **WHEN DID YOU BECOME INTERESTED IN MEDICINE?**

I've always liked being in a social work environment, and I was interested in both the arts and the sciences at school. Medicine first caught my attention when I underwent a life-threatening surgical procedure at 8 years old. I felt so helpless and had lost hope in a successful outcome. The team of nurses, physicians and staff kept me positive during and after the surgery. I remember them cheering me on as I started walking again around the unit!

Studying medicine became a serious option when I volunteered at the UCLA Santa Monica Medical Center. I was at university studying biology and I interned as a care extender for three years. I rotated through

emergency medicine, paediatrics, labour and delivery, etc., which was fulfilling to say the least. I realised I had made the right decision to major in biology and complete the premed requirements [courses you need for medical school]. Feeling like I'm positively contributing to the team and patient care is something I can see myself doing for the rest of my career.

## **WHAT DO YOU HOPE TO DO WITH YOUR MEDICAL DEGREE?**

With my medical degree, I hope to be of service as an emergency physician and, later on, subspecialise in sports medicine. This subspeciality brings together my love for medicine and my background as a dancer and dance choreographer.

## **HOW LONG HAVE YOU BEEN DANCING?**

I began taking ballroom/Latin dance classes at the age of 7. Since then, dance has shaped my personality as it forced me to become more expressive, sociable, disciplined and fit.

## **YOU OFFER ONLINE DANCE TUTORIALS. WHY ARE YOU PASSIONATE ABOUT SHARING YOUR DANCE SKILLS WITH OTHERS?**

Yes, I do have a few free dance tutorials on my website and YouTube channel. At some point in my dance journey, I stumbled upon a few choreographers who were pioneering how we learn dance by uploading free tutorials online. I remember learning so much, from breakdancing to hip hop and popping in the comfort of my home. I wanted to do my part in advancing and expanding the accessibility of dance online.

## **VIDEOGRAPHY AND PHOTOGRAPHY ALSO FEATURE ON YOUR WEBSITE. WHAT SERVICES DO YOU OFFER?**

I work as a freelance photographer and videographer in Los Angeles and San Francisco, and offer professional photoshoots, photography for social media and events (such as graduation), and videography services for dancers and performers. I'm very happy with the progress I've been making in this space.

## **HOW DO YOU MANAGE YOUR TIME BETWEEN STUDYING MEDICINE, DANCING AND TAKING PROFESSIONAL PHOTOS/VIDEOS?**

If you don't take control of your time, it'll take control of you! We work or do tasks for a reason, whether it's for money, socialising, physical health, mental health, etc. The more purpose you can attach to a hobby, the more likely you are to satisfy all of your needs while doing something fun.

## ABOUT AVO

Avo has a BA in biology from California State University, Northridge, USA. He is currently studying medicine at Touro College of Medicine.

Website: [www.avoguedekelian.com](http://www.avoguedekelian.com)

YouTube: [www.youtube.com/c/AvoGuedekelian](https://www.youtube.com/c/AvoGuedekelian)

Instagram: [www.instagram.com/avoug](https://www.instagram.com/avoug)

Dancing, for example, helps me with my physical health and mental health, provides social opportunities, and money if I'm the one teaching a class. I don't have a full-time job because my income comes from photography/videography, and I rarely go out to party with friends since I already see them during dance classes. Additionally, I organise my days with Google calendar to make sure nothing overlaps. When classes begin at med school, I'll have to adapt and balance my needs and wants.

### OF YOUR FOUR INTERESTS (MEDICINE, DANCE, PHOTOGRAPHY, VIDEOGRAPHY), WHICH BRINGS YOU THE MOST JOY?

I think of these four interests as a vessel through which human connection is forged. Simply put, seeing a patient get better or having a friend tell me that a photograph I took of them helped them get the job both bring me joy.

### ARE YOU AIMING TO WORK IN BOTH MEDICINE AND THE ARTS OR WILL YOU VEER TOWARDS ONE OR THE OTHER OF THESE FIELDS?

Although my work in the arts always comes secondary to my academic career time-wise, I value both of the fields I'm in as much as each other. It will all come down to finding a healthy balance and coming up with proper time management strategies.

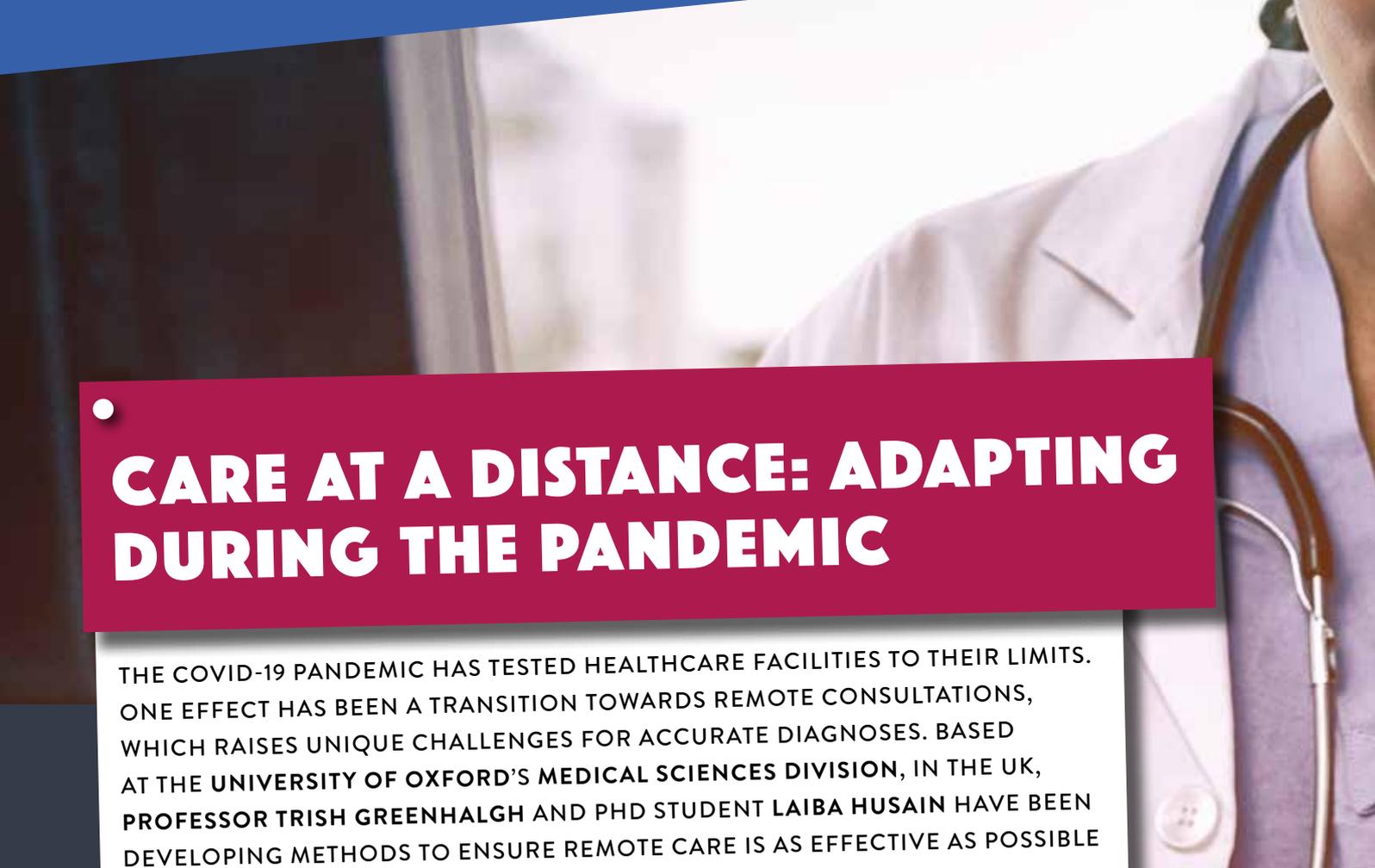
### WHAT HAS LIFE TAUGHT YOU SO FAR?

Life has taught me that our view of the world is skewed and even backward.

In a micro-world view, you celebrate your grades, degrees, awards and job opportunities, which are metrics by which others value you. Life has taught me to look at the bigger picture. In a macro-world view, you evaluate your happiness and fulfillment no matter what you're doing. That is what matters to you, and we should zoom out once in a while.

### FINALLY, WHAT ADVICE DO YOU HAVE FOR YOUNG PEOPLE WHO WOULD LIKE TO PURSUE CAREERS IN THE SCIENCES AND THE ARTS?

This is the time for you to experiment and explore various careers and interests. Take risks while you're young. Don't force yourself onto a path. If it's meant to happen, it will happen. All it takes is one elective/optional class in high school or college to alter a student's career choice, and even if it doesn't change your initial career goal, you will possess a unique perspective in your field. Steve Jobs sat through a calligraphy class in college, and although he didn't become an artist, his work with Apple benefited and was influenced by his unique perspective in the tech space.



# CARE AT A DISTANCE: ADAPTING DURING THE PANDEMIC

THE COVID-19 PANDEMIC HAS TESTED HEALTHCARE FACILITIES TO THEIR LIMITS. ONE EFFECT HAS BEEN A TRANSITION TOWARDS REMOTE CONSULTATIONS, WHICH RAISES UNIQUE CHALLENGES FOR ACCURATE DIAGNOSES. BASED AT THE UNIVERSITY OF OXFORD'S MEDICAL SCIENCES DIVISION, IN THE UK, PROFESSOR TRISH GREENHALGH AND PHD STUDENT LAIBA HUSAIN HAVE BEEN DEVELOPING METHODS TO ENSURE REMOTE CARE IS AS EFFECTIVE AS POSSIBLE

## GLOSSARY

**BAME** – Black, Asian, and minority ethnic groups

**MPH** – Master's of Public Health

**QUALITATIVE DATA** – non-numerical data – for example people's descriptions of their feelings

**QUANTITATIVE DATA** – numerical data, typically a measurement

**REMOTE-BY-DEFAULT CARE** – a form of medical care where the baseline point of contact is via phone, video or web portal

“Before the pandemic, very few people had phone or video consultations with their GP,” says Professor Trish Greenhalgh. “When the pandemic broke out, the high infection risk meant that GPs found themselves carrying out many more remote consultations.” Trish is Professor of Primary Care Health Sciences at the University of Oxford's Medical Sciences Division, and has been involved in both the academic and practical sides of healthcare. She has had her work cut out during the pandemic, helping the health service adapt to a rapidly changing situation by researching how to make their Remote-by-Default Care system as effective as possible.

## REMOTE CONSULTATIONS

“There are a number of challenges to remote consultations,” says Trish. “Firstly, they rely upon technology that may not work

100% of the time, depending on internet, signal, and the devices that patients and clinicians have available. It is also an unfamiliar format for many, leading to frustrations, misunderstandings and even giving up. Perhaps most importantly, it is impossible to undertake a full examination remotely, including for possible symptoms of COVID-19.” A physical examination for COVID-19 would involve taking a patient's temperature, pulse and blood pressure, looking into their mouth and throat, listening to their lungs using a stethoscope, and using an oximeter to estimate blood oxygen levels. “None of these things can be done easily via a remote connection,” says Trish.

This shift to remote consultations has had profound impacts for many patients, both those suffering from COVID-19 and from other

illnesses. This was especially apparent during the first wave of infections when COVID-19 symptoms were less well understood. “Some people who were very sick were misdiagnosed as only moderately sick, and some people who were only moderately sick were misdiagnosed as very sick – and then sent to hospital where they were potentially exposed to COVID-19 infection from others,” says Trish. “We don't know how many people were affected in these ways, but we do know the shortcomings of remote consultation had a role to play.”

## THE EARLY WARNING SCORE

In a study called RECAP (Remote COVID-19 Assessment in Primary Care), Trish has worked with other researchers to develop an ‘early warning score’ – a series of questions that GPs can ask to accurately identify seriously unwell patients and fast-track them for urgent assessment. “Questions cover the history of illness and symptoms, current symptoms, and some elements of physical examination or home tests that could be undertaken by the patient or someone else in the household,” says Trish. “Where kit wasn't available, we investigated whether self-reported answers would suffice – for instance, could a description of ‘feeling hot and shivery’ replace a thermometer reading to confirm a fever?”

The score used the latest research into the virus to work out what symptoms were most concerning. “We read a lot of scientific papers



that had been rapidly published in the early days of the pandemic to learn as much as we could,” says Trish. “For example, loss of smell is a strong predictor of COVID-19 infection, but is just as likely to happen in mild cases as serious cases. On the other hand, both aching muscles and drowsiness are seen much more commonly in serious cases.”

Trish’s team also interviewed over 100 people who had experienced COVID-19 infections, both mild and severe, to learn about their experiences of remote consultation. This included recounting what doctors had asked them, and also whether they felt their concerns over symptoms had been taken seriously. “We also interviewed about 70 frontline clinicians to get their experiences of performing remote consultations,” says Trish. “They helped us draft a list of severity indicators, which we refined through online discussion. After a few weeks, we had produced a 10-item score which we then went on to validate.”

### NUMBERS AND WORDS

One main impact of shifting to remote consultation is that quantitative data – such as readings from thermometers or oximeters – became a lot more difficult to collect. Instead, GPs relied more on patients’ subjective accounts of their symptoms. Qualitative data is often treated with mistrust in the hard sciences, but Trish wanted to see whether particular words and expressions might accurately distinguish between mild and severe cases.

“We found that questions such as ‘How breathless are you feeling compared to yesterday?’ seemed to be as accurate – and possibly more accurate – in identifying serious illness than so-called ‘objective’ measurements such as respiratory rate,” she says. “This was because open-ended questions drew rich descriptions of how the illness was affecting people, and experienced doctors could identify ‘red flags’ within these descriptions that would be missed by one-off measurements.” Her team drew from a wide pool of experience to ensure questions were worded in such a way that

they could be understood by people of different ages and ethnic backgrounds.

However, while this qualitative data is undeniably useful for individual diagnoses, it is still difficult to process on a large scale. Trish’s team had to find a way to convert it to quantitative data so it could be a useful part of national or international datasets. “Each response to our 10-item score is coded,” says Trish. “For instance, responses to do with change in breathlessness may be categorised as ‘same or better than yesterday’, ‘worse than yesterday’, or ‘significant deterioration in the last hour’, each of which is assigned a different code.”

### DATA LINKAGE

Once the responses of several thousand patients have been coded in this way, they start to form useful datasets for spotting trends. “We use data linkage to see how these codes correlate with key outcomes we’re interested in: hospital admission, intensive care unit admission, and death within 28 days,” says Trish.

This is not necessarily a straightforward task, given that personal data is dispersed around several different systems. “GP medical records contain data on consultations and medication, but they are separate from hospital records,” says Trish. “Similarly, deaths may be recorded separately if they don’t take place in a hospital.” Fortunately, these datasets can all be linked, for example by a patient’s NHS number, so that if the same NHS number can be identified in the different datasets, then the records should link to the same person.

However, there is another catch. “Medical information is highly sensitive, and is rightly covered by data protection laws,” says Trish. “This means that compiling the datasets involves a lot of legal permissions, and special care to ensure no patient within the dataset can be identified with their name. But once these hurdles are cleared, we can get a clearer idea of how particular symptoms are linked to outcomes.”

### BEYOND THE PANDEMIC

What comes next for healthcare in the UK?



### PROFESSOR TRISH GREENHALGH

Professor of Primary Care Health Sciences, Medical Sciences Division, University of Oxford, UK

### FIELD OF RESEARCH

Academic Primary Health Care

### RESEARCH PROJECT

Addressing the challenges surrounding the radical new service model of remote care in the COVID-19 pandemic

### FUNDERS

UK Research and Innovation, Health Foundation, Wellcome Trust, Medical Research Council, National Institute for Health Research, Scottish Government, Department of Health

Trish is interested in the role of an ‘integrated care dashboard’, which could streamline patient care. “The dashboard summarises both a patient’s health record (including GP and hospital data) and their social care record (such as level of vulnerability),” she says. “This means GPs will be able to give more informed consultations, and means that any people at risk of a particular disease can be offered proactive checks. Hopefully, it will encourage coordination of care across all professionals involved.”

