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February 2026

EUK Education

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Inspiring students to pursue engineering

Young Caregiver Council of Canada
Fostering community and advocating for change

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WELCOME

ISSUE 36
Tackling misconceptions

It is easy to have misconceptions – about a field of study, an industry or a career path, and about people's abilities, including our own. But we can overcome these misconceptions, and exposure and advocacy are highly effective ways of doing so.

Charlie Cantwell, Marketing and Communications Manager at EngineeringUK, explains how the EUK Education initiative is exposing young people to opportunities in engineering (p 04). There is a common misconception that engineering is only suitable for a specific type of person, but, in reality, the field is hugely varied. "Engineers work in so many different sectors – from food and fashion to transport and climate change solutions," says Charlie. "They get to be creative, solve problems and make a difference in the world."

Motivated by her own experience as a young carer, Rebekah Gold co-founded and leads the Young Caregiver Council of Canada (YCCC), which advocates for young carers (p 48). Many people do not understand what caregiving involves and some carers may not even see themselves as such, so it is easy to underestimate the knowledge and skills that carers have. "The YCCC lifts up young carers as leaders, wisdom-holders, advocates, storytellers and change-makers across Canada," says Rebekah.

Neurovascular epidemiologist Dr Timothy Hughes reflects on his time in high school, when he struggled to see "the direct relevance" of some subjects (p 70). Tim embraced the challenge of 'learning-to-learn' and, despite initially having had misconceptions about what epidemiology entails, is now a neurovascular epidemiologist. He is inspired by the field he once misunderstood and values the range of projects he gets to work on.

Misconceptions can limit what we expect of ourselves and others, but the inspiring researchers who feature in Futurum remind us that career paths can take unexpected turns, with rewards found in unexpected places. Expose yourself to their stories...

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Inspiring students to consider careers in engineering

The UK is facing a shortage of skilled engineering and technology professionals. To address this, **EUK Education** provides STEM lesson plans and competitions, along with engineering role-models, to help teachers increase students' interest in the field. **Charlie Cantwell**, Marketing and Communications Manager at **EngineeringUK**, tells us about the range of resources and activities available to inspire young people to consider careers in engineering.

What ideas and misconceptions do young people commonly have about careers in engineering?

Overall, young people have some understanding of engineering and engineering careers. Our research shows that 32% of young people surveyed know a fair amount about what engineers do. However, more needs to be done to encourage them that a future career in engineering is for them, especially girls. Just 16% of girls surveyed said that engineering is suitable for them, compared with 44% of boys.

A common misconception is that engineering is a career for a specific type of person. The reality is that engineering and technology jobs offer a wide range of opportunities for young people. Engineers work in so many different sectors – from food and fashion to transport and climate change solutions. They get to be creative, solve problems and make a difference in the world.

Why did EngineeringUK launch EUK Education?

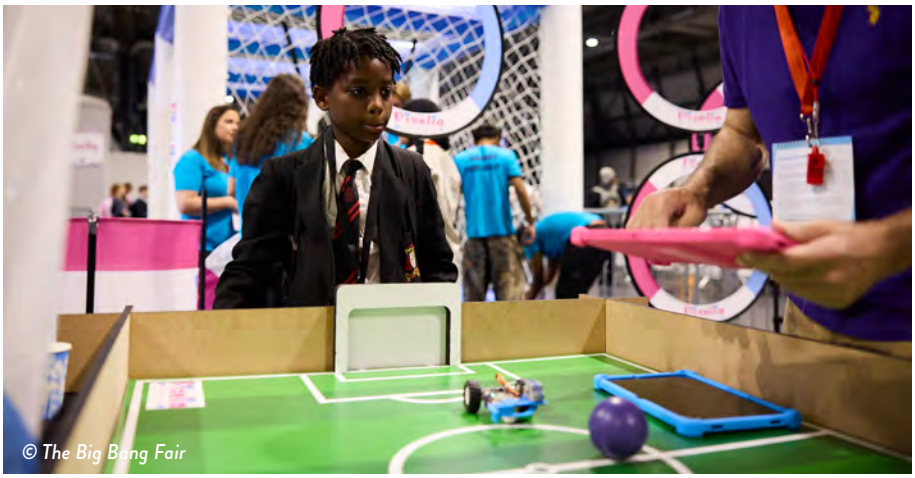
The engineering and technology sector employs 6.3 million people in the UK, accounting for 19% of all jobs. But the sector is facing a huge skills and labour shortage. More needs to be done to encourage young people from all backgrounds into careers in engineering and technology.

We launched EUK Education to give educators everything they need to inspire and encourage young people into STEM and to increase their knowledge of the diverse career paths available. EUK Education provides free curriculum-linked lesson plans, activities, competitions and programmes. These resources all support teachers to showcase a wide range of STEM role models to their students, as well as highlighting future jobs and routes into careers in engineering and technology.

How do you support teachers to find STEM activities and resources?

EUK Education hosts **Neon**, the UK's dedicated platform helping primary and secondary teachers find quality-assured engineering and technology activities. There is so much to discover on Neon, from live lessons, assemblies and guest speakers to technology-focused workshops, school trips and exciting competitions.

We take the guesswork out of finding external activities, as everything on Neon is checked by our expert team. This means that, as a teacher, you can be confident that what you are booking is high quality, impactful and good value. With filters and location-based searches, you can find



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the perfect STEM activity for your class. You can also use the cost filter to find free experiences – whatever your school budget, we have a wealth of activities for you.