The pandemic has had a deep impact on society, highlighting both the strengths and vulnerabilities of healthcare systems around the world. “Some NHS staff would say the pandemic revealed the lack of resilience in the NHS, in terms of underfunding, understaffing, and lack of capacity,” says Trish. “However, I also think the pandemic brought about the best in the NHS, with frontline teams pulling together and solving local problems with creativity and courage. One important insight is that decision-making works best if it is in the hands of the people closest to the problem, which is a lesson for both policymakers and healthcare professionals at every level.”

# ABOUT ACADEMIC PRIMARY HEALTH CARE

*Primary health care covers the first point of contact for healthcare. GPs are the best-known example of this, helping to diagnose patients and propose solutions such as prescriptions or referral to hospital departments. Academic primary health care involves studying how to make this process as effective as possible, using evidence from research to propose changes to the ways that primary health care is undertaken. Trish explains more about the field and her role.*

**Almost all medically-qualified professors split their time between working in the NHS and in their academic role.** I used to work two days a week as a GP and three in the university, though I later cut down to one

day a week as a GP as my university job was very demanding. A few years ago, I dropped the clinical aspects of my job entirely, as my university research and teaching responsibilities expanded.

**People often debate whether medicine is a science or an art, but I believe it's best defined as a professional practice** - just like law or social work. Like any professional practice, our duty is to do what's best for the patient or client, while maintaining confidentiality and drawing on science and other relevant evidence when needed. So, for instance, for an acutely unwell patient, science is needed to diagnose and treat the ailment, but compassion and respect for

autonomy are needed to ensure the patient receives the best care they can. There is no conflict here – both science and art are equally vital.

**If you have a high level of scientific curiosity and enjoy discovering answers, you may be cut out for research.** While reading this article, did you find the ideas of diagnostic tools and data linkage interesting? Can you come up with any of your own ideas for improving assessment of patients, or consider any other scientific questions that could be answered through data linkage? If so, academic primary care could be for you.

## EXPLORE A CAREER IN ACADEMIC PRIMARY HEALTH CARE

- Medicine is the most obvious subject to study at university to pursue a career in academic primary health care. A good understanding of the health service and the science behind it will be necessary for such a career.
- Relevant work experience is often essential when applying to a medicine-based degree. The Medical Schools Council has some useful tips for getting started in this space: [www.medschools.ac.uk/studying-medicine/making-an-application/work-experience](http://www.medschools.ac.uk/studying-medicine/making-an-application/work-experience)
- Salaries for careers in medicine can vary substantially but are generally quite well-paid. The British Medical Association has more information: [www.bma.org.uk/pay-and-contracts/pay/other-doctors-pay-scales/medical-academics-pay-scales](http://www.bma.org.uk/pay-and-contracts/pay/other-doctors-pay-scales/medical-academics-pay-scales)

## PATHWAY FROM SCHOOL TO ACADEMIC PRIMARY CARE

Trish says to see what particular medical schools require at A-Level (typically biology, chemistry, and maths and/or physics). She emphasises the importance of getting involved in research projects once at university – she says academic recruiters pay more attention to these research experiences than to the specific choice of A-level subjects. Once you have your medical degree, you'll need to do a PhD before being ready to lead your own research study.

These can be done part-time while also pursuing your clinical training.

For those who prefer not to train as a doctor first, Laiba (Trish's research assistant who you will meet on the following pages) recommends an undergraduate degree in one of the human sciences (such as psychology or sociology) and then seeking university master's courses with a clear research component where you would learn qualitative methods (such as how to conduct interviews with people) and quantitative research methods (such as how to analyse datasets using statistics).

Laiba did a psychology and neuroscience bachelor's and a public health master's. Her route illustrates how people without a medical degree can build a career in a health-related subject with a view to going on to lead research in that field.



## HOW DID TRISH BECOME A GP AND PRIMARY HEALTH CARE ACADEMIC?

### WHAT WERE YOUR INTERESTS WHEN YOU WERE GROWING UP?

I did a lot of sport. I swam, played hockey, and ran cross-country. I was also in the St John Ambulance Brigade and the Royal Life Saving Society, which were excellent preparation for medical school. I still love sport, and after university I was briefly in the UK Ironman triathlon team. Sport was a great relaxation for me when studying hard for exams, which you have to do to succeed in medicine. It also taught me self-discipline and the value of teamwork. You don't have to be good at sport to get into medical school – other leisure activities which prepare you well include music, drama or being on a school council.

### WHAT INSPIRED YOU TO BECOME A GP?

A patient. I initially trained as a hospital doctor, specialising in diabetes. One patient, who I had helped with some tough challenges in her life, turned to me and said, "I wish you were my GP." That made me realise that I wanted to care for all aspects of people's health, not just diabetes.

### HAVE YOU HAD ANY EUREKA MOMENTS IN YOUR CAREER?

There have been few eureka moments. It's a bit like motherhood – on a day-to-day basis it feels like slow progress, but when you look back at what you've created, be it a well-adjusted child or a life-saving research programme, you see it's worth the grind.

### HOW DO YOU SWITCH OFF FROM YOUR WORK?

I never go a day without exercise. I begin each day at 6am with 40 minutes of yoga and stretching. I am also a wild swimmer, plunging into the Thames all year round. With a husband and two grown-up children, I make sure I enjoy family life, as well as academia and medicine!

### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS SO FAR?

In 2001, I received an OBE for Services to Medicine from the Queen. I also think I played a part in persuading UK policymakers to introduce mask mandates during the pandemic, which have probably saved many lives.

## TRISH'S TOP TIPS

- 01** Get involved in a small research project as soon as you can when you start university. Look out for opportunities!
- 02** Be curious. Science is not all about taking measurements and analysing data. It's also about having the imagination to work out what to measure and what to analyse, and why.
- 03** If you are seriously considering a career in research, choose a research-oriented university. This could be any of the 'golden triangle' (Cambridge, Oxford, and London), but a lot of excellent research is also happening at other universities, such as Edinburgh, Manchester, Leeds, Sheffield, Birmingham and Newcastle. Ask about research opportunities at your interview.



# LAIBA HUSAIN

LAIBA HUSAIN IS A PHD STUDENT WHO WORKS CLOSELY WITH TRISH. SHE EXPLAINS HER ROLE IN THE REMOTE-BY-DEFAULT CARE PROJECT, HOW IT TIES IN WITH HER PHD, AND THE PATH SHE HAS TAKEN TO REACH THIS POINT.

## WHAT IS YOUR ROLE IN THIS RESEARCH PROJECT?

I've been able to take on a lot of roles as research assistant to Professor Trish Greenhalgh. I have conducted interviews and facilitated virtual discussion groups with people who have had long COVID, and led a design project to create resources for patients. I have also been involved with the RECAP (Remote COVID-19 Assessment in Primary Care) study to develop the tool for identification of COVID-19 patients who are at higher risk of poor outcome.

## WHAT LED YOU TO THIS PROJECT?

Before moving to the UK, I was involved in community engagement projects with incoming Syrian refugees back home in Michigan, USA. I really enjoyed this work and was passionate about continuing it when I moved. Once I had started my Fulbright Scholarship here in the UK, I began research into qualitatively exploring trust in healthcare within UK refugee and migrant populations. I realised how valuable it is to work with vulnerable populations on their healthcare needs, especially if research can help those populations who don't have a voice of their own. After graduating, I worked with an autism charity to research ways of using video technology to diagnose autism. When I began working with Trish on the Remote-by-Default Care project, I was able to further explore this

interaction of vulnerable populations and digital inclusion, and here we are now!

## WHAT DOES YOUR PHD COVER?

My research question is: What are the barriers to remote consultations for those with low uptake (especially BAME, low-income, and older people), and how can we work in partnership with patients and the public to help overcome these? I aim to identify, and develop methods to overcome, patient-level inequities in scaling up virtual consultations, focusing on those groups who have shown the most limited uptake of video consultation services.

## HOW DOES YOUR PHD TIE IN TO THE REMOTE-BY-DEFAULT CARE PROJECT?

The pandemic has shown the usefulness of remote consultations to deliver care, but for them to be truly effective, they need to be a routinely used part of our health system. Remote consultations can be very different to in-person consultations, so there is a need to monitor and support adoption of this technology by patients as part of the implementation process. It is worth noting that COVID-19 has had a disproportionate impact on the elderly, the poor, and those from BAME groups. Ironically, these are also the groups who, overall, are least able to effectively access digital consultations. My PhD aims to produce a rich and detailed understanding

of the barriers they face, and how they can be overcome, to ensure effective and equitable care for all.

## WHAT CHALLENGES DOES THIS RESEARCH POSE FOR YOU?

We've been organising structured sessions to address the challenges faced by clinicians and service providers when using video consultation platforms. These platforms have been successful within small-scale pilot projects, but the routine use of video consultations nationwide remains limited. This is because they bring in major changes to the nature of care, such as changes to workflows for clinicians and new barriers for patients, especially those with lower digital capabilities. These sessions have given me an in-depth understanding of the challenges involved in scaling up, and the barriers to patient adoption.

## HOW HAVE YOU FOUND BEGINNING A PHD IN A PANDEMIC?

Being a PhD student involves a lot of independent study and work, and this has been amplified by the pandemic. I've learned to adapt and find it really helpful to maintain a routine and study schedule at home. I have my own study space and schedule breaks to get some exercise and fresh air, which makes all the difference.

## ABOUT PUBLIC HEALTH RESEARCH

*Public health research covers anything that affects the health of populations. This can be purely biological, such as genetics; environmental, such as air quality; or social, such as equity and accessibility. Research findings can be used to provide evidence for changes to policy, to improve population health and well-being. Laiba explains more.*

**A career in research can be challenging.** We are constantly made to question our assumptions and produce new outputs. However, the collaborative nature of research also broadens your mind, connecting you to people who help your research develop in unforeseen ways. A research career is quite holistic, involving adaptation, curiosity, and teamwork skills.

**Research is also a rewarding career,** as you are able to try out new ideas, experiment with cutting-edge technology, and take part in engaging discussions. I am proud to be part of a network that is working to improve people's lives.

**I recommend starting early to prepare for a career in public health research.** Look for local volunteer work, involvement in non-profit organisations, and public health internships. This will give you a better sense of what a career in the field could entail. Some university courses offer a semester abroad in a global health programme, which can be a great way to gain an international perspective.



### LAIBA HUSAIN

PhD Student and Research Assistant, Nuffield Department of Primary Care Health Services, Medical Sciences Division, University of Oxford, UK

### FIELD OF RESEARCH

Public Health, Qualitative Research

### RESEARCH PROJECT

Understanding barriers to remote consultations for vulnerable groups, and how they can be overcome

### FUNDERS

THIS Institute (The Healthcare Improvement Studies Institute), National Institute for Health Research

## HOW DID LAIBA BECOME A PUBLIC HEALTH RESEARCHER?

### WHAT WERE YOUR INTERESTS WHEN YOU WERE GROWING UP?

I loved to read! I still try to find time to read now. When I was younger, I would practically live in the library.

### WHAT INSPIRED YOU TO BECOME A RESEARCHER?

My mentor (and now PhD supervisor) Trish Greenhalgh has been my main inspiration. She is absolutely brilliant and watching her in action daily has exemplified what it means to be a successful researcher and an amazing woman. I can only dream of being at her level one day!

### WHAT ATTRIBUTES HELP MAKE YOU SUCCESSFUL AS A RESEARCHER?

I think my curious nature and focused work ethic have played a big part. Resourcefulness,

tenacity and strong attention to detail are also worthwhile traits.

### HOW DO YOU SWITCH OFF FROM YOUR WORK?

I love art – I paint, crochet, and do design work in my free time. This creative outlet helps me relax and unwind.

### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS SO FAR?

I was proud to receive the THIS Institute Fellowship Award to do my PhD at Oxford! Another great moment was being awarded the US-UK Fulbright Scholar Award to conduct public health research and do my MPH abroad. Also up there is when I gave a talk on BBC Four Thought on the empowerment of Muslim women.

### WHAT ARE YOUR GOALS AFTER YOU HAVE COMPLETED YOUR PHD?

I plan to do a post-doctoral fellowship and ultimately work my way up to professorship.

### LAIBA'S TOP TIP

Always be open to new opportunities! Your university years will be a great time to step outside of your comfort zone and explore various fields outside of the classroom setting. Become a student researcher, get involved in student-run campus organisations, and don't be afraid to ask professors and lecturers for advice.

# HOW POVERTY CONTRIBUTES TO ANTIMICROBIAL RESISTANCE

OVERUSE OF ANTIMICROBIAL DRUGS CREATES DANGEROUS RESISTANT STRAINS OF MICROORGANISMS. YET IN SOME PLACES OF THE WORLD TODAY, IT IS IMPOSSIBLE TO GET BY WITHOUT THEM. MEDICAL ANTHROPOLOGISTS PROFESSOR CLARE CHANDLER AND SUSAN NAYIGA, OF THE LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE IN THE UK, STUDY HOW CONDITIONS IN UGANDA FORCE RESIDENTS TO RELY ON ANTIBIOTICS ON A DAILY BASIS

## TALK LIKE A MEDICAL ANTHROPOLOGIST

**ANTIMICROBIAL DRUGS** – drugs that kill or suppress the growth of bacteria, fungi, viruses and other microorganisms in or on the human body, other animals or plants

**ANTIBIOTICS** – a type of antimicrobial drug that kills or suppresses the growth of bacteria

**ANTIMICROBIAL RESISTANCE (AMR)** – the ability of microorganisms to survive antimicrobial drugs due to evolutionary adaptations gained through repeated exposure to these drugs

**MULTIMORBIDITY** – multiple conditions that combine to create ill-health

**PARTICIPANT OBSERVATION** – an anthropological data collection method in which researchers join in with the activities of the people they are studying in order to observe through experience

**‘ONE HEALTH’ APPROACH** – an approach to health that combines diverse academic disciplines and considers animals, plants and the environment as well as humans

Antibiotics have transformed human life. Infections that once killed millions can now be cured by taking a few tablets. Yet this miraculous technology contains the seeds of its own destruction – the more we use antimicrobial drugs, the more microorganisms evolve, adapt and become resistant to them. Overuse of antimicrobials can breed dangerous ‘superbugs’ immune to any treatment. As a result, the United Nations considers antimicrobial resistance (AMR) to be a global high priority health issue and recommends reducing antimicrobial drug use.

But why do we overuse antibiotics, and why is it difficult to stop overusing them? With the Antimicrobials in Society (AMIS) project, Professor Clare Chandler and PhD researcher Susan Nayiga of the London School of Hygiene and Tropical Medicine are studying antibiotic use in rural and urban Uganda, highlighting the

difficult choices local people face when it comes to health and work.

### THE PROBLEM OF ANTIMICROBIAL OVERUSE

Antimicrobial drugs have many important uses. They cure and prevent infections in humans, animals and even crops. However, they have come to be used in cases beyond the strictly medically necessary. For example, people might use them to increase livestock productivity and as a quick fix to stop infections, rather than avoiding infections in the first place through better hygiene and sanitation infrastructure.

As human use of antimicrobials has increased, microorganisms have adapted and evolved to become resistant to these drugs. “It has been estimated that by 2050, 10 million lives a year could be lost due to drug-resistant infections,”

says Clare. The problem is a global one, as resistant strains bred in one small region can quickly travel around the world thanks to the interconnectedness of modern life and the world economy.

But reducing antimicrobial use is easier said than done. Many people have good reasons to rely on antibiotics in the short term, even if doing so increases the risk of superbugs in the long term. Medical anthropologists like Clare and Susan study how people interact with medicines. They use their research findings to help policy-makers develop policies that allow people to live with less reliance on antimicrobial drugs.

### ANTHROPOLOGICAL METHODS

To study antibiotic use in rural and urban Uganda, Clare, Susan and the AMIS team used a method called ‘participant observation’. They spent extended periods of time living with the communities they were studying, getting to know how things are done and what day-to-day life is like, immersing themselves in the local culture to understand the rules, the local community’s idea of common sense, and how people respond to challenges within their cultural context.

They also used surveys and ‘medicine bags’ to discover how people interact with antibiotics. “Rather than asking ‘do you use antibiotics?’ which might be interpreted differently by different people, we showed people packets of locally available antibiotics,” explains Susan. “We asked them to sort them into piles of medicines they recognised, medicines they used frequently and medicines they don’t know. This helped us to understand the significance of medicines in people’s lives.”

In addition to gathering data from communities, Susan and Clare put what they learnt into historical and political context. By examining past policy documents and evaluation reports, they were able to trace the influence of different local, national and international programmes and policies that had attempted to improve the health of particular populations. “Our analysis pulled together different threads of research, weaving together narratives that could describe and explain what we were seeing about antibiotic use in everyday lives,” says Susan. This approach helped them understand why people use certain medicines and why they must rely on antibiotics instead of avoiding infections through hygiene and infrastructure.

#### ISSUES IN RURAL AND URBAN UGANDAN COMMUNITIES

Clare and Susan investigated antimicrobial use in two communities in Uganda. Nagongera is a rural village in Tororo District, while Namuwongo is an informal settlement (also called a ‘slum’) in Kampala, the capital of Uganda. In both communities, residents struggle with food poverty and access to clean water and public health infrastructure.

In Nagongera, water is available from wells and boreholes. The boreholes are a source of clean water, but the monthly access fee is more than many residents can afford. Instead, they must collect drinking water from wells that are contaminated by animals and potentially human waste. People in Namuwongo also lack reliable access to safe water, as water sources become contaminated during the rainy season.

In both communities, most households do not have access to a private latrine. Public toilets are available in the urban settlement of Namuwongo, but they are expensive to use and are closed at night. As a result, people are forced to use bushes, buckets and polythene bags as toilets. Residents are warned by public health campaigns to boil water before using it for cooking or drinking, but they do not always have the money for fuel or the time to boil water for multiple uses throughout the day.

Lack of clean water and sanitary facilities leads to diarrhoea and water-borne diseases. Although residents know why they are getting sick, they

do not have the money to access facilities or the power to demand better infrastructure. They deal with poor health caused by lack of sanitation by taking small doses of antibiotics, sometimes forgoing food in favour of medicine. Residents must remain well enough to work or they will be unable to afford basics like food.

Susan recounts that “in Kampala diarrhoea was common and there was frequent use of antibiotics in anticipation of diarrhoea almost every week.” This level of antimicrobial use contributes to AMR, but simply targeting antibiotic use reduction fails to address the root causes of overuse in these communities – poverty and lack of access to hygienic facilities. Policy-makers in local, national and international governments must address these infrastructural issues in order to reduce the risks from AMR.

#### HOW LINKING POVERTY TO ANTIBIOTIC USE IN UGANDA CAN HELP PREVENT GLOBAL SUPERBUGS

Clare and Susan hope that their research will help global policy-makers address the causes of antimicrobial overuse. “We have promoted the concept that antibiotics are ‘infrastructural’, meaning that they are not only a part of the fabric of our health systems but also our societies,” says Clare.

Awareness of why people overuse antibiotics highlights how merely restricting the use of these drugs is unlikely to be effective and will in fact harm struggling communities. Instead, providing access to clean water and public latrines in communities such as Nagongera and Namuwongo would make constant use of antibiotics unnecessary, improve public health and quality of life in these communities and lower medical costs for residents. Not only that, but antibiotic use in Uganda is a global problem, not a local one, as drug-resistant microbes can quickly spread across the world. That makes poverty and lack of public health infrastructure in Ugandan slums a global problem, too.

Clare and Susan’s research highlights the important contributions medical anthropology can make on many levels. Advances in medical technology are not enough to solve global public health issues because medicines are used by people and distributed by human political and



#### PROFESSOR CLARE CHANDLER

Professor in Medical Anthropology  
London School of Hygiene and Tropical  
Medicine, UK



#### SUSAN NAYIGA

PhD student, London School of Hygiene  
and Tropical Medicine, UK  
Researcher, Infectious Diseases Research  
Collaboration, Kampala, Uganda

#### FIELD OF RESEARCH

Medical Anthropology

#### RESEARCH PROJECT

Understanding how rural and urban  
communities in Uganda interact with  
antibiotics as a foundation for tackling  
global antimicrobial resistance

#### FUNDERS

ESRC, DHSC, GCRF  
*The Antimicrobials in Society (AMIS) grant was awarded by the Economic and Social Research Council (ESRC) on behalf of the Antimicrobial Resistance Cross Council Initiative supported by the seven research councils of UK Research Innovation (UKRI) in partnership with other funders [ES/P008100/1]*

economic systems. Medical anthropologists forge links between these different domains, allowing holistic solutions to be found in a ‘one health’ approach that help to solve pressing, real-world problems that affect us all.

# ABOUT MEDICAL ANTHROPOLOGY

## WHAT IS MEDICAL ANTHROPOLOGY?

Medical anthropology is a branch of anthropology – the study of humans, and how humans live together in the world. Medical anthropologists study health, illness and medical systems. This includes the social processes, rituals and meanings around health and illness, western and traditional medicines, different medical systems, and death and dying.

## WHY DO WE NEED MEDICAL ANTHROPOLOGY?

The health of people around the world continues to face challenges, with many infectious diseases that take a serious toll on peoples' lives – including drug resistant infections. Ageing populations, urbanisation

and migration lead to an increase in multimorbidity, with multiple conditions combining to create ill-health. Medical anthropology has been critical in informing understanding of the conditions and drivers of both infectious and chronic diseases. It has been instrumental in directing preventative action as well as responding to epidemics and longer-term health crises. The ability to link social, economic and political dimensions to distributions, conditions and experiences of ill health is critical in informing understandings and responses. Anthropologists are now commonly involved in health planning, health systems and health response teams on both national and international stages.

## WHAT DOES THE FUTURE HOLD FOR MEDICAL ANTHROPOLOGISTS?

There is growing interest in medical anthropology due to recent events like the COVID-19 and Ebola crises, the growth of the anti-vaccination movement and the threat of antimicrobial resistance. "This means anthropologists are having to find ways to communicate about their research more with the general public as well as with people working in decision making positions," says Clare. "Future generations will advance our methodological toolkits to address changes in anthropology and to enhance the ways that we come to know and communicate about topics of study."

## EXPLORE A CAREER IN MEDICAL ANTHROPOLOGY

The Royal Anthropological Institute has great learning resources and events for people interested in a career in anthropology: [www.discoveranthropology.org.uk](http://www.discoveranthropology.org.uk)

Medical anthropologists may work in academic institutions conducting research, like Clare and Susan. There are also career opportunities in industry and the public sector, for example as health care consultants, health policy analysts or health services directors.

## PATHWAY FROM SCHOOL TO MEDICAL ANTHROPOLOGIST

"At school and college, any of your subjects will help towards learning about anthropology later on," says Clare. "At university you can study straight anthropology, or with archaeology or human sciences." Specialisation in medical anthropology will usually occur at postgraduate level.

## CLARE AND SUSAN'S TOP TIPS

**CLARE:** Follow your passions and make it count! Work hard, with focus, and forge your own path.

**SUSAN:** Work on your dream every day. With hard work and perseverance, you will achieve it.

A homestead in Tororo district



## HOW DID CLARE BECOME A MEDICAL ANTHROPOLOGIST?

**When I was younger I was interested in why people lived differently in different places.** I was fortunate to spend time in West Africa as a child and was fascinated by the comparison between life in rural Sierra Leone compared with life in a cosmopolitan area of England. I was struck by the ways that histories of different places meant that life, values, political priorities and health could be so different depending on where you lived.

**I didn't deliberately become a researcher** – I didn't plan it, and I'm rather surprised to find myself as a university professor! The way I think was inspired by my father, who was an engineer working on rural telecommunication systems, and I liked his methodical approach to working out problems. I was more interested in people than technology and went on to study anthropology.

**I love music** – I play violin and enjoy singing,

and I enjoy walking and cycling. But most of my out-of-work time is spent with my children who continue to inspire me!

**I was really proud to be awarded the Woodruff Medal for my PhD.** It is awarded each year to someone whose thesis has an impact on medicine. I was really pleased my research was recognised in this way, especially as I was an anthropologist rather than a medic.

## HOW DID SUSAN BECOME A SOCIAL SCIENTIST?

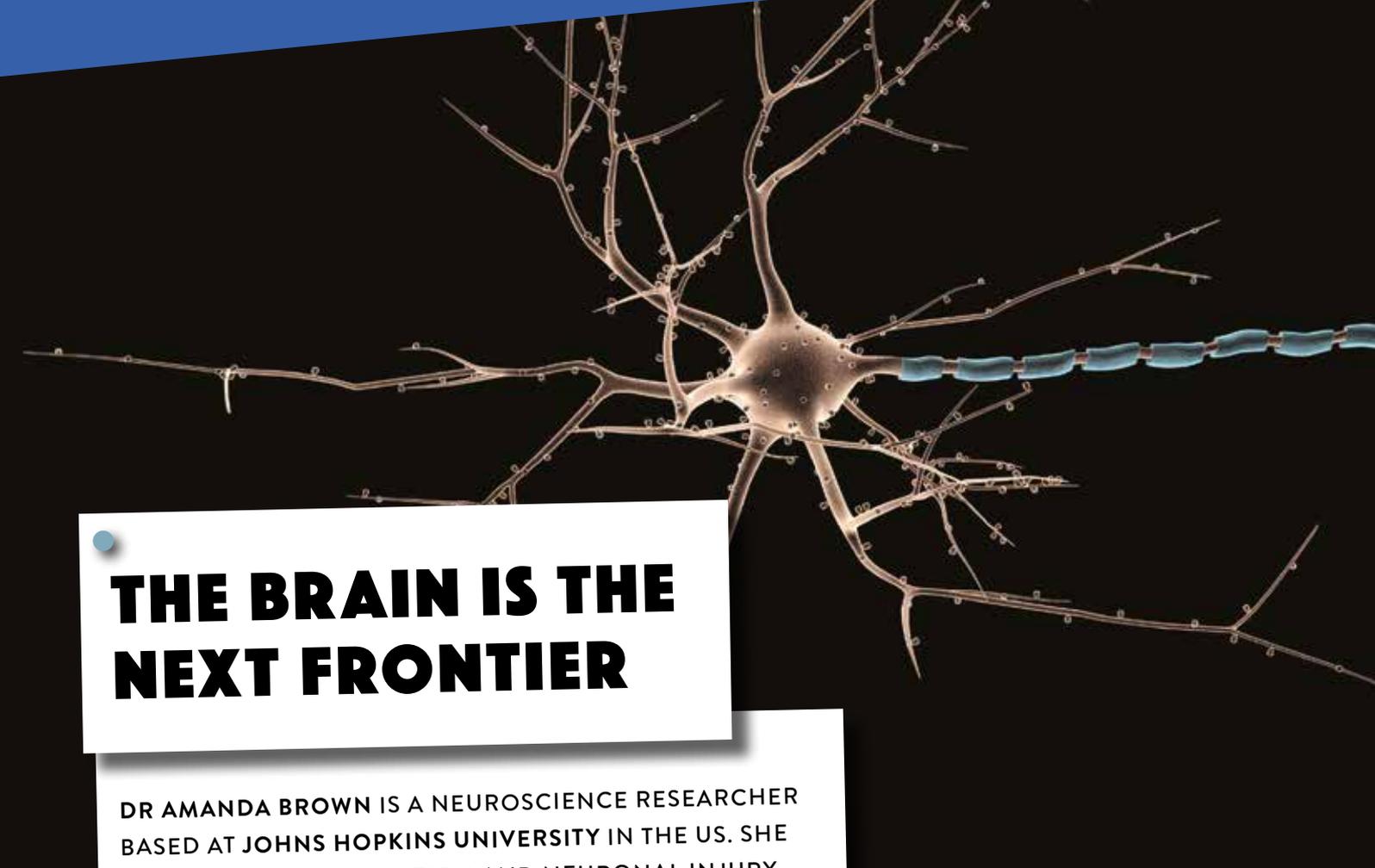
**When I was younger I was interested in people that were vulnerable and I aspired to give a voice to those who were oppressed.** I spent my early life in Eldoret, Kenya, during the 1980s due to civil war in my home country, Uganda. As a child, listening to the stories told by my parents about the suffering of relatives and friends back home, I was fascinated by their stories about life, survival and escape.

**My journey as a researcher started when**

**I was offered a government scholarship to study social sciences at university.** I had the opportunity to be part of research teams which played a big role in shaping my interest in social aspects of community healthcare. It was most exciting to get a job with a malaria research project after leaving university, which marked the beginning of my career as a social scientist.

**I enjoy playing golf** and spend most of my free time doing that.

**I was proud to attain a PhD scholarship at the London School of Hygiene and Tropical Medicine.** The field is dominated by medical scientists so I never imagined that, as a social scientist, I would be considered for such an opportunity. I was proud to be the first social scientist in my organisation to be offered this scholarship. After, I hope to join an academic institution to engage in teaching and continue to conduct social science research.



# THE BRAIN IS THE NEXT FRONTIER

DR AMANDA BROWN IS A NEUROSCIENCE RESEARCHER BASED AT JOHNS HOPKINS UNIVERSITY IN THE US. SHE IS STUDYING INFLAMMATION AND NEURONAL INJURY IN THE BRAIN, PARTICULARLY THAT CAUSED BY HIV-ASSOCIATED DISORDERS. THE FINDINGS COULD LEAD TO THE DEVELOPMENT OF NEW AND BETTER TREATMENTS

## TALK LIKE A NEUROSCIENCE RESEARCHER

**HIV** – a virus that damages the cells in your immune system and weakens your ability to fight everyday infections and disease

**HIV-ASSOCIATED NEUROCOGNITIVE DISORDER (HAND)** – a syndrome of progressive deterioration of memory, cognition, behaviour and motor function in HIV-infected individuals that can range from mild to severe with extensive immunodeficiency

**OSTEOPONTIN** – a protein that is implicated in the pathogenesis of a variety of disease states, including several chronic inflammatory diseases

**ANTI-RETROVIRAL THERAPY (ART)** – any HIV treatment that uses a combination of two or more drugs

**INFLAMMATION** – the body's process of fighting against things that harm it, such as infections, injuries and toxins, in an attempt to heal itself

**CENTRAL NERVOUS SYSTEM** – a system consisting of the brain and spinal cord. It is referred to as 'central' because it combines information from the entire body and coordinates activity across the whole organism

**MICROGLIA** – a type of neuroglia (glial cell) located throughout the brain and spinal cord

**MACROPHAGES** – specialised cells involved in the detection, phagocytosis and destruction of bacteria and other harmful organisms

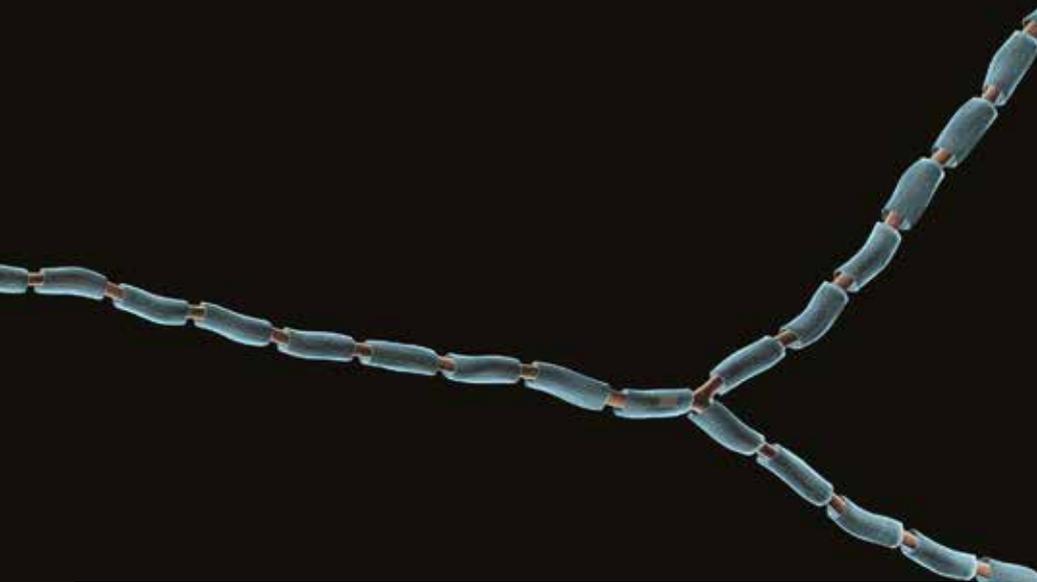
**PHAGOCYTOSIS** – the process by which a cell ingests other cells

HIV (human immunodeficiency virus) is a virus that, over time, damages the cells in your immune system. Eventually, it weakens a patient's ability to fight everyday infections and disease, which can result in death. There is currently no cure for HIV, but improved understanding has led to better treatments, the result of which has been HIV patients living near-normal lifespans.