What annual events can students look forward to?

Every year, we host **The Big Bang Competition** and **The Big Bang Fair**.

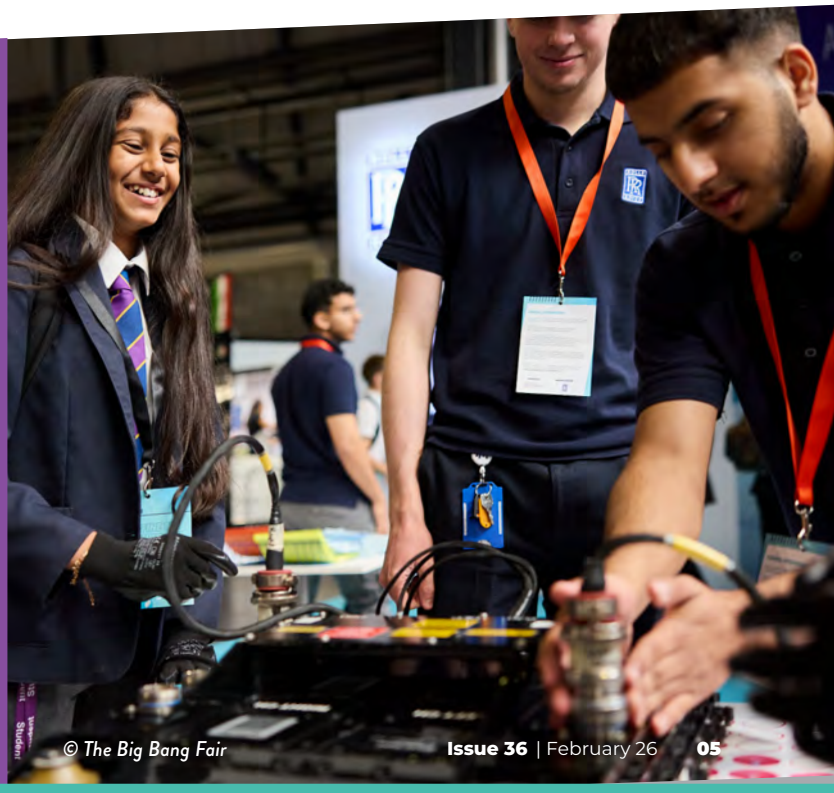
The Big Bang Competition aims to inspire students to bring their ideas to life and celebrate their skills. Projects can be on any topic in STEM, and they don't need to be perfect or finished – it's all about the journey! The Big Bang Competition celebrates projects of all shapes and sizes, from climate change to life-saving healthcare. UK students aged 11 to 18 can enter individually or as a team, with no limit on team size. For the 2026 competition, **enter for free** by 5 pm on 4th March. If you miss the 2026 event, try again next year!

The Big Bang Fair is the UK's largest celebration of STEM. It brings together workshops and activities from all over the STEM community. From cutting-edge tech and robots to renewable energy, biology and sustainability – we have it all! There are also exclusive live shows, careers panels where students can meet real STEM professionals, and hundreds of exciting hands-on activities to get stuck into. This year, we'll be at the NEC in Birmingham from the 9th to the 11th of June. Tickets are completely free, and schools can book to attend a morning or afternoon slot.

What do students gain from participating in The Big Bang Competition?

A real highlight of The Big Bang Competition is seeing students grow their skills and confidence in STEM. Every student who enters a project in the competition gets feedback from real STEM professionals working in a similar field, which helps them expand their skills and knowledge.