Early diagnosis is extremely important in ensuring that HIV patients live long and fruitful lives. However, even at an early stage, HIV is able to enter the brain and cause damage that disrupts the proper neural function of a patient. Dr Amanda Brown is a neuroscience researcher who is working on improving our understanding of the precise mechanisms involved in HIV-associated neurocognitive disorder (HAND). Based at Johns Hopkins

University in the US, Amanda started out studying microbiology and immunology, before moving across to neuroscience research.

The starting point for Amanda's research was to ascertain the significance of HIV entering the brain at an early stage. "Research using different experimental models suggests that the protective and basic functions of the blood-brain-barrier are compromised during



infection. In this context, HIV particles and infected immune cells from the blood gain entry into the brain at a higher frequency,” explains Amanda. “The impact of this is significant because the major cell type in which the virus replicates are microglia. Microglia have a relatively long lifespan and are replaced by new ones on the order of months to years. In addition, HIV replication in microglia does not result in their immediate death. This means that HIV-infected microglia can reside in the brain, act as a reservoir and disrupt the proper neural function.”

#### HOW DOES HAND IMPACT A PATIENT'S LIFE?

Inflammation and neuronal injury to the brain can cause many problems, to differing extents, across patients. The inflammation and injury can be more or less severe in people, but common issues include people having difficulty remembering important tasks, such as taking their medicine (which has knock-on effects that are problematic in their own right). There are also instances where people struggle to focus on a task for any length of time or make decisions. Amanda and other researchers in the field have come to understand the evolving nature of HAND and the role that anxiety, depression and sleep disorders can play.

#### CAN'T HIV TREATMENTS PREVENT HAND?

Treatments and therapies for HIV patients have come a long way over the past couple of decades. Anti-retroviral therapy (ART) has been shown to be highly effective at remedying many of the issues relating to HIV and extending a patient's life. However, unfortunately, low-level viral replications and inflammation are still able to persist in patients on ART. “Both clinical and laboratory-based research suggests that not all antiviral treatments penetrate into brain tissue at concentrations needed to completely block

HIV replication,” explains Amanda. “While there are excellent treatments that block many steps in the HIV life cycle, as yet there is no drug used in the clinic that can stop the stage where viral DNA is transcribed into RNA (ribonucleic acid), which is when we also know that other tissues in the body – while more accessible to anti-retroviral drugs – can still harbour the virus in a state that resists complete eradication.”

#### WHAT ROLE DOES OSTEOPONTIN PLAY IN HAND?

Osteopontin (OPN) is a protein that is implicated in the pathogenesis of a variety of disease states, including HIV. One of Amanda's focuses is understanding more about the role of OPN in HAND – whether it contributes to the problem, is a result of it, or both. It is known that OPN induction is a protective response of host cells to the injuries caused by HIV infection, but there is still more work to be done. “OPN has many functions, one of which is its ability to recruit other immune cells acting as a chemokine or cytokine. OPN expression is elevated over normal levels in the central nervous system of people living with HIV who have moderate to severe cognitive impairment,” says Amanda. “Early on, we thought OPN was contributing to the problem, but all our evidence to date suggests that OPN acts to block the negative impacts of HIV replication and the chronic inflammation associated with it.”

#### WHAT ELSE IS KNOWN ABOUT OPN AND HOW ARE HYPOTHESES TESTED?

Amanda and the team have been conducting experiments on OPN and have discovered that OPN signalling through specific integrin receptors activates the mTORC (mammalian target of rapamycin) which is linked to many pro-survival, growth stimulating and metabolic pathways. They are also investigating the



#### DR AMANDA BROWN

Associate Professor, Department of Neurology and Neuroscience, School of Medicine, Johns Hopkins University, Baltimore, Maryland, USA

#### FIELD OF RESEARCH

Neuroimmunology, Neuroscience

#### RESEARCH PROJECT

Developing understanding of the role that osteopontin plays in HIV-associated neurocognitive disorder. The findings could lead to new and improved treatments that benefit patients around the world.

#### FUNDERS

National Institutes of Neurological Disorders and Stroke, National Institutes of Health and National Institutes of Mental Health (USA)

pathways in the brain that OPN engages to regulate inflammatory signalling.

The team began their studies using culture human macrophages, but needed to understand whether their observations were relevant to what people living with HIV experience. They tested their hypotheses using blood, cerebrospinal fluid and post-mortem brain tissue. “There are good rodent models that mimic specific aspects of HIV neuropathogenesis,” explains Amanda. “The ability to conduct such studies in an ethical fashion is important because it is the best way to most accurately study the brain.”

Amanda and her team believe the new research they are performing will help develop understanding of how OPN turns inflammatory signalling up and down – and which proteins are responsible. If this can be ascertained, it could lead to new and better treatments that prevent or minimise the inflammation and neuronal injury that can take place in the brain as a result of HIV.

# ABOUT NEUROSCIENCE RESEARCH

Neuroscience is a relatively new discipline that arose just a few decades ago. Amanda took what could be considered an atypical pathway into it, having previously focused on microbiology and immunology, but that only serves to highlight the breadth of neuroscience research and how it links to many other scientific disciplines.

The brain is one of the – if not the – most complex things in the Universe, so it follows that understanding more about it relies on multidisciplinary research, with contributions from engineers, physicists, mathematicians, biologists and immunologists. While Amanda works with HIV at present, her research translates to neurodegenerative disorders and other viruses that affect the brain. Thus, her findings, and those of her colleagues, can have significant impacts across a broad range of disciplines and applications.

## WHAT DOES A TYPICAL DAY LOOK LIKE FOR A RESEARCH NEUROSCIENTIST?

One of the most appealing aspects of being

a neuroscience researcher is that there is no such thing as a typical day! Amanda begins most days talking to her research staff, as well as students (she has undergraduates working in her laboratory), but she is still engaged in practical research at the bench. “We will soon be ramping up our animal studies, so once that has been set up, we will check the animals every day, maybe collecting blood samples for analysis,” says Amanda. “Sometimes, there will be seminars to present so that we can communicate science to our peers, but also feature guest speakers. Before you know it, the day is over!”

## WHAT WILL THE NEXT GENERATION OF RESEARCHERS FACE?

The brain can reasonably be considered the next frontier for science. Understanding has developed significantly in the past few years, but there is still so much we do not know. For Amanda, understanding how we can repair or modify the brain to protect against diseases such as Alzheimer’s will be a key focus. There is also much work to be done

on microglia and the central nervous system. “We all need some inflammation, as that is a necessary mechanism to protect us against various threats,” explains Amanda. “But if we cannot properly understand inflammatory signalling, there is always the danger that it could go overboard and represent a threat that causes damage. Understanding how we can modulate inflammation or develop treatments that thwart it is certainly an area of research I expect to develop in the future.”

## PATHWAY FROM SCHOOL TO NEUROSCIENCE RESEARCH

Most neuroscientists complete a science-based undergraduate degree followed by a PhD. Some will also complete a master’s degree. As neuroscience combines many scientific disciplines, there are a range of physical and life sciences degrees that can form a starting point to your career, including biochemistry, biology, biomedical sciences, pharmacology and psychology.

[www.prospects.ac.uk/job-profiles/neuroscientist](http://www.prospects.ac.uk/job-profiles/neuroscientist)

## EXPLORE A CAREER IN NEUROSCIENCE RESEARCH

- Amanda suggests that budding neuroscientists should look for societies, such as the Society for Neuroscience, to help them understand what is happening in the field:  
[www.sfn.org/](http://www.sfn.org/)
- The British Neuroscience Association has a wealth of resources that are designed to help people understand the wonders of the brain:  
[www.bna.org.uk/resources/](http://www.bna.org.uk/resources/)

There is also a list of current positions, which should give you an idea of the breadth of possibility in the field:  
[www.bna.org.uk/jobs/](http://www.bna.org.uk/jobs/)

- According to Payscale.com, the starting salary for a neuroscientist with a master’s degree in the US is \$44,000, and the average salary is \$81,000.

## AMANDA’S TOP TIPS

- 01** Take advantage of the fact that you are just starting out and still know relatively little. I often find that as trainees get older, they become more reluctant to reach out to people, so never be afraid to ask questions. Knocking on doors can help you make progress, so bear that in mind.
- 02** Try and maintain a good support network through friends and family members. There will be times when the research is tough but having friends and family to support you will be a big help.
- 03** There is nothing wrong with failing; in fact, failing fast is the best. Then you can regroup and try again!



Image of human myeloid progenitors differentiated into a microglia-like cell.

# HOW DID AMANDA BECOME A NEUROSCIENCE RESEARCHER?

## WHAT WERE YOUR INTERESTS AS A YOUNGSTER?

My family moved from a city area to a more rural area which made me fascinated with nature – there were lizards and snakes... we even had tarantulas! With the seasons, the insects and birds around us changed. I was always very observant about nature and noticed the stars at night. Astronomy involves the challenge of math and physics, but I think my curiosity in nature and how things worked set me on my current pathway.

## WHO OR WHAT INSPIRED YOU TO BECOME A SCIENTIST?

I always wanted to be an educator, so I found out what I could do about teaching and having wonderful teachers myself helped. It was at college that my biology professor talked about research and that process of discovery, and I had the opportunity to do research at a deeper level. During the summers, I went to other universities around the country to do research and learned about how one can make a living doing research. And so that led to graduate school.

That started this pathway of developing as an independent researcher, because it does take time to learn the scientific method, how to ask questions, and how to communicate.

Having the self-efficacy and confidence in making observations, developing hypotheses, and understanding what experiments are needed to test it. Research science is not an occupation that is dominant within the African American community that I come from. It became clear that there's an opportunity – a big gap in having young people like me, or young people in general, to understand what science is, what we do, and that it can be a valuable, enriching career.

## WHAT ATTRIBUTES HAVE MADE YOU A SUCCESSFUL SCIENTIST?

Research can take a lot of time and there are so many publications coming out, so it involves a lot of reading. Fortunately, I am passionate about reading and consider it a hobby, so that helps! In fact, I am not sure that people who see academia as just a job could have a successful career. When you are the head of a lab, or you are working in an academic environment, you are trying to improve things and understand what is out there in the field – being passionate about what you do and believing in it is essential.

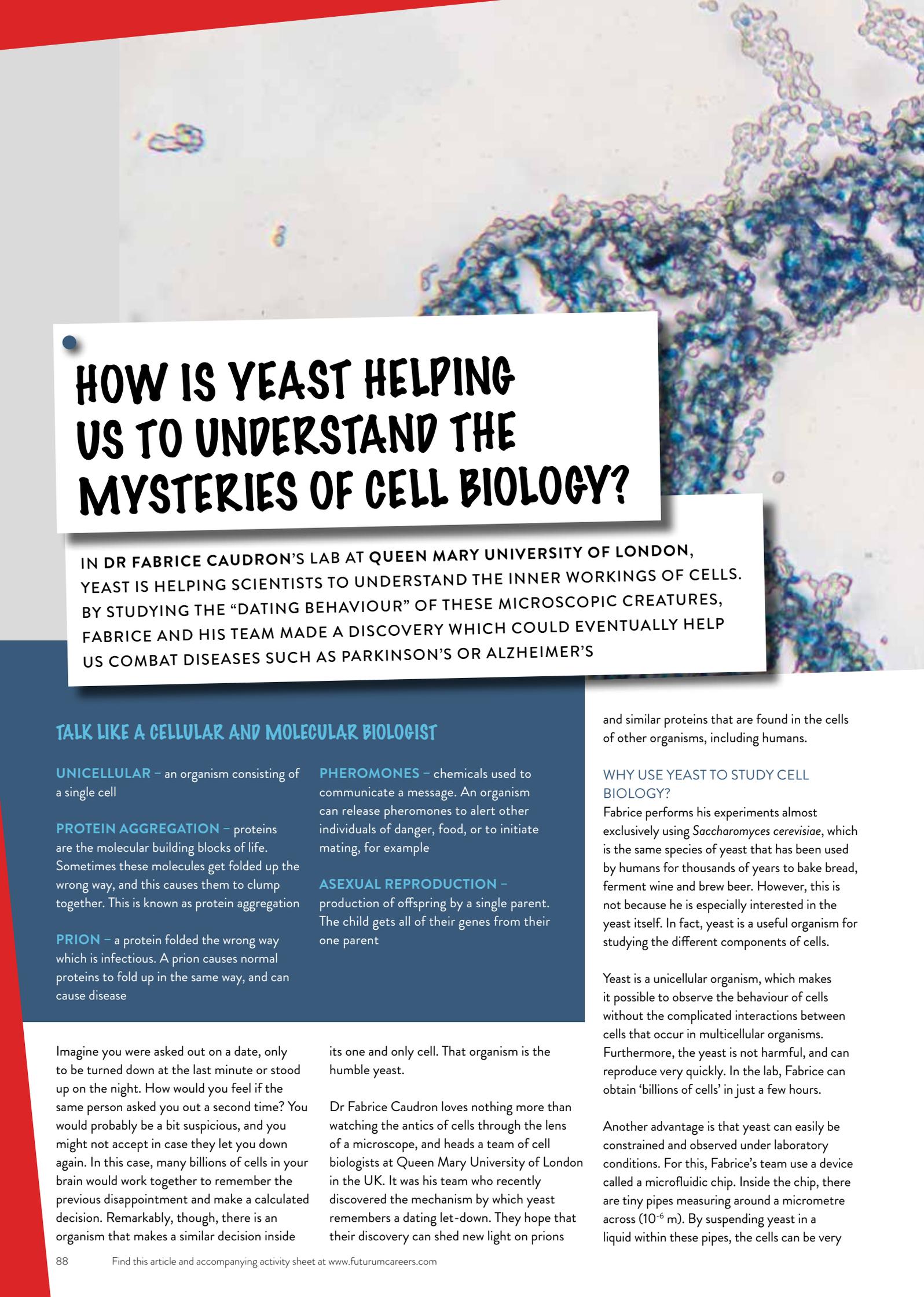
## HOW DO YOU SWITCH OFF FROM YOUR WORK?

I love gardening and cooking, which helps me get out of the lab and into a different

headspace. I like to travel and see new places – and I love music and dancing!

## WHAT IS YOUR PROUDEST ACHIEVEMENT SO FAR?

That I am still here doing this work. When I started, there were less programmes to encourage women and minorities. Universities weren't originally designed to welcome a diversity of people – it could feel like a foreign environment, and you question whether you belong. When you get your PhD, you show that you understand how science is done and can apply it to a new problem. You move from school to a professional environment and then you transition to an independent head of lab position. At each of those transitions, you question whether you are good enough. I am now at Johns Hopkins, I've secured funding, I've got recognition from the institution, my employer and the NIH and I'm an associate professor, looking to be a professor. I never envisioned that I would be in this position. That is why I say my greatest accomplishment is persisting, working hard and getting to where I am now.



# HOW IS YEAST HELPING US TO UNDERSTAND THE MYSTERIES OF CELL BIOLOGY?

IN DR FABRICE CAUDRON'S LAB AT QUEEN MARY UNIVERSITY OF LONDON, YEAST IS HELPING SCIENTISTS TO UNDERSTAND THE INNER WORKINGS OF CELLS. BY STUDYING THE "DATING BEHAVIOUR" OF THESE MICROSCOPIC CREATURES, FABRICE AND HIS TEAM MADE A DISCOVERY WHICH COULD EVENTUALLY HELP US COMBAT DISEASES SUCH AS PARKINSON'S OR ALZHEIMER'S

## TALK LIKE A CELLULAR AND MOLECULAR BIOLOGIST

**UNICELLULAR** – an organism consisting of a single cell

**PROTEIN AGGREGATION** – proteins are the molecular building blocks of life. Sometimes these molecules get folded up the wrong way, and this causes them to clump together. This is known as protein aggregation

**PRION** – a protein folded the wrong way which is infectious. A prion causes normal proteins to fold up in the same way, and can cause disease

**PHEROMONES** – chemicals used to communicate a message. An organism can release pheromones to alert other individuals of danger, food, or to initiate mating, for example

**ASEXUAL REPRODUCTION** – production of offspring by a single parent. The child gets all of their genes from their one parent

Imagine you were asked out on a date, only to be turned down at the last minute or stood up on the night. How would you feel if the same person asked you out a second time? You would probably be a bit suspicious, and you might not accept in case they let you down again. In this case, many billions of cells in your brain would work together to remember the previous disappointment and make a calculated decision. Remarkably, though, there is an organism that makes a similar decision inside

its one and only cell. That organism is the humble yeast.

Dr Fabrice Caudron loves nothing more than watching the antics of cells through the lens of a microscope, and heads a team of cell biologists at Queen Mary University of London in the UK. It was his team who recently discovered the mechanism by which yeast remembers a dating let-down. They hope that their discovery can shed new light on prions

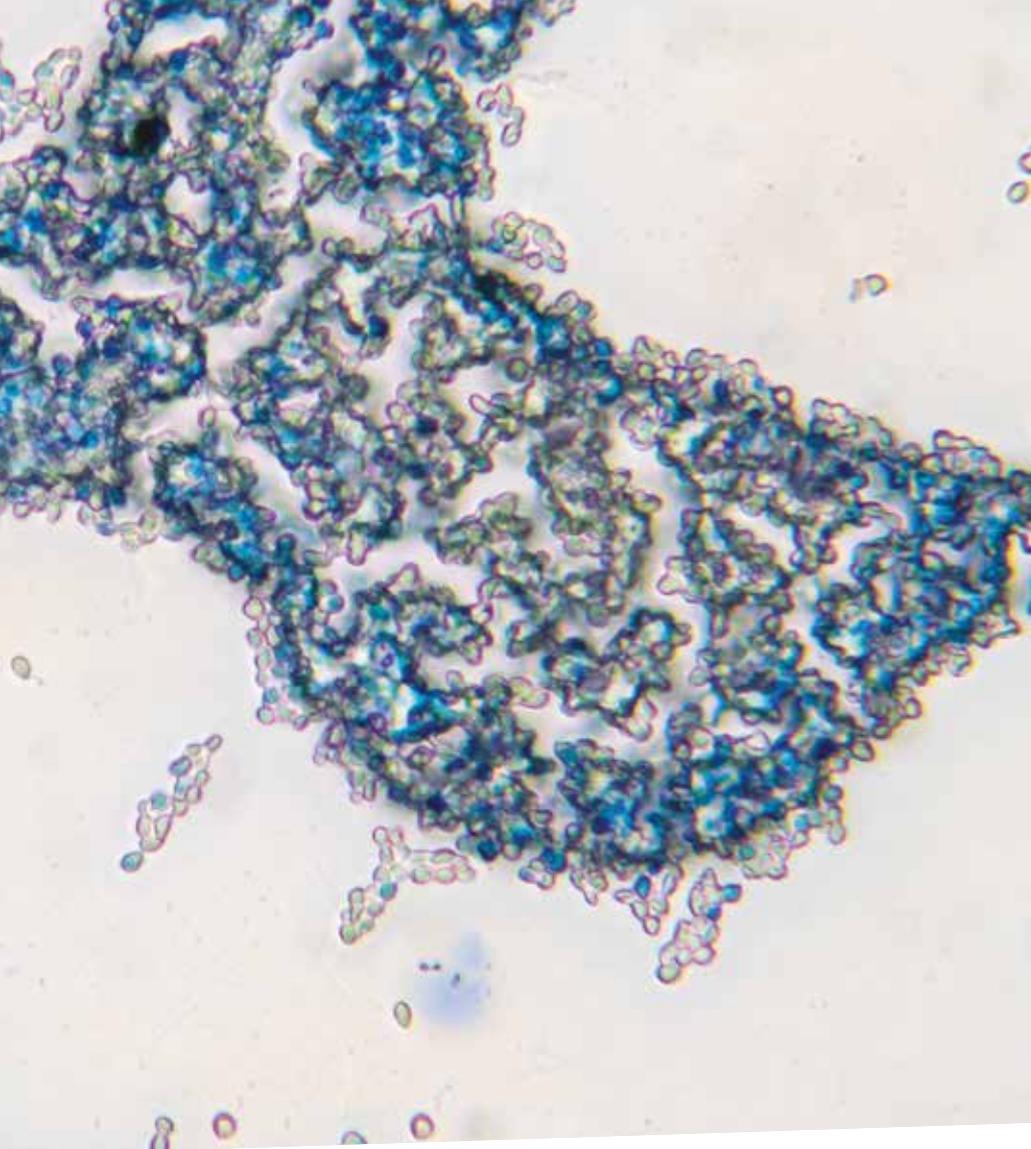
and similar proteins that are found in the cells of other organisms, including humans.

## WHY USE YEAST TO STUDY CELL BIOLOGY?

Fabrice performs his experiments almost exclusively using *Saccharomyces cerevisiae*, which is the same species of yeast that has been used by humans for thousands of years to bake bread, ferment wine and brew beer. However, this is not because he is especially interested in the yeast itself. In fact, yeast is a useful organism for studying the different components of cells.

Yeast is a unicellular organism, which makes it possible to observe the behaviour of cells without the complicated interactions between cells that occur in multicellular organisms. Furthermore, the yeast is not harmful, and can reproduce very quickly. In the lab, Fabrice can obtain 'billions of cells' in just a few hours.

Another advantage is that yeast can easily be constrained and observed under laboratory conditions. For this, Fabrice's team use a device called a microfluidic chip. Inside the chip, there are tiny pipes measuring around a micrometre across ( $10^{-6}$  m). By suspending yeast in a liquid within these pipes, the cells can be very



**DR FABRICE CAUDRON**

Lecturer in Microbiology  
Queen Mary University of London, UK

**FIELD OF RESEARCH**

Cellular and Molecular Biology

**RESEARCH PROJECT**

By experimenting with yeast, Fabrice aims to understand prion-like proteins, how they are used in cell memory and what affect they have on cell ageing.

**FUNDER**

Biotechnology and Biological Sciences  
Research Council

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precisely controlled and monitored. It is even possible to change the fluid in the pipes to see how yeast reacts to different conditions, while keeping the cells trapped inside and under a microscope at all times.

**HOW DOES YEAST REPRODUCE?**

Normally, a yeast cell reproduces asexually, so there is no need for any ‘dating’. A small bud grows from the parent cell, and eventually the two split apart to become separate cells. However, under stressful conditions, yeast can also reproduce sexually. There are two types of mating *S. cerevisiae*, termed type a and type α (alpha). For sexual reproduction, a type a cell needs to meet a type α cell. When a cell wants to mate, it releases pheromones that signal its intent to the other mating type.

The pheromones cause nearby cells of the opposite type to grow a projection towards their potential mate. The distinctive shape of the cell at this stage led to it being named a Shmoo, after a fictional cartoon character by American cartoonist Al Capp. If the two cells touch, they fuse together to mate.

**HOW DOES CELL MEMORY WORK?**

The shmooing procedure is not always

successful. Fabrice decided to investigate what happens when a cell is exposed to pheromones, but is unable to find a partner or is beaten to it by another cell of the same mating type.

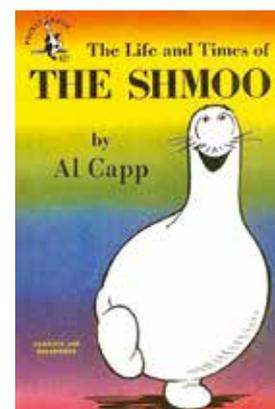
He discovered that cells that are ‘deceived’ by pheromones remember the experience through a protein named Whi3. When the cell receives the signal but does not find a mate, Whi3 forms a protein aggregate, causing the cell to ignore future pheromone signals. In this way, the cell learns not to make an effort if there is not a good chance of the shmooing process being a success. Instead, the cell will go back to reproducing asexually.

**WHY IS FABRICE’S DISCOVERY IMPORTANT?**

Protein aggregation has long been associated with brain diseases like Alzheimer’s and Parkinson’s. Fabrice’s discovery is exciting because it shows that protein aggregates can also be used as a memory mechanism, without harming the cell. In particular, the Whi3 protein aggregate that Fabrice discovered in yeast behaves similarly to a prion, the type of misshaped protein that causes Mad Cow Disease. There is, however, a crucial difference. While prions are passed down through the

generations of cells, the memory stored by the Whi3 protein is not inherited by the cell’s offspring.

Going forward, Fabrice hopes to build a clearer picture of when prion-like proteins are useful as well as when they cause disease. He aims to observe the process of protein aggregation in zebrafish to test his theories in a multicellular organism. Eventually, if we know how and why protein aggregation occurs in humans, this will help to design new medical treatments for conditions such as Alzheimer’s and Parkinson’s.



*Shmoo is a fictional cartoon character created by American cartoonist Al Capp. When yeast cells grow a projection towards a potential mate, their distinctive shape looks like the Shmoo ©Al Capp*

# ABOUT CELLULAR AND MOLECULAR BIOLOGY

Cells are the basic building blocks of life on Earth. The only living things on our planet that are not made up of cells are viruses (and some scientists do not even class them as living things). That means that the more we know about the inner workings of cells, the better we will understand the biology of all creatures. This is the broad aim of cell biology.

## ARE YOU MADE OF CELLS?

To see how amazing cell biology is, you only need to look in the mirror. Your body is made up of roughly 100 trillion cells! Despite the fact that every single one of your cells has similar biology to the cells that make up a banana, they somehow 'know' how to perform the diverse functions of your different organs.

To manage this, each cell needs to organise its molecules, nanosecond by nanosecond.

## HOW ARE MOLECULES ORGANISED INSIDE A CELL?

A cell is a bit like a tiny bag filled with a soup of molecules. However, for the molecules to fulfil their functions, the 'soup' needs to be organised so that the right ingredients are in the right place at the right time. So, the matter inside a cell is actually quite structured, albeit in a fluid way that allows the components to move about as required.

The structure of a cell changes depending on the conditions it finds itself in. For example, if a yeast cell growing on a grape were suddenly exposed to the sun on a summer afternoon,

it would need to rearrange its molecules to survive. Restructuring also happens when the cell multiplies or, in time, becomes older. This is the kind of thing that cell biologists try to understand through lab experiments.

## WHY DO WE NEED CELLULAR AND MOLECULAR BIOLOGISTS?

Do you know of someone who has been ill with meningitis, malaria, diabetes, cancer or cystic fibrosis? These are just some examples of diseases and disorders in humans that are caused by cellular or molecular problems. Even common injuries such as burns and broken bones cause damage to your cells. By understanding how cells work, it is possible to develop new vaccines and search for new medicines.

## EXPLORE A CAREER IN CELLULAR AND MOLECULAR BIOLOGY

- The British Society for Cell Biology has an e-learning website where you can discover more about cell biology and training opportunities: [bscb.org/learning-resources/softcell-e-learning/](http://bscb.org/learning-resources/softcell-e-learning/)
- Visit the Centre of the Cell in London and check out their youth mentorship scheme: [www.centreofthecell.org/](http://www.centreofthecell.org/)
- The average salary for a molecular and cellular biologist in the UK is over £37,000.

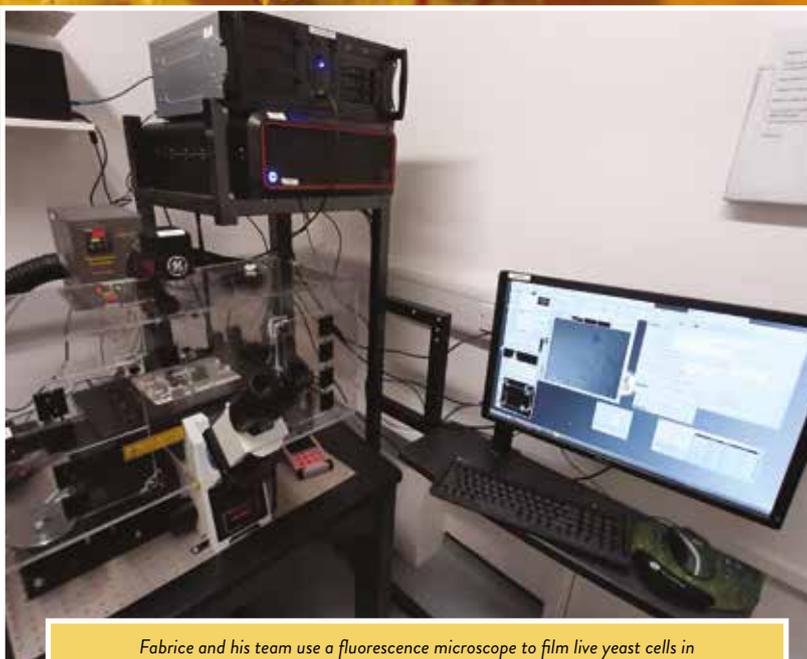
## PATHWAY FROM SCHOOL TO CELLULAR AND MOLECULAR BIOLOGY

Almost everyone working in cellular and molecular biology has a science degree (BSc), and many have a further qualification such as an MSc. Most people in leading roles will have a doctorate (PhD, DPhil, or DSc). However, not all people study biology for their first degree. It is increasingly common for people to transfer from other disciplines such as chemistry and computer science.

If you chose to aim straight for a degree in biology, good school grades in biology and chemistry will probably be required. Selecting physics and maths at school will also make your application stronger.

## FABRICE'S TOP TIPS

- 01** Keep an open mind and have a broad education. Many paths can lead to science, and education is a gift we have, so always try to follow your aspirations.
- 02** Be passionate and pro-active. You have to find and make the most of opportunities, so try to read either magazines or online content about science.
- 03** You may need to move a lot during your studies and career: between cities and, if possible, countries. It is important to evaluate if you would be happy with this kind of life and with a job that often requires long days of work.



Fabrice and his team use a fluorescence microscope to film live yeast cells in microscopic detail.

# HOW DID FABRICE BECOME A CELLULAR AND MOLECULAR BIOLOGIST?



## WHY WOULD YOU RECOMMEND A CAREER IN CELLULAR AND MOLECULAR BIOLOGY?

Studies in cellular and molecular biology are reaching very deep details of the mechanisms sustaining life, so it is a very satisfying feeling when you make a discovery in this field. There are still so many unknowns in cellular and molecular biology that many researchers will be needed to answer them. At the same time, having a background in cellular and molecular biology does not mean that you must stay in academia – you would have many skills that are valued in industry, such as critical thinking and clear communication.

## WHAT DID YOU WANT TO BE WHEN YOU WERE YOUNGER?

For as long as I remember, I wanted to be a scientist, even though I had very little idea of what it really meant. I think this was driven by our yearly family holidays in

the French Alps and the observations of nature this offered. I also remember vividly the first time I looked at cells under a toy microscope. Since then, I wanted to look at cells and this increased more and more during my studies.

## YOU HAVE A BSC, MSC AND PHD IN CELLULAR AND MOLECULAR BIOLOGY. WHO OR WHAT INSPIRED YOU TO STUDY THESE FIELDS?

After high school in France, I engaged in medical studies. For some reason I had developed an aspiration to become a medical doctor. I failed, because the competition was tough and I was only really interested by the molecular and cellular biology lectures. So, I diverted back to biology, and it was much more my thing. I think I chose cell biology because it is the discipline in which I feel most comfortable. Of course, my instinct is very often wrong, but this is part of what makes cell biology interesting!

## YOU ARE A BIG FAN OF COMICS AND HAVE USED A COMIC TO CONVEY SOME ASPECTS OF YOUR RESEARCH. DO YOU DRAW COMICS IN YOUR SPARE TIME?