> ***"A common misconception is that engineering is a career for a specific type of person. The reality is that engineering and technology jobs offer a wide range of opportunities for young people."***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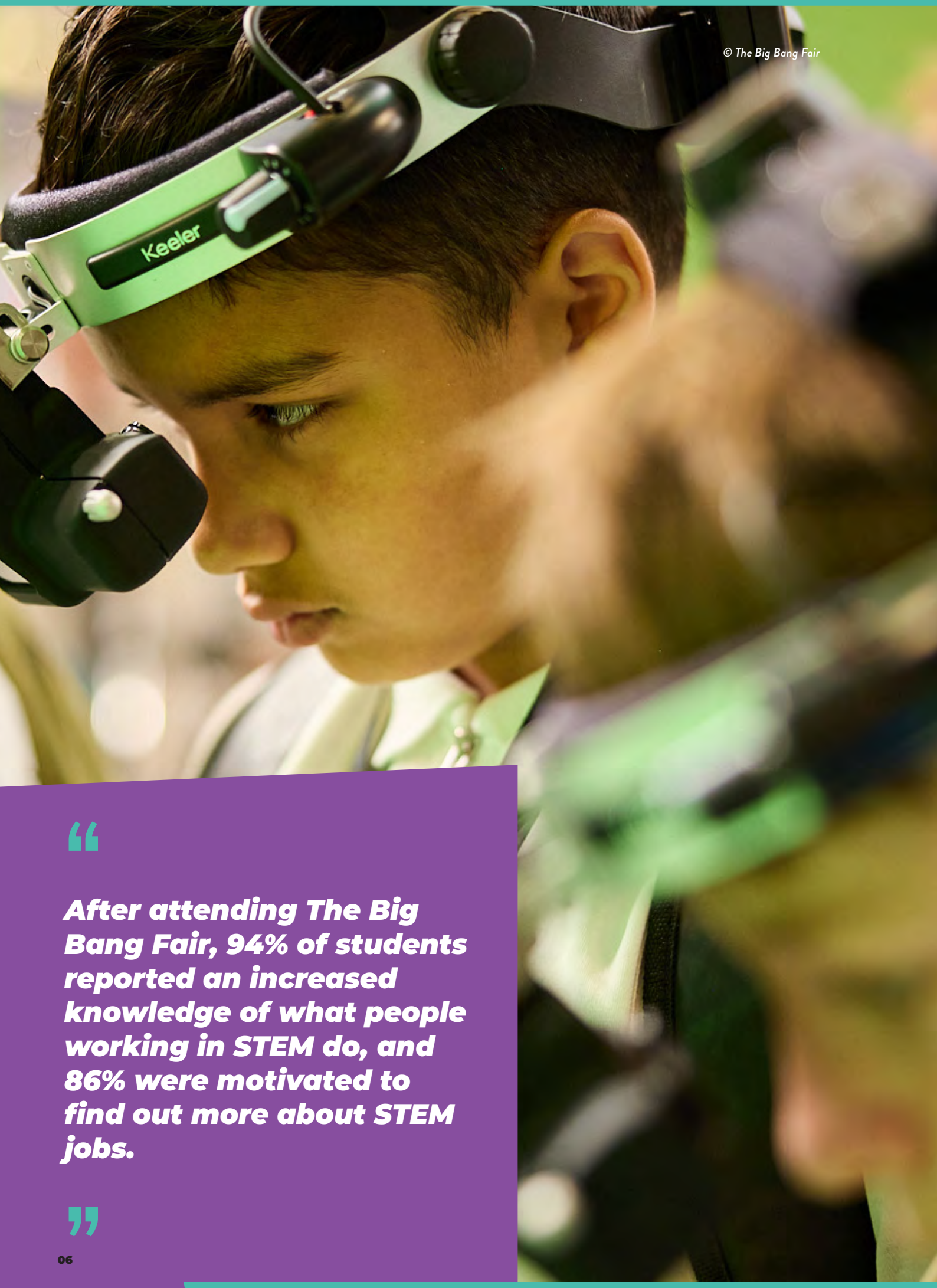

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After attending The Big Bang Fair, 94% of students reported an increased knowledge of what people working in STEM do, and 86% were motivated to find out more about STEM jobs.

Find out more

EUK Education: eukeducation.org.uk

Engineering UK: engineeringuk.com

The Big Bang Competition: thebigbang.org.uk/the-big-bang-competition

Entry deadline: 5 pm, 4th March 2026

The Big Bang Fair: thebigbang.org.uk/the-big-bang-fair

Dates: 9th to 11th June 2026
Location: NEC, Birmingham

Neon: neonfutures.org.uk

We truly celebrate students' amazing ideas. Prizes include international celebrations and conferences, work experience opportunities, and cash sums. Some students have even gone on to patent their inventions or share their projects on TV shows such as *Steph's Packed Lunch* and *BBC Breakfast*. There's so much to gain from entering The Big Bang Competition!

How is The Big Bang Fair increasing students' interest in STEM?

The Big Bang Fair is an amazing tool for engaging young people in STEM, and attendance makes a real difference in their STEM outcomes. Our evaluation shows high levels of enjoyment – in 2025, 88% of students who attended The Big Bang Fair said they enjoyed it. This is across the board for all young people, with no significant differences by gender, ethnicity, disability, free school meal eligibility or school type. And teachers love The Big Bang Fair too! In 2025, 98% of educators rated it as 'excellent' or 'good'.

What other programmes are available?

EUK Education also runs **Energy Quest**, which highlights the role of engineering in the renewable energy sector, and the **Climate Schools Programme**, which showcases the role of STEM careers in creating climate change solutions. The Climate Schools Programme also supports cross-curricular learning – why not team up with colleagues in English and geography to deliver lessons focusing on debate, government policies and more?

What impact is EUK Education having on young people's engineering career aspirations?

We're pleased to say that we're making a difference! After attending The Big Bang Fair, 94% of students reported an increased knowledge of what people working in STEM do, and 86% were motivated to find out more about STEM jobs. We know that students have an interest in topics that support a career in engineering. For example, 64% of young people are interested in climate change issues, and 35% are interested in a career that will reduce the impact of climate change. We're confident that by continuing to support teachers to deliver impactful STEM engagement activities, we will make a real change for students. Together, we can show students how they can tackle the issues that matter to them and shape the future of the engineering workforce.

"We launched EUK Education to give educators everything they need to inspire and encourage young people into STEM."

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Building community resilience for disaster response

Natural and man-made disasters can destroy infrastructure and take lives – but the way that communities and organisations respond is what defines the magnitude of their impact. Digital infrastructure, such as social media and artificial intelligence, present opportunities for improving responses, but also present challenges around equity and accessibility. **Dr Christin Salley** at **Virginia Tech** in the US is researching how community resilience efforts can be optimised through the careful and effective integration of technologies into disaster preparation and response.