I am not really skilled at drawing, but we did draw a comic for a scientific article recently. It felt fitting because the shape yeast cells adopt when trying to reproduce sexually is called a 'shmoo', and this name comes from the comic book *The Shmoo* by Al Capp. We just had to adapt our story to it. I would certainly try to do it again, as it is a neat way of conveying a message very simply. There are some artists who create comics and drawings to explain science in a simple and fun way (look at the works of David Goodsell and Beata Mierzwa, for example). But I do not draw in my spare time, I am more inclined to play guitar or train with the local handball team.

## MEET DR HENRY OAMEN



*Dr Henry Oamen has joined Fabrice's lab as a postdoctoral research assistant. In academia, this is known as a 'post-doc', and researchers typically spend a few years of their career doing one or more post-docs before securing a permanent role in a university.*

### **Biotechnology was a one of the modules I took while studying botany at the University of Benin in Nigeria.**

As I gained more understanding of biotechnology, I became more interested because I realised that through biotechnology, I could modify microorganisms genetically to make useful compounds which will improve our world. This inspired me to pursue a MSc and PhD in biotechnology.

**I became interested in yeast during my PhD.** Some of the techniques I applied in biotechnology, such as gene deletions, modifications, protein expression and cloning of genes, have been very useful in my work in Fabrice's lab.

**I enjoy being a post-doctoral researcher because it allows me to be at the cutting edge** of breakthroughs

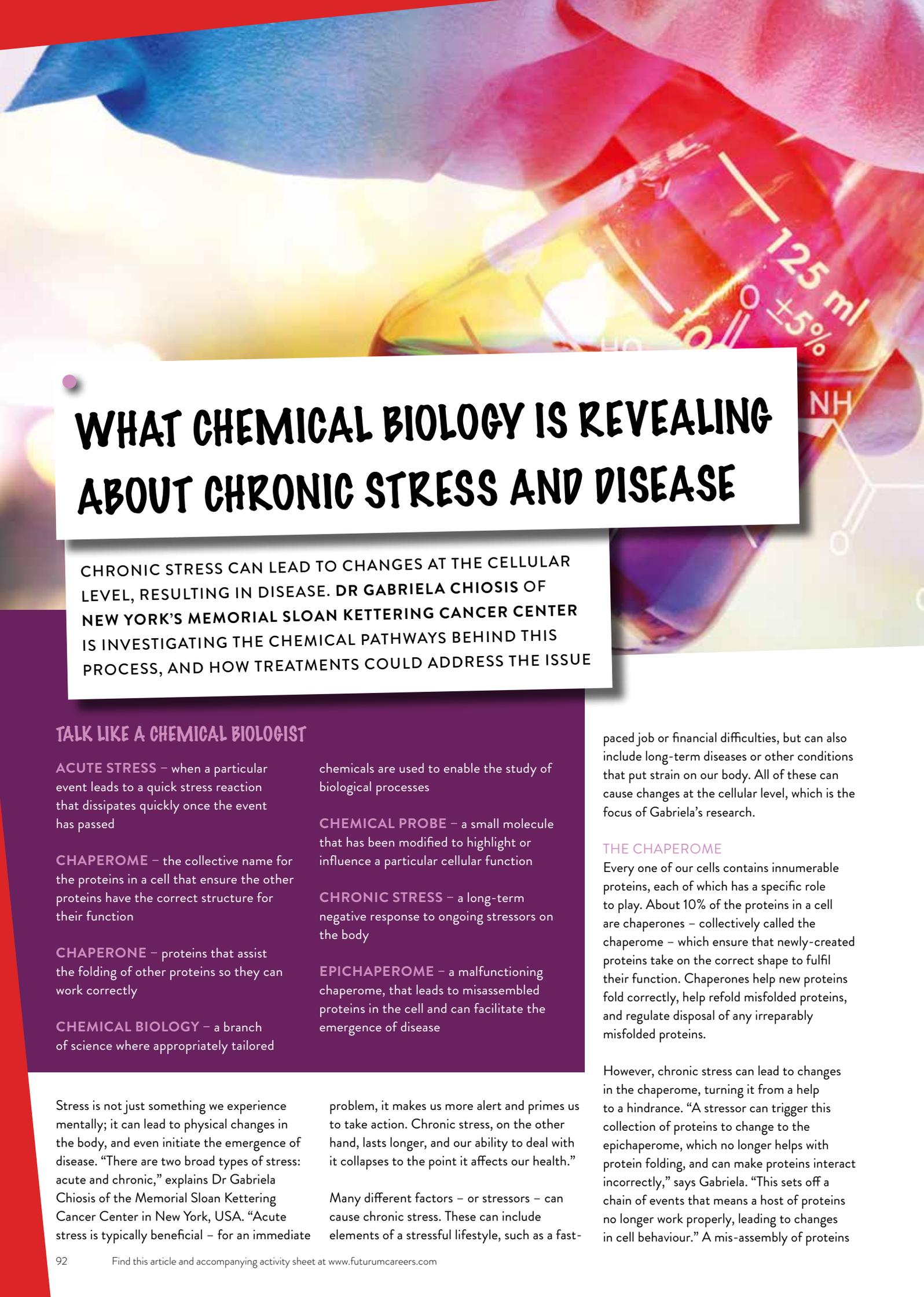
and to share ideas with other research scientists and the wider community. I enjoy doing experiments and the possibility of discovering something new and interesting that could revolutionise our world.

### **My top tip for someone hoping to follow in my footsteps would be to stay focused, inquisitive and bold.**

I believe in the potential of young people irrespective of race or gender, and I will particularly be happy to see more young black, biological scientists. I think the most important tip for success is to believe in yourself and in your abilities. With this, there is no limit to what you can achieve.

### **Outside of work, I got involved with Jubilee Charity while I was studying and living in Manchester.**

They operate a foodbank, donate to the elderly at Christmas and also assist widows, single mothers and homeless people. I think the number of homeless people on the streets in the UK is alarming. I do recommend Jubilee Charity to anyone willing to be part of community building in Manchester.



# WHAT CHEMICAL BIOLOGY IS REVEALING ABOUT CHRONIC STRESS AND DISEASE

CHRONIC STRESS CAN LEAD TO CHANGES AT THE CELLULAR LEVEL, RESULTING IN DISEASE. DR GABRIELA CHIOSIS OF NEW YORK'S MEMORIAL SLOAN KETTERING CANCER CENTER IS INVESTIGATING THE CHEMICAL PATHWAYS BEHIND THIS PROCESS, AND HOW TREATMENTS COULD ADDRESS THE ISSUE

## TALK LIKE A CHEMICAL BIOLOGIST

**ACUTE STRESS** – when a particular event leads to a quick stress reaction that dissipates quickly once the event has passed

**CHAPEROME** – the collective name for the proteins in a cell that ensure the other proteins have the correct structure for their function

**CHAPERONE** – proteins that assist the folding of other proteins so they can work correctly

**CHEMICAL BIOLOGY** – a branch of science where appropriately tailored

chemicals are used to enable the study of biological processes

**CHEMICAL PROBE** – a small molecule that has been modified to highlight or influence a particular cellular function

**CHRONIC STRESS** – a long-term negative response to ongoing stressors on the body

**EPICHAPEROME** – a malfunctioning chaperome, that leads to misassembled proteins in the cell and can facilitate the emergence of disease

Stress is not just something we experience mentally; it can lead to physical changes in the body, and even initiate the emergence of disease. “There are two broad types of stress: acute and chronic,” explains Dr Gabriela Chiosis of the Memorial Sloan Kettering Cancer Center in New York, USA. “Acute stress is typically beneficial – for an immediate

problem, it makes us more alert and primes us to take action. Chronic stress, on the other hand, lasts longer, and our ability to deal with it collapses to the point it affects our health.”

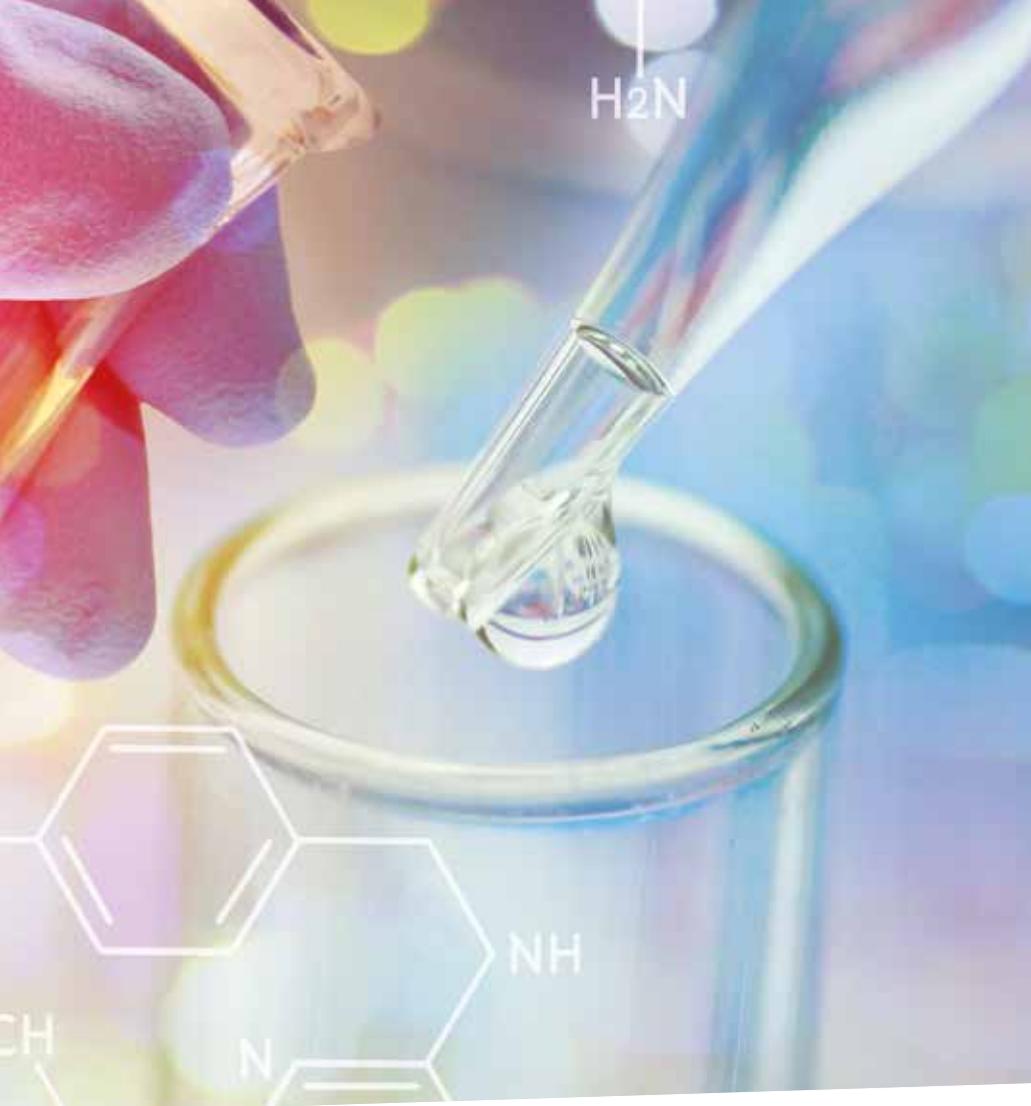
Many different factors – or stressors – can cause chronic stress. These can include elements of a stressful lifestyle, such as a fast-

paced job or financial difficulties, but can also include long-term diseases or other conditions that put strain on our body. All of these can cause changes at the cellular level, which is the focus of Gabriela's research.

## THE CHAPEROME

Every one of our cells contains innumerable proteins, each of which has a specific role to play. About 10% of the proteins in a cell are chaperones – collectively called the chaperome – which ensure that newly-created proteins take on the correct shape to fulfil their function. Chaperones help new proteins fold correctly, help refold misfolded proteins, and regulate disposal of any irreparably misfolded proteins.

However, chronic stress can lead to changes in the chaperome, turning it from a help to a hindrance. “A stressor can trigger this collection of proteins to change to the epichaperome, which no longer helps with protein folding, and can make proteins interact incorrectly,” says Gabriela. “This sets off a chain of events that means a host of proteins no longer work properly, leading to changes in cell behaviour.” A mis-assembly of proteins



### DR GABRIELA CHIOSIS

Chiosis Lab, Memorial Sloan Kettering Cancer Center, New York, USA

#### FIELD OF RESEARCH

Chemical Biology

#### RESEARCH PROJECT

Taking a unique chemical biology approach to understand, diagnose, and treat cellular processes associated with chronic stress

#### FUNDER

This work was supported by the National Institute on Aging under award numbers R01 AG067598 and R56 AG072599.

like this can easily become the basis for diseases like cancer and also neurodegenerative disorders like Alzheimer's disease.

#### CHEMICAL BIOLOGY

"Chemical biology is an emerging field and has only really been recognised in the last few decades," says Gabriela. Her work involves creating completely novel chemicals that can be inserted into cells to detect or affect the epichaperome. "We make unique chemicals that we add to cells, without affecting the cells' native state," she says. Gabriela's training in chemistry helps her visualise the shape and properties of chemicals that may never have existed before she synthesises them. "Science involves a lot of creativity and innovation," she says. "I have always been driven to try things that challenge me."

"We make chemical probes that can detect the epichaperome in the human body," explains Gabriela. "By labelling these chemicals with fluorescence or a particular radio tag, you can then scan the patient to see where these chemicals – and thus the epichaperome – are showing up in the body." The presence of the epichaperome is an indicator of disease. The magnitude and location of the signal in the body gives an indication of the type of disease, such as different cancers or Alzheimer's. These chemicals – manufactured in Gabriela's lab

– are becoming an important diagnostic tool in medicine.

#### DIAGNOSIS AND TREATMENT

As well as simply detecting the epichaperome, these chemical tools are also uncovering the specific changes that proteins undergo when exposed to chronic stress. These changes are many and varied, and can include changes to cellular processes such as the manufacture of new proteins and the controlled destruction of faulty cells. This technique also helps to identify the stressors that led to the condition in the first place. Together, this information helps piece together which stressors lead to what diseases, and why.

These chemical biology tools can also prove useful in developing new drugs and treatment strategies. Gabriela's lab has successfully invented and disseminated a number of drug candidates. For instance, it has created a chemical that inhibits one of the key proteins within the epichaperome, but only when it is performing useful functions elsewhere in the cell. This helps to mitigate the damage that the epichaperome is causing to the body and, as a result, slow or stop the growth of cancer.

#### NEW FINDINGS FOR MEDICINE

Gabriela and her team investigated the link

between epichaperomes and cancer, which led to some interesting conclusions. "Cancers are dependent on epichaperomes to different degrees, but this is not defined by type of cancer – say, brain or breast cancer," says Gabriela. "Rather, there are groups within each type of cancer that behave differently." Clinical trials address cancer by type, but Gabriela is in favour of a move towards 'basket trials', where patients are grouped depending on the changes seen at the cellular level rather than the location of the cancer.

Currently, Gabriela's team is looking into the roots of Alzheimer's disease. "Alzheimer's can start decades before patients show neurological symptoms, but nobody really knows what causes it," says Gabriela. "It appears that Alzheimer's emerges from a combination of stressors, which can be linked to stressful lifestyle traits, infectious diseases, or other conditions such as diabetes." However, not everyone who experiences these stressors develops Alzheimer's, so there remain many unknowns, which Gabriela's team is attempting to address. It is known that neurons are among the cell types most sensitive to internal disruption, which very much includes the effects of the epichaperome. The team's findings could potentially revolutionise the diagnosis and treatment of Alzheimer's.

# ABOUT CHEMICAL BIOLOGY

**Chemical biology is an emerging discipline that uses chemical tools to investigate biological processes, learns how these processes go awry in disease, and uses this learning to discover and, potentially, develop treatments for disease. Gabriela explains more.**

## HOW IS CHEMICAL BIOLOGY DIFFERENT TO RELATED FIELDS, SUCH AS CELL BIOLOGY, GENETICS, AND BIOCHEMISTRY?

Chemical biologists have a unique toolkit for finding answers to cellular problems that other disciplines cannot address in the same way. For instance, we use chemical tools to identify and understand diseases, without having to modify cells.

## HOW IMPORTANT IS COLLABORATION IN YOUR FIELD?

Chemical biology starts with chemists, who make the chemical probes. Then, other lab members will have expertise in biochemistry and cell biology, which they apply to chemical biology to identify disease mechanisms and develop drugs or diagnostics. People with expertise in bioinformatics can amplify the

work we do – they develop ways of examining thousands of proteins using our methods. We are a small lab, so lots of collaboration involves working with other institutions – and there are plenty of high-quality universities and medical centres in New York and further afield that we enjoy working with.

## HAVE THERE BEEN ANY EUREKA MOMENTS IN YOUR RESEARCH?

I think science is all about eureka moments! They are what keep you motivated, interested and dedicated because science is not an easy job. There are two types of eureka moment, I believe. The first is the scientific discovery, which can happen relatively often, but takes a long time to bring results in the real world. The second is when these results start to materialise. For instance, recently a patient called me and thanked me for the extra years of life they had been gifted thanks to a drug I discovered. That is what matters.

## WHAT DO YOU FIND REWARDING ABOUT YOUR WORK?

It's always exciting to see when years of research culminate in advances in the clinic.

This can be a long process – sometimes, the time between discovering a new chemical probe and it being used by doctors can be fifteen years or so. I have learnt many things beyond science to promote my inventions and become an entrepreneur, to push this process as much as possible.

## WHAT CHALLENGES WILL FACE THE NEXT GENERATION OF CHEMICAL BIOLOGISTS?

Chemical biology is very broad, which is part of its allure. It really is a field of open and endless opportunity. The same applies for related fields – biology, biomedicine, medicine, all are changing so fast, and many doors are opening.

## WHAT ARE THE NEXT STEPS FOR YOUR RESEARCH?

At the moment, I am very interested in understanding the mind, and in particular what leads to Alzheimer's. Understanding the underlying stressors and cellular processes, and why different people have different levels of vulnerability, will be my goal for at least the next few years.

## EXPLORE A CAREER IN CHEMICAL BIOLOGY

- The Memorial Sloan Kettering Cancer Center, where Gabriela works, offers a number of programmes for young people. These include an annual seminar and an eight-week summer experience for high school students interested in biomedical sciences: [www.mskcc.org/research/ski/education-training#college-high-school](http://www.mskcc.org/research/ski/education-training#college-high-school)
- This article explains more about what chemical biology entails as a career: [work.chron.com/chemical-biologists-do-21926.html](http://work.chron.com/chemical-biologists-do-21926.html)

## GABRIELA'S TOP TIPS

- 01 Get to know yourself. Aim for what you are best at and what you enjoy, rather than aiming for a career that doesn't inspire you.
- 02 Never listen to naysayers – believe in yourself!

## PATHWAY FROM SCHOOL TO CHEMICAL BIOLOGY

Chemical biology is an interdisciplinary field, and draws on many other areas of science, namely chemistry, biology, biochemistry and medicine. To pursue an undergraduate degree in any of these areas, sensible subjects to take at school include chemistry, biology and mathematics.

Chemical biologists can work in fields such as academia, biotechnology and medicine. A degree in a relative science subject is essential, and often further study is recommended. For instance, Gabriela has an undergraduate degree in biomedical sciences and a PhD in organic chemistry.

Gabriela also emphasises that creativity forms a large part of her work, so arts or humanities subjects can help balance these skills.



Gabriela's team in the laboratory - Chander, Sahil, Suhasini, Ananda, Pengrong, Anna and Palak (from left to right)

## HOW DID GABRIELA BECOME A CHEMICAL BIOLOGIST?

### WHAT WERE YOUR INTERESTS AS A CHILD?

I was always an avid reader and especially enjoyed poetry. I also loved sports, and played basketball at college. But science has always been my main interest – at school I was very good at mathematics but also wanted to use my creativity and imagination, which led to me choosing biomedical sciences.

### WHAT HAS MADE YOU SUCCESSFUL AS A SCIENTIST?

Believing in myself and pursuing my dreams relentlessly!

### HOW DO YOU SWITCH OFF FROM YOUR WORK?

I like to be able to switch off completely. When I was younger, this involved going to art galleries, listening to music, or playing sports, and now it is gardening and spending time in nature. I think this balance is important, for maintaining high performance in your work and also your wider life.

### WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS?

I have been able to overcome obstacles and become who I am. I realised this when I graduated from Columbia University and my mother told me she was happy I could become what she could never be. It made me see that not everyone can follow their calling – and it hasn't been easy for me either, but determination has seen me through.



Gabriela in the lab talking to her team

# HOW DO CELLS CONTROL PROTEIN LEVELS?

THE GENETIC INFORMATION THAT DEFINES EACH OF US IS STORED IN THE DNA WITHIN OUR CELLS. DR GEORG KUSTATSCHER, FROM THE UNIVERSITY OF EDINBURGH IN THE UK, IS RESEARCHING HOW THIS INFORMATION IS TRANSLATED INTO THE PROTEINS THAT ARE ESSENTIAL FOR LIFE. HE WANTS TO DISCOVER HOW OUR CELLS REGULATE THE AMOUNT OF PROTEINS PRODUCED, AND WHAT HAPPENS WHEN THIS PROCESS GOES WRONG. HOPEFULLY, THE ANSWERS WILL INCREASE OUR UNDERSTANDING OF CANCER AND HELP TO DEVELOP NEW TREATMENTS FOR CANCER PATIENTS

## TALK LIKE A PROTEOMICS RESEARCHER

**DNA** – the molecule that stores the genetic information in our cells

**GENE** – a section of DNA containing genetic information and instructions to produce proteins

**MACHINE LEARNING** – computer programmes which learn to perform complex tasks without being explicitly programmed to do so

**mRNA** – the molecule that copies the genetic information when it is used to make proteins

**PEPTIDE** – a section of protein produced, for example, when proteins are digested by enzymes

**PROTEINS** – biological molecules that contribute to the activities in our cells

**PROTEOME** – the complete set of all the thousands of proteins that make up our body

**PROTEOMICS** – the large-scale study of proteins

The cells in your body only have a diameter of ~0.01 mm, and yet every one contains two metres of DNA! These two-metre-strands of DNA are tightly coiled inside the nucleus of every cell and contain all the genetic information that your cells need to make you who you are.

Genes are small stretches of DNA that encode for different functions in the body. Every cell should have two copies of each gene, one inherited from each biological parent, and humans have over 20,000 different genes in total. These genes also carry all the information which the cell needs to create different proteins, the biomolecules that carry out the actual biological activities in a cell. These proteins range from enzymes that break down nutrients to antibodies that fight bacteria to regulator molecules that control cell division.

But sometimes, the biological processes required to create proteins from DNA go wrong. And this is what Dr Georg Kustatscher is investigating. Georg is a proteomics researcher at the University of Edinburgh, where he is studying how our cells regulate their protein levels.

## HOW ARE PROTEINS PRODUCED?

The process of turning a gene into a protein

is called gene expression and consists of two stages. In the first stage, transcription, genes are copied into molecules called 'messenger RNA' (mRNA). mRNA is similar to DNA, but it only contains the single gene that was copied, rather than the whole two-metre DNA sequence. mRNA travels from the cell nucleus, where the DNA is stored, to the cytoplasmic part of the cell, where most biological activities take place. In the second stage, translation, the mRNA is converted into proteins by molecular machines known as ribosomes.

"This basic relationship of how DNA turns into mRNA and then into proteins has been known for 60 years," says Georg, "but where it really gets interesting is how these processes are controlled."

The genetic information stored in your DNA is the same in every cell in your body. So a liver cell and a neuron contain exactly the same genes, yet they have completely different functions in the body and so need different proteins to operate. About half of our 20,000 genes are 'always on', because they produce proteins that all cells need at all times. The remaining genes produce proteins that are only needed by certain types of cells, or in certain situations, such as to repair a cell when it gets damaged.



This means cells must control which proteins they produce, and in what amounts, depending on their function in the body and their situation. This can be done either by alternating the amount of mRNA transcribed from DNA, or by altering the amount of protein translated from mRNA.

### WHAT GOES WRONG IN CANCER CELLS?

“In a living cell, the proteome is very dynamic,” says Georg. “Proteins are constantly being made and broken down. The balance of these processes is essential for healthy cells, and proteome imbalance is a feature of many diseases, including cancer.”

In cancer cells, the relationship between DNA, mRNA and proteins can be out of balance. A common problem is gene-copy number alterations. Normal cells have two copies of each gene, but some cells lose one of those copies, or they acquire additional copies of the same gene. Gene additions or deletions should result in more or less mRNA being produced, and therefore an excess or shortage of certain proteins. However, there is an unknown mechanism that normally protects cells against the negative consequences of this. This mechanism ensures that the protein levels of deleted or amplified genes remain unaffected. “But for some genes in some situations, this compensation mechanism doesn’t work,” says Georg. He thinks that when this happens, these genetic mutations cause cells to become cancerous. Georg’s team is researching how this compensation mechanism works in the hope that they can find ways to activate or modify it to help cure cancer.

### HOW DOES GEORG STUDY PROTEINS?

To investigate how proteins are produced, Georg’s team need to measure the amounts and types of different proteins in cells. First, they extract the proteins by dissolving the entire cell in a strong detergent. Next, the proteins are digested into smaller chunks (known as peptides) using enzymes that are naturally found in the intestine. These peptides

are then analysed using a mass spectrometer which measures the amount of each peptide and its mass. It then splits each peptide into even smaller fragments and determines their masses as well, creating a ‘fingerprint’ which is unique for each peptide. As each protein produces a unique combination of peptides, the data from the mass spectrometer can be used to identify which proteins were present in the cells, and in what amounts.

### THE IMPORTANCE OF MACHINE LEARNING

In the past, researchers had to identify proteins by hand. Today, mass spectrometers can collect data on thousands of proteins in one single sample, so examining each result by hand would be far too time consuming. To help analyse the big data sets that proteomics experiments produce, researchers are using ‘machine learning’. To identify differences between proteomics samples from healthy individuals and patients with a certain disease, researchers label some example cases. The computer uses these examples to ‘learn’ the differences between the samples and identify which of the thousands of proteins are critical for distinguishing the two sample types. The trained algorithm can then assign unknown samples to one of the two classes, helping to diagnose potentially ill people.

### SO HOW WILL GEORG DETERMINE HOW CELLS REGULATE PROTEIN LEVELS?

“Our first important question is about the nature of the regulatory processes,” says Georg. “If a cell needs to increase the concentration of a protein, will it increase the rate of transcription (mRNA synthesis) or that of translation (protein synthesis)?”

To answer this question, Georg will measure the levels of proteins in the cell, as well as the amount of mRNA and DNA. If high levels of mRNA correlate with high levels of the protein that it produces, this would suggest that the cells are controlling the protein level through transcription, by altering the amount of



### DR GEORG KUSTATSCHER

Institute for Quantitative Biology,  
Biochemistry and Biotechnology  
University of Edinburgh, UK

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### FIELD OF RESEARCH

Proteomics, Cancer Biology

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### RESEARCH PROJECT

Investigating how cells regulate protein levels and fail to do so in cancer

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### FUNDER

Medical Research Council

*This work was supported by the MRC, under grant number MR/T03050X/1. The contents are solely the responsibility of the authors and do not necessarily represent the official views of the MRC.*

mRNA produced. Conversely, if high protein concentrations do not correlate with high mRNA levels, this would suggest that the cells control the protein level through translation, by altering the amount of proteins generated.

Mass spectrometry and machine learning will allow Georg to measure thousands of different proteins and mRNA at the same time, so he can work out which proteins are controlled by which mechanism. Comparing the mechanisms in healthy cells and cancer cells will help scientists to understand how protein production is going wrong in cells with cancer. Hopefully, they will then be able to develop new treatments to correct these processes in cancer cells.

Georg’s research shows how fundamental research into biological processes allows us to think about new approaches to treating diseases such as cancer. With knowledge of how cells control protein levels, and how this goes wrong in cancer cells, future scientists may be able to correct the causes of cancer.

# ABOUT PROTEOMICS

Proteomics is the study of proteins on a large scale. Our body contains many thousands of different proteins; proteomics involves investigating how these proteins are produced, used and broken down inside cells. The field combines ideas from areas such as medicine, biology, chemistry, engineering and computer science, so it is a very diverse and rapidly growing research area.

Georg tells us more about the field of proteomics:

## WHY IS IT IMPORTANT THAT BIOLOGISTS CONSIDER THE WHOLE CELL AS A COMPLEX SYSTEM, RATHER THAN STUDYING INDIVIDUAL PROTEINS IN ISOLATION?

Until recently, biologists believed that a complex system like our cells or body is simply the sum of its parts. If we were to study and understand each gene and each protein on

its own, we would eventually understand how entire cells work. But this is the same as trying to capture a symphony by listening to each instrument on its own rather than the whole orchestra. Now, biologists realise that we must understand how genes and proteins interact with each other to build the complex system that is a cell. Proteomics allows us to study many proteins at the same time to understand these interactions.

## HOW IS MACHINE LEARNING USED IN THIS FIELD?

Proteomics produces huge amounts of data on the many thousands of different proteins in a single cell. To process and understand these data, we need to use computational techniques such as machine learning. A network of proteins in a cell is not unlike a social network, and many of the computational tools that we use are similar to the algorithms Facebook is using. For example, we try to understand which proteins form communities and what those

proteins have in common. We have also used machine learning to predict the function of unknown proteins. By teaching the computer how well-known proteins behave, it has learnt to identify which features of a new protein will likely correspond to which functions in the body.

## WHAT IS THE FUTURE OF PROTEOMICS?

The next frontier for proteomics is the clinic. Over the past 10-20 years, we have seen how genomics (the large-scale study of DNA and genes) is transforming medicine and health care, and the potential of proteomics for medical research and diagnosis is even greater. I think proteomics has a great future and will be one of the key technologies for biomedical research and clinical diagnosis over the next decades. This is the most rewarding thing about working in this field.

## EXPLORE A CAREER IN PROTEOMICS

- Many countries have proteomics societies, such as the British Society for Proteome Research ([www.bspr.org](http://www.bspr.org)) or the US Human Proteome Organization ([www.ushupo.org](http://www.ushupo.org)). Find the proteomics society in your country at [www.hupo.org/National-and-Regional-Societies](http://www.hupo.org/National-and-Regional-Societies)
- Many academics and research institutions run outreach activities on cell biology, which can be a good route into proteomics. For example, The Wellcome Centre for Cell Biology at the University of Edinburgh runs events such as lab visits for secondary school students ([public-engage.bio.ed.ac.uk](http://public-engage.bio.ed.ac.uk))
- After completing a PhD, a proteomics researcher can expect a starting salary of around £34,300 which will increase with experience.

## PATHWAY FROM SCHOOL TO PROTEOMICS RESEARCHER

At school, study STEM subjects such as biology, chemistry, maths and computer science.

Proteomics can be entered through a wide range of undergraduate and postgraduate degrees, including biochemistry, molecular biology and bioinformatics. As Georg explains, "Proteomics is a very interdisciplinary research area. We need biologists, chemists, physicists, engineers, computer scientists and medical doctors."

Most proteomics projects struggle to find researchers with the required computational analysis skills. "So, whatever you do, make sure you learn some computer programming," advises Georg.

## GEORG'S TOP TIPS

- 01 Follow the ideas that genuinely interest you rather than second-guessing what other people might like to read about.
- 02 Recognise opportunities when they arise and be prepared to take advantage of them.
- 03 Get some hands-on lab experience early on.



# HOW DID GEORG BECOME A PROTEOMICS RESEARCHER?

**I didn't really consider becoming a scientist until my last year in high school, even though I almost failed biology that year.** I would have loved to become a musician (I spent most of my free time playing in a band) or a writer, but I did always like the idea of performing experiments.

**My earliest experiment that I can remember was when I tried to create a rainbow paint!** I ground up all my pencils and mixed them together in some water, stirring and cooking for days. Needless to say, that never worked! But then again, most experiments fail, at least the first time round.