Dr Christin Salley

Research Assistant Professor, Department of Civil and Environmental Engineering, Virginia Tech, USA

PROFILE

Fields of research
Infrastructure systems; applications of AI; community resilience; disaster studies; human-centred design

Research project
Investigating how digital infrastructure can improve community resilience in emergency situations

Funders
Schmidt Sciences; Virginia Tech Institute for Society, Culture, and Environment

doi: 10.33424/FUTURUM677

Talk like an ... infrastructure systems engineer

Disaster literacy — the ability to access, understand and apply information about disaster risks and responses to make informed decisions

Infrastructure — the physical and organisational structures needed for a society to operate

Resilience — the ability to withstand and/or recover quickly from challenges or damage

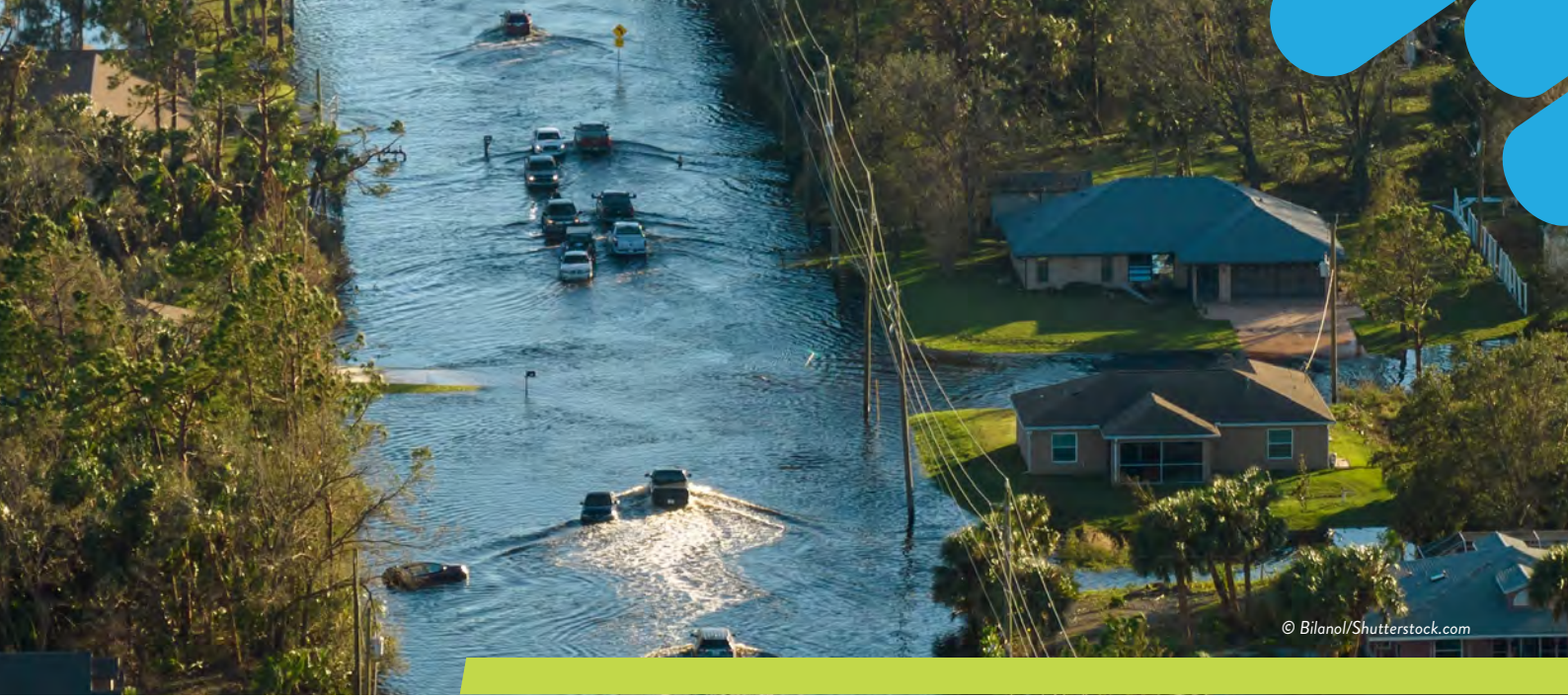
Two-way communication — an interactive form of communication where both parties involved share and receive information, enabling mutual engagement

Disasters, whether natural or man-made, can be catastrophic for communities. We've all seen news reports about devastating earthquakes, floods or terrorist attacks and felt shocked and powerless to help. When these emergencies occur, it is often the stories of teamwork and community resilience that give us hope. However, some communities are more prepared for these situations than others, depending on the quality of their infrastructure and their ability to communicate effectively. Dr Christin Salley at Virginia Tech is investigating how digital infrastructure, such as social media and artificial intelligence (AI), can help communities prepare for and respond to emergencies.

Community resilience

Community resilience is the ability of a community to withstand and recover from the negative impacts of a disaster. "Many factors affect community resilience including access to resources, effective infrastructure systems, clear and trustworthy communications, strong social connections, and the ability to work together," says Christin. Much of her work focuses on how technology can improve community resilience, particularly when it is used for communication.

When disaster strikes, effective communication is vital. "Without effective communication, important information can be delayed or confused, and organisations may struggle to make coordinated decisions," says Christin. "When this happens, the safety of communities can be put at risk." Technical limitations and a lack of capacity can make it difficult for organisations to gather and combine data from various sources to develop a clear picture of the emergency situation, and to share accurate, timely, actionable information with communities in need.



In today's world, for better or worse, people often communicate through technology such as phones, computers and social media platforms. While this digital communication may have drawbacks, it also facilitates the rapid sharing of information between large groups of people and organisations. To build community resilience, these communication efforts must begin long before disaster strikes, so that people know what to do in an emergency situation. "Disaster literacy is powerful," says Christin. "Knowing what to do, where to find resources and who to contact for help makes a huge difference to the outcome of an emergency."

Two-way communication

Rather than simply disseminating information, organisations involved in disaster response should engage in two-way communication with affected communities by listening and responding to their needs. "Effective two-way communication can help to ensure that people get the help and resources that they need," says Christin. "It also helps disaster response organisations build trust with community members."

In disaster situations, trust is especially important. For communication efforts to work during an emergency, communities need to be able to trust the information that they are receiving, and the organisations providing that information. "This trust is important because it supports community resilience," says Christin. "When there is trust between groups, there is better cooperation and participation in the response to a disaster." However, it is difficult to build this trust in the midst of a disaster; instead, the relationship-building must begin before an emergency takes place. "For example, intentionally including community voices in disaster preparation and planning means that communities feel heard and that their needs are acknowledged," explains Christin.

> ***"When there is trust between groups, there is better cooperation and participation in the response to a disaster."***

Social media can help facilitate two-way communication, though Christin cautions against over-reliance on it. "Not everyone is active online, and the people who engage with social media only represent a portion of the community," she says. "Social media should be used as an additional tool to support risk communication, but not the only tool." Planning efforts should therefore aim to make use of social media's strengths. For example, social media allows organisations to quickly share on-the-ground information, such as damage to infrastructure, and gives people a platform to communicate their needs and express their feelings during and after a disaster. However, it should not be assumed that information shared on social media will reach all of the people who need it.

AI for disaster response

AI is also proving to be an increasingly useful tool for emergency response. "It can be an assistive tool and help with certain time-consuming tasks, freeing up capacity for meaningful community outreach, communication and discussion," says Christin. "However, there are concerns around bias and access." AI tools are 'trained' on huge amounts of data, allowing them to make human-like decisions. However, if this training data is biased, the AI tool can reinforce social inequities. "For example, if an AI is trained on data mostly from one demographic group, it may work better for that group but not as well for other people," says Christin.

Other AI-related challenges are more practical. "It is expensive to buy, operate and maintain AI tools," says Christin. "There are also generational differences in people's comfort with using new technologies." It is important to address all of these concerns to ensure that AI is used effectively in disaster response – in ways that are equitable, cost-effective and accessible to all. "I am starting new projects to develop benchmarks and reduce bias in AI, specifically for emergency call systems," says Christin. "I want my research to lead to real social good."

Christin has lots of projects in the pipeline, not just focusing on AI. "I will also research community engagement, risk communication and modelling, and how to combine multiple datasets to better understand emergency situations," she says. "Along the way, I also hope to mentor others and strengthen disaster communications efforts across the world."

About *infrastructure systems engineering*

Infrastructure is all around us. Roads, electricity, water, public services and health networks are all systems that keep society running. "Infrastructure touches so many parts of life, which means there are many different pathways to work in this field," says Christin. "You can find a career in infrastructure systems not just through engineering, but also through public health, medicine, urban planning and other fields."

A big challenge for working with digital infrastructure systems is ensuring that the data being used is high-quality and representative. "It's important to include many different perspectives when making decisions about infrastructure," says Christin. "Sometimes this means creating new data, which takes time and active participation from community members." Christin uses and supplements existing datasets, creating new data through surveys, interviews and workshops with the people affected by the project in question. "You may not be able to solve everyone's problems at once, but by focusing on one problem at a time, you can make meaningful progress," she says.

And because infrastructure is all around us, it is no surprise that careers can be found in many different sectors. "This is a highly interdisciplinary field," Christin says. "Academic institutions, governments, national laboratories, private industry and consultancies, non-profits and community organisations, public policy and advocacy organisations, and environmental and sustainability organisations are all looking for specialists in infrastructure systems."

Pathway from school to *infrastructure systems engineering*

At school, build a foundation in mathematics, physics, computer science and other sciences. The humanities can also provide a useful lens to build a more holistic understanding of the world.

Although Christin mentions that many fields can lead to a career in infrastructure systems, her own path involved studying engineering. She recommends taking core engineering modules at university, but supplementing these through classes in the humanities, public health, urban planning or computing.

Explore careers in *infrastructure systems engineering*

Christin recommends exploring the different types of infrastructure systems and thinking about which of them you are most interested in. The US Cybersecurity and Infrastructure Security Agency provides a list of sixteen critical infrastructure sectors to get you started: **cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors**

Virginia Tech has several programmes to help young people get involved in engineering, such as those hosted by the Center for Engineering Excellence and Discovery: **eng.vt.edu/ceed/ceed-pre-college-programs.html**

Virginia Tech also runs summer programmes for high school students throughout the greater Washington DC area: **dcarea.vt.edu/k12/camps.html**

Download Christin's resources from **futurumcareers.com/building-community-resilience-for-disaster-response**

Meet *Christin*

I was interested in both sports and the arts as a teenager. Sports taught me perseverance and resilience in the face of adversity, while the arts nurtured my creativity and curiosity. On top of that, my family and friends played a formative role in shaping who I am today.

My desire to help others led me to pursue engineering. I wanted a career where I could make a meaningful difference in everyday life. Engineering was once described to me as 'helping behind the scenes' – solving complex problems in ways that quietly but profoundly improve society.

I love many aspects of my job. It gives me the chance to creatively solve problems, work alongside communities and collaborators, and meaningfully contribute to society. As a professor, I also love mentoring the next generation of scholars and leaders, encouraging them to pursue careers centred on social responsibility.

Infrastructure is everywhere and affects everyone. The roads we travel on, the water we drink, the electricity we rely on – all are infrastructure. Disasters can create chain reactions affecting many elements of infrastructure, and therefore lives, so it's important to keep improving how these systems are designed, maintained and managed to better protect people, communities and the environment.

The support of mentors and loved ones has been integral to building my career. Throughout every stage of my life, I've always had at least one person who believed in me. That really matters. Even when you are determined and resilient, the path is not always straightforward. Having someone who can listen, offer advice or help you think through your next steps can make all the difference.

After work, I love binge-watching my favourite TV shows, travelling, or catching up with friends and family. When I was younger, I enjoyed baking, and lately I've been rekindling that love!

Christin's *top tips*

1. Find a topic or real-world problem that truly interests you, and choose an engineering field that will enable you to work in that area.
2. Don't shy away from engineering just because it seems challenging – anything worth pursuing takes effort.
3. There is no 'right' timeline for becoming an engineer. You will not be 'late' if you have not had prior exposure to the field or if you study or work in another area before coming to engineering.

Preparing the world for the next generation of flying machines

Advanced air mobility could revolutionise how we transport people and goods. The technology for new aerial vehicles, focused on sustainability and automation, is developing fast – but to make them a reality, we need to understand how they can integrate into today's world. In Canada, **Professor Jean-Marc Frayret**, of the **Polytechnique Montréal**, and his colleagues at the **SDG Institute of Advanced Air Mobility** are using advanced 'digital twin' simulations and other industrial engineering techniques to research how technologies such as drones, flying taxis and vertiports could move from science fiction to reality.

Professor Jean-Marc Frayret

Department of Mathematical and Industrial Engineering, Polytechnique Montréal; Director of Research, SDG Institute of Advanced Air Mobility, Canada

Fields of research
Industrial engineering; aeronautics; business administration; computer sciences

Research project
Advanced air mobility research in Canada

Funders
Aéroports de Montréal; Humanitas Solutions

Collaborator
Espace Aéro

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PROFILE

Talk like an ...

industrial engineer

Advanced air mobility (AAM) — a rapidly-emerging aerospace sector focused on systems that support next-generation air transport

Aerospace — the science and industry of aircraft and spacecraft

Digital twin — a virtual representation of a physical system, object or process that uses real-time data to support design and operations decisions

Demographic — relating to different groups within a population of people

Drone — a flying device that can be controlled remotely

Hybrid — combining two or more energy sources (eg., a hybrid car can run on electricity or petrol/diesel)

Optimise — making something the best it can be (for example, the most energy efficient)

Vertiport — a take-off and landing site for aircraft that take off and land vertically

Flying cars, electric planes and AI-powered delivery drones are regular features in science fiction, but it might not be long until they become a reality. However, it is not as simple as developing these technologies and releasing them into the world. Before these technologies can become part of our daily lives, a few conditions must be in place, such as supporting infrastructure and networks, operational knowledge and societal acceptance.

These new technologies are known collectively as advanced air mobility (AAM). "AAM is a new transportation system that uses innovative aircraft, often electric or hybrid, that are capable of vertical take-off and landing," says Professor Jean-Marc Frayret of Polytechnique Montréal and the SDG Institute of Advanced Air Mobility. This transportation includes the movement of people and goods in both urban and regional contexts and opens up a wide range of possibilities: air taxis, flying ambulances, and drones of all sizes and capabilities, to name a few. "AAM can help reduce the carbon footprint of existing mobility systems, provide new flexible transportation options, accelerate supply chains and enable advanced data collection," says Jean-Marc.

Why Canada?

The SDG Institute of Advanced Air Mobility is based in Montréal, Canada, and for good reasons. "Montréal is recognised as a global aerospace hub, home to major manufacturers and a highly developed industrial ecosystem closely connected to local universities and colleges," explains Jean-Marc. "More broadly, Canada has a uniquely rich environment for studying and deploying AAM, combining real-world

© Jean-Marc Frayret

complexity with world-class expertise." The region has a wide array of terrains and environments, from fields to forests to cities. "This geographical variability is matched by Canada's extreme climatic variability," says Jean-Marc. "From winter snowstorms to summer heatwaves, we can test AAM systems under many different environmental conditions."

Urban centres like Montréal suffer from severe traffic congestion and have a high demand for sustainable transport alternatives – challenges that AAM could provide solutions to. In contrast, Canada's rural northern communities are very hard to reach over land, which impacts the services, resources and opportunities they can access. AAM could potentially connect these communities, offering easy transport of both people and resources between remote and highly-populated areas.

Preparing for take-off

Integrating such radically different vehicles into our current system will not be straightforward – which is where scientists, managers, social scientists and engineers, like Jean-Marc and his team, come in. "AAM is not just about new aircraft and propulsion technologies," he says. "Its success depends on building a complete ecosystem of interconnected social and technical systems." This will involve a huge shift in societal infrastructure, but the team is up for the challenge.

"One facet of this new ecosystem that we're focusing on is 'vertiports' – the places where AAM vehicles can take off, land, recharge and board passengers or cargo," says Jean-Marc. "This includes both high-tech hubs in urban areas and simple landing pads in remote areas." Jean-Marc's team is developing advanced decision-support systems to facilitate this process, considering suitable vertiport locations, energy requirements and how such ports will operate day-to-day.

In addition to designing, building and supplying these facilities, policymakers will need to design measures to effectively manage this new influx of vehicles. "This will require a new generation of air traffic management tailored to low-altitude operations, including unmanned vehicles," says Jean-Marc. "Unlike traditional air traffic control, this system will consist of digital, automated systems designed to coordinate both piloted and autonomous aircraft." Getting these systems right is crucial – errors could result in catastrophe. But a smooth system could enable fine control of many aircraft at once, far beyond what humans could achieve manually.

Digital twins

To trial such systems before they become a reality, Jean-Marc and his team use simulations. "A digital twin is a virtual replica of a physical system that simulates, predicts and optimises real-world performance," explains Jean-Marc. "Digital twins can represent individual aircraft, vertiports or even the entire mobility network of a city." An important factor that distinguishes digital twins from traditional systems is that they are directly connected to live operational data – meaning they evolve over time. "We can test scenarios such as weather disruptions, emergency landings or passenger demand peaks in a safe virtual environment," explains Jean-Marc. "This supports decision-making in the real world around the development and eventual operation of AAM systems." These models will lay the groundwork for new AAM systems, as well as build societal confidence in these technologies. "We have to integrate societal realities," says Jean-Marc. "This includes seasonal challenges, demographic diversity and social acceptance." One aspect of this involves demonstrating how economically feasible AAM systems are – that, financially, they can be created and maintained. Another aspect involves thinking about how wider society will respond to these changes. Many people will have serious reservations about these technologies and how they may be used or abused. "Citizens must perceive AAM as beneficial, fair, safe, and not disruptive or elitist," says Jean-Marc. "This means they must be designed and implemented with these perceptions in mind."

What's next?

The team's research is in its early stages but has already made significant leaps. "We have a running vertiport simulation model that enables us to study the flow of passengers through the travel process," says Jean-Marc. "This means we will soon be able to assess the relationship between passenger experience and vertiport design features."

The team has also begun creating a 3D model of Montréal's airspace and how it is currently used, with the aim of integrating AAM systems to understand how all airspace users can coexist. "For the rest of the programme, we need to recruit students!" says Jean-Marc. "The work and ideas of the next generation of industrial engineers are essential for our success."

About *industrial engineering*

Industrial engineering involves the design, operation and continuous improvement of industrial processes, in particular optimising complex systems. "Industrial engineering can be applied to any complex system where people and technologies interact, which is intrinsically rewarding," says Jean-Marc. Work in this field requires many different disciplines coming together, from expertise in fundamental engineering principles through to knowledge of how societies function and develop.

And given that new technologies are always developing and become ever-more complex, careers in the sector are continually growing and diversifying. "Research opportunities in the field are virtually limitless," says Jean-Marc. "New technologies and systems are constantly emerging and must be integrated and adapted to meet societal needs such as profitability, sustainability and safety."

Advanced air mobility (AAM) is one important example of the new frontiers that industrial engineering is embracing.

"Working on AAM allows me to contribute to a creative process that is shaping entirely new forms of mobility that will have meaningful social impact," says Jean-Marc. "The field requires continuous learning and exploration of methodological and technological solutions." Given that such efforts could reshape the world as we know it, industrial engineers have a lot of responsibility – which entails exciting opportunities to work at the forefront of progress.

Pathway from school to *industrial engineering*

Jean-Marc says that a strong scientific or technological background is essential. At school, this could involve building strong knowledge and skills in physics, mathematics and computer science – supplemented, if possible, with humanities subjects to build understanding of society and human psychology.

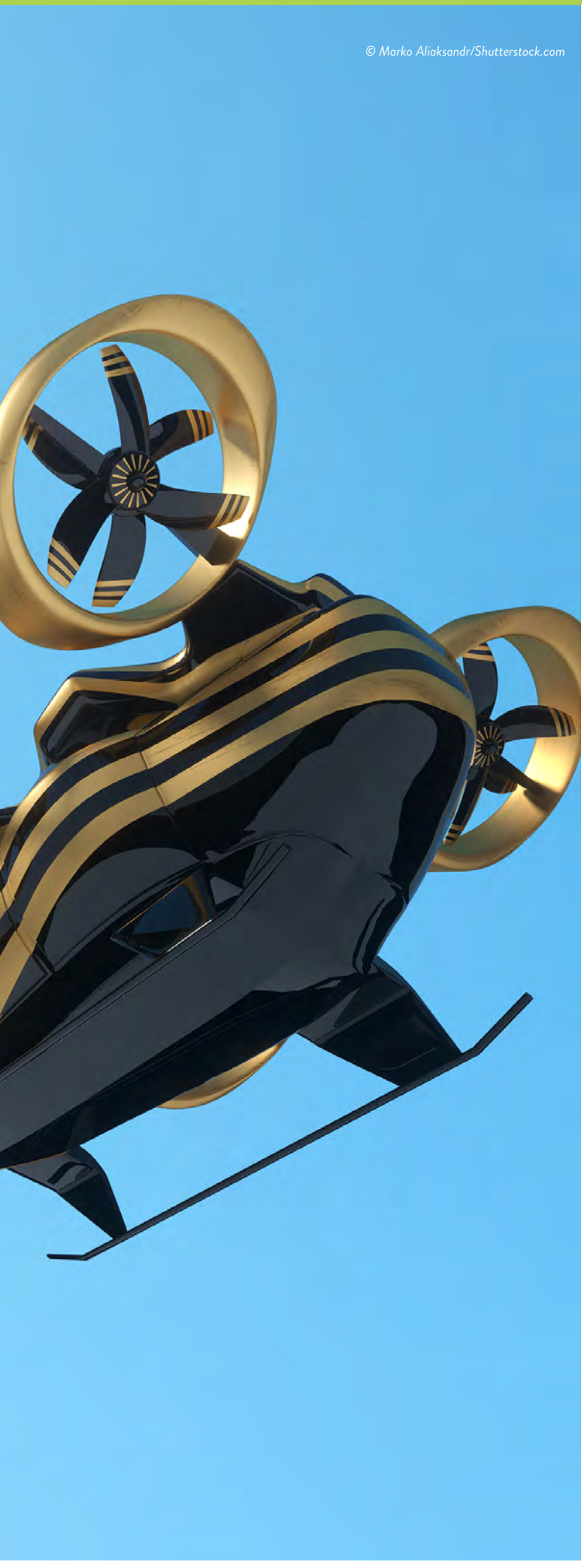
At university, a wide range of degrees can lead to a career in industrial engineering. A degree in industrial engineering itself is the most straightforward, but many engineering disciplines, such as mechanical engineering, manufacturing engineering, electrical engineering and systems engineering are relevant, as are other disciplines such as mathematics and computer science.

Explore careers in *industrial engineering*

The Institute of Industrial and Systems Engineers' website is full of resources to learn more about industrial engineering and ways to get involved: **iise.org/details.aspx?id=851**

The SDG Institute of Advanced Air Mobility, which Jean-Marc co-leads, organises an annual public forum to introduce AAM to a broad audience: **sdgnetworkaami.com**

According to Glassdoor, an industrial engineer in Canada can expect to make an average of CAN $73,000 per year: **glassdoor.ca/Salaries/industrial-engineer-salary-SRCH_KO0,19.htm**



Download Jean-Marc's resources from **futurumcareers.com/preparing-the-world-for-the-next-generation-of-flying-machines**

Meet *Jean-Marc*

An industrial engineer's career can evolve in many directions over time. They will have expertise that can be applied to virtually any system with people and machines or organisational context.

I began my career as the junior research director of an academic group. The group went on to create a long-term research consortium on forest product logistics. When we began, we had no governance structure, no established processes and no students – it felt like launching a start-up. It was both intimidating and exciting!

As a PhD student, I knew a professor whose expertise and personality naturally inspired respect. I often hoped that one day I might earn that same kind of respect from my own students. You can imagine how proud I was when a student told me that I had achieved exactly what I had aimed for.

My goal is for the SDG Institute of Advanced Air Mobility to become an internationally recognised institution. I want it to make tangible contributions to Canada's adoption of AAM, and to offer young people meaningful opportunities to build the careers they aspire to.

Jean-Marc's *top tip*

Stay curious about the world. Never stop pursuing your desire to understand how things work. One day, that drive will lead you to something that changes your life.

Mineral exploration: future-proofing the availability of essential metals

Metals such as copper are not often talked about, but they are essential for many electrical items that we use every day. With the rapid rise in our technology use, these metals are becoming increasingly sought after. **Dr James Mungall** and **Samuel Robb**, of **Bronzite Exploration**, and **Karim El Ghawi**, a PhD student at **Carleton University**, in Canada, are exploring unique locations and using remote sensing tools and laboratory techniques to discover potential new copper mining sites, and new ways of deciding which rocks may be useful for copper extraction.

Dr James Mungall

Chairman and President, Bronzite Exploration; Professor, Department of Earth Sciences, Carleton University, Canada

Samuel Robb

Director and Vice President, Bronzite Exploration, Canada

Karim El Ghawi

PhD student, Department of Earth Sciences, Carleton University, Canada

Talk like a ... geologist

Geology — the study of the Earth, its materials and the processes that shape it

Geophysics — the study of the Earth using physical principles such as gravity, magnetism and seismic waves

Igneous petrology — the study of rocks formed from cooled magma or lava

Inuit — Indigenous People of the Arctic

Magma — molten rock found within or beneath the Earth's crust

Metal ore — a naturally occurring rock with a significant amount of a metal or metal compound that can be extracted for economic gain

Mineral — a natural solid found in rocks, made of one or more basic substances, with its own shape and colour. Examples include quartz and calcite, and copper minerals such as chalcopyrite, from which copper metal can be extracted

Permafrost — ground that remains frozen for two years or more

Tundra — a large, flat and cold area of land where no trees grow

Fields of research
Geology; igneous petrology; geophysics

Website
bronziteexploration.com

doi: 10.33424/FUTURUM656

PROFILES

At some point today, possibly in the last hour, you have probably used a mobile phone. That mobile phone, and the household wiring that allows you to charge it every night, contains copper – a metal mined from rocks. "Everything humanity has is either grown in a field or forest or dug out of the Earth," says Dr James Mungall of Bronzite Exploration. "The lives and future security of billions of people depend on the fertilisers, metals and minerals that are mined to allow us to eat, shelter ourselves, and reach for future achievements in science, medicine and the arts."

James and his colleague Samuel Robb are both incredibly enthusiastic about geology and identifying new locations from which to extract metals and minerals. This has led them to start Bronzite Exploration, a mineral exploration company that hunts for new undiscovered mining locations.

Copper in the Canadian Arctic

Metals and minerals are vital for the production of many essential products

Somerset Island, 2023 © James Mungall

in our rapidly advancing world, making them highly sought after. "As most of the world moves out of poverty and into relative comfort, our need for materials grows," says Samuel. "Overall, metal demand is expected to double by 2060, so the competition to find metals is going to be intense. This is a growing industry with huge career potential for decades to come."

James and Samuel are concentrating on unexplored land within the Canadian Arctic, where there is significant potential for discovering minerals and metals. "Expanding exploration to remote areas will open the door to more economic growth and prosperity for Canadians," says James. Bronzite Exploration's leading project, the