**I don't believe that anyone is born as a scientist, or as anything else for that matter.**

If you enjoy doing something then you are going to be good at doing it, sooner or later. Many of the most successful scientists in the world have had very unusual career paths, and that probably goes for all walks of life.

**I had been an active researcher for 15 years before I received the funding to start my own research group.** I worked in several fields over those years, including cell biology, mass spectrometry and bioinformatics. Some people may consider that a lack of focus or poor career planning, but it has put me in a position to pursue a unique type of interdisciplinary research now.

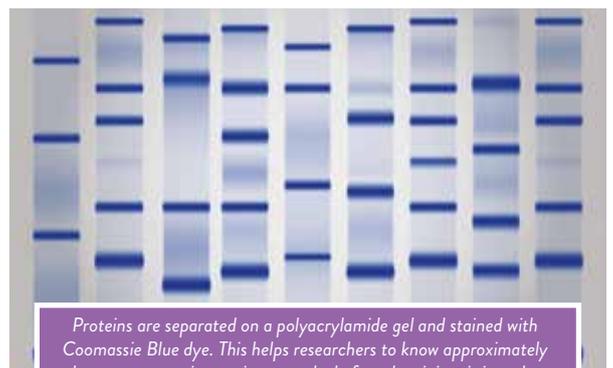
**Outside of work, I enjoy spending time with my family and being outdoors, playing**

**football or visiting the Scottish Highlands.** But fair warning: academic research is not really a 9 to 5 job, so you don't have too much free time as a scientist.

**My biggest career achievement was obtaining a group leader position in Edinburgh.** Running an independent research group has always been a dream for me, but has at many times felt unachievable, especially when trying to balance work and being a single parent, which I was for 5 years or so. I'm also proud that some of my research insights were added to a new edition of a famous biology text book, so students all over the world will learn about them!



*The result of a proteomics experiment where the concentration of proteins was measured in many mutant cells. A machine learning algorithm then grouped proteins together that were up- or down-regulated in similar ways across these mutants, suggesting that they are functionally related.*



*Proteins are separated on a polyacrylamide gel and stained with Coomassie Blue dye. This helps researchers to know approximately how many proteins are in a sample, before they inject it into the mass spectrometer.*

# HELPING TO DEVELOP A GONORRHOEA VACCINE

DR CYNTHIA NAU CORNELISSEN IS A MICROBIOLOGIST WHO RUNS HER OWN LABORATORY AT GEORGIA STATE UNIVERSITY IN THE US. HER CURRENT RESEARCH IS FOCUSED ON UNDERSTANDING MORE ABOUT GONORRHOEA. THE FINDINGS COULD ONE DAY LEAD TO A VACCINE FOR THIS SEXUALLY TRANSMITTED DISEASE

## TALK LIKE A MICROBIOLOGIST

**GONORRHOEA** – a sexually transmitted disease

**NEISSERIA GONORRHOEA** – a bacterium that causes gonorrhoea

**PATHOGEN** – an organism that causes disease to its host

**OBLIGATE HUMAN PATHOGEN** – a pathogen that must infect a human and cannot infect other animals and does not exist freely in the environment

**GLYCOPROTEIN** – a protein with a carbohydrate – or sugar – attached to it

**TRANSFERRIN** – glycoproteins found in

vertebrates which bind to and consequently mediate the transport of iron through blood plasma

**BACTERIAL PATHOGENESIS** – the process by which bacteria infect and cause disease in a host

**BACTERIAL PHYSIOLOGY** – a scientific discipline that concerns the life-supporting functions and processes of bacteria

**CHELATION** – a type of bonding of ions and molecules to metal ions

**METAL-BINDING PROTEINS** – proteins or protein domains that chelate a metal ion

Gonorrhoea is a sexually transmitted disease caused by the bacterium *Neisseria gonorrhoeae* (*N. gonorrhoeae*). The Centers for Disease Control and Prevention estimates that approximately 1.6 million new gonococcal infections occurred in the United States in 2018, and more than half occur among young people aged 15-24. The World Health Organization puts the global figure at 100 million cases every year.

The disease can infect both men and women and, like all sexually transmitted infections, cases have dramatically increased over the

past decade or so. There are some potentially serious implications of contracting gonorrhoea, such as pelvic inflammatory disease, ectopic pregnancy, and infertility – all of which can have significant implications for the fertility of the younger generation.

It is with these issues in mind that Dr Cynthia Nau Cornelissen is conducting research in her laboratory at the Institute for Biomedical Sciences at Georgia State University in the US. Cindi (Cynthia) is a microbiologist who leads a team attempting to characterise the virulence factors that enable *N. gonorrhoeae*

to cause infection. The findings from her team's research could lead to the development of a vaccine that prevents individuals from contracting gonorrhoea.

## THE NEED FOR A VACCINE

Like many bacterial infections and diseases, the overuse of antibiotics has led to antibiotic resistance in gonorrhoea. The genetic flexibility of the organism has given rise to an infection referred to as super gonorrhoea, which is when *N. gonorrhoeae* develops a high level of resistance to ceftriaxone, the antibiotic normally used to treat the infection. Such resistance has led to a scenario where untreatable gonorrhoea could soon become a reality. With antibiotic resistance reaching critical levels, a better way to approach this problem is by developing a preventative vaccine to protect against gonorrhoea disease. "Researchers have been trying to develop vaccines against this pathogen for decades, but the variable surface structure of *N. gonorrhoeae* has thwarted these efforts. The gonococcus has been referred to as a chameleon because almost all of its surface structures are subject to high-frequency variation. This variation means that the human immune response cannot keep ahead of the variation, plus these surface structures are so variable among different strains, that their use in a vaccine would not be universally protective," explains Cindi. "So, our approach has been to try to identify proteins on the cell surface that are necessary for the pathogen to grow and cause disease but that are also not subject to high



## DR CYNTHIA NAU CORNELISSEN

Director of the Center for Translational Immunology, Associate Director Institute for Biomedical Sciences Georgia State University, USA

### FIELD OF RESEARCH

Microbiology and Immunology

### RESEARCH PROJECT

Characterising virulence factors that enable the sexually transmitted pathogen, *N. gonorrhoeae*, to cause infection, with the aim of developing a gonorrhoea vaccine

### FUNDERS

National Institute of Allergy and Infectious Diseases, National Institutes of Health

frequency variation. Nutrient transporters fulfil these requirements, so we are pursuing them as potential vaccine components.”

Cindi has been studying the physiology of bacteria, i.e. how bacteria develop and flourish, since she was an undergraduate at college. All of her training has led her to pursue the hypothesis that blocking nutrient transport to interfere with bacterial growth will be the key to prevention and perhaps lead to the development of novel treatments, too.

### INVADING PATHOGENS

Nutritional immunity is a form of innate immunity. The human host goes to great lengths to hide metals from invading pathogens. This is an attempt to thwart the microbes because these metals are critical to microbial replication and pathogenesis. Human hosts do so by making a whole suite of proteins that bind to metals with very high affinity. “Most pathogens try to overcome this metal restriction by producing low molecular weight molecules called siderophores. These metal cages can also bind metals, mostly iron, with very high affinity,” says Cindi. “In this way, the pathogens can compete with the human metal-sequestering proteins and overcome nutritional immunity.”

### METAL PIRACY

Interestingly, *Neisseria gonorrhoeae* does not have the genes that enable it to produce siderophores. Instead, it can use siderophores produced by other bacteria, such as *E. coli*. But *N. gonorrhoeae* also uses the metal binding proteins directly, in a process the team has called metal piracy. “They actually hijack the human metal binding proteins by directly binding these proteins to bacterial outer membrane receptors,” explains Cindi. “When this binding event happens, the bacteria can literally extract the metals from the host proteins, internalise the iron, and then release

the host protein back into solution without breaking it down or changing it in any way. This pathogen is very stealthy.”

### IRON TRANSPORT

Humans produce a series of nutritional immunity proteins. Some of these bind to iron and some bind to other important transition metal proteins, such as zinc and manganese. Examples of these proteins are transferrin and lactoferrin, which bind iron, and some S100 proteins, which bind to zinc and manganese. The outer membrane proteins produced by *N. gonorrhoeae* can directly bind to these human metal sequestering proteins and relieve them of their metal cargo.

### IN THE LAB

Cindi and the team use a range of genetic techniques, including bacterial transformation and PCR, also known as polymerase chain reaction. (A modified form of PCR called reverse transcriptase-PCR, or RT-PCR, is used to detect coronavirus.) The team also uses fluorescent techniques, including confocal microscopy and it does a lot of gene expression studies using techniques like RT-qPCR and RNA-seq. Fascinatingly, the lab also grows *N. gonorrhoeae* – a necessity for a team intent on finding a means of thwarting it. This can be challenging because *N. gonorrhoeae* is known for being quite picky about the conditions it needs to grow; the team cultures it in media that are very rich in nutrients, and at human body temperature in an environment that includes 5 percent CO<sub>2</sub>.

### SUCCESSSES

When Cindi was a postdoc, she and the team showed that a *N. gonorrhoeae* mutant that could not produce the transferrin receptor was unable to cause experimental infection in human males. Since then, Cindi’s laboratory has shown that these nutritional immunity protein receptors are exquisitely specific for

the human forms of the metal binding proteins. “They do not recognise any other forms of these proteins, including those of mice or other mammals. This means that animal modelling with this pathogen is exceedingly difficult,” explains Cindi. “We have also shown that these outer membrane receptors are very well conserved, critical to survival and are potential vaccine or drug targets in the future.”

### THE NEXT STEPS

Cindi and the team are collaborating with several groups that do vaccine studies to test whether outer membrane proteins can protect against *N. gonorrhoeae* infection. Such experiments are challenging because the receptors do not bind to the mouse forms of these proteins; the team has to produce transgenic mice that produce the human forms of the nutritional immunity proteins. It is a long process, but one that will reap significant rewards if successful. Incredibly, Cindi was once told she would never make it as a scientist! We can see how far she has come and how determined she is to succeed at this challenging task.

# ABOUT MICROBIOLOGY

Microbiologists study micro-organisms like bacteria, viruses, fungi and algae, which means the field is enormously complex and diverse. For those that achieve the necessary qualifications to study microbiology, you could just as easily end up working for a company as you could work as an academic in a laboratory – it all depends on which area you want to head into.

Because of the diverse nature of the work, it is difficult to sum up the field in a nutshell. In Cindi's case, she is focused on developing experiments that could one day lead to a gonorrhoea vaccine, but you could find yourself working on the study of nematodes or parasites. Irrespective of the specific area that any given microbiologist is focused on, the principles are the same and involve studying extremely small examples of life.

## THE REWARDS

Above anything else, Cindi is excited to go to work every day. "I love doing and teaching microbiology. I have taught all types of students at all levels about the wonders, and perils, of microbiology. I have given lectures to elementary, middle and honours high school students," says Cindi. "I taught medical and dental students for decades, in addition to graduate students. I love training the next generation and microbiology is certainly my passion."

## THE NEXT GENERATION

The COVID-19 pandemic has certainly brought the importance of microbiology into sharp focus. "I think the last two years have taught us that pathogens will continue to emerge, and that the next worldwide pandemic could be right around the corner," explains Cindi. "Microbes are always evolving

to become more effective pathogens, even if that means they are more transmissible, but not more virulent. Or maybe it means they change to escape existing immune responses, whether vaccine-mediated or due to natural infection. We can never turn a blind eye to microbial evolution. I also think we will have to do a much better job of overcoming vaccine hesitancy."

## A PASSION FOR MENTORING

Ultimately, the reason for Cindi's passion in this area is that we need more STEM-trained citizens. "The next generation of scientists can go on to do many important things in society, including communication, administration, clinical microbiology, industry, academia, or even enter politics!" says Cindi. "We need more scientific literacy at large and training an outstanding next generation of scientists is the best way to get there."

## EXPLORE A CAREER IN MICROBIOLOGY

Microbiology societies play an important role in helping students develop their career.

Check out the American Society for Microbiology, which features a wide range of resources for budding microbiologists: [asm.org/Articles/2018/November/Careers-in-Microbiology-and-the-Microbial-Sciences](https://asm.org/Articles/2018/November/Careers-in-Microbiology-and-the-Microbial-Sciences)

The Microbiology Society also provides a wealth of interesting careers resources: [microbiologysociety.org/members-outreach-resources/careers-resources.html](https://microbiologysociety.org/members-outreach-resources/careers-resources.html)

According to Payscale.com, the average salary for a microbiologist in the US is \$55,000.

## PATHWAY FROM SCHOOL TO MICROBIOLOGY

Cindi believes it is critical that students have a firm background in chemistry, especially biochemistry and cell biology, to be successful in microbiology. "Other sciences are obviously helpful too, but some subjects are more critical than others," she explains. "I would also say that knowing something about coding and computer science will be valuable. Bioinformatics has become a huge part of the microbial sciences."

## CINDI'S TOP TIPS

- 01 Never listen to any people that tell you cannot do science. I was told that upon applying to college and it only served as motivation to work harder!
- 02 Try your best to put everything you have into your education and career – it is the best way of ensuring you will be successful.
- 03 If you are interested in pursuing a career in microbiology, do your best to join a society. I have been an active member of the American Society for Microbiology for decades. They provide conference and workshop opportunities for all levels of microbial scientists.



## HOW DID CINDI BECOME A MICROBIOLOGIST?

**I was always very immersed in school.** I gravitated towards biology, chemistry and physics. I was lucky in that I also always read a lot. Interestingly, in my freshman year in college, I took a mandatory composition course. My professor told me that I would never write a flowery novel but that I would be very good at scientific writing. That advice and realisation served me well in my chosen career!

**I think my upbringing in a very small town in southern Illinois spurred me to work really hard to get into and then through college.** I very much wanted a career in science and knew that it would take a college degree, at least, to get me there. There was always the expectation that I would go to college when I was growing up. I did well in high school and got a partial scholarship as a result. I always felt it was up to me to work as hard as I possibly could to get where I wanted to go. Nothing would be given to me.

**I evolved into realising that I could be a scientist. I think I always wanted to be**

**one but didn't have any role models.** I took all science courses in college – biology, chemistry, physics, math and computer science – , but when I started working as a dishwasher in a microbiology lab, I learned what microbiology was all about. After that, I declared microbiology as my major, and did a senior research project in the same lab. By this time, I was also doing all of the lab ordering and maintenance. In retrospect, these experiences really helped me in setting up my own lab. I ended up acquiring both a MSc and PhD in microbiology but wasn't sure that I wanted to be a professor. My postdoctoral mentor allowed me the freedom to do research, have a family and get my first grant. From that point forward, it didn't matter if I didn't have any role models. I decided I wanted to be a role model for others; thus, my desire to help mentor and train the next generation.

**I overcome scientific obstacles by facing them, asking questions and reading the literature.** Switching off from work is a different matter – it's about a work-life

balance. When my children were small, spending time with them was my only 'hobby' outside of work. I have a supportive husband who helped me juggle all the parental responsibilities. After the kids grew up, my husband and I cultivated new hobbies. We sailed for years on the Chesapeake Bay when we lived in Virginia. Now that we are in Georgia, we have other fun 'switch off' activities, such as swimming, hiking and camping. These activities are very important to staying balanced and not burning out.

**What are my proudest achievements?** Being awarded my first NIH grant, being promoted to Full Professor, being the first author on two textbooks and one set of microbiology flash cards, being awarded an NIH programme project grant, being inducted as a fellow into the American Academy of Microbiology, and being promoted to Associate Director of the Institute for Biomedical Sciences at GSU! I am also enormously proud of all of my trainees and students.

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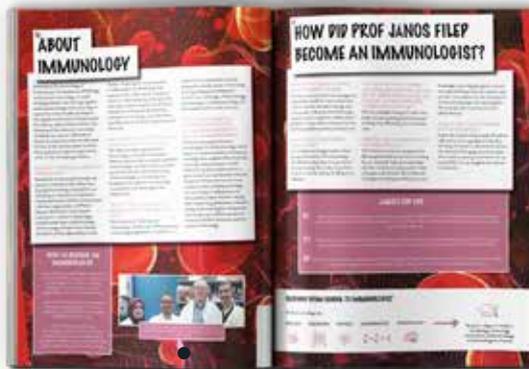


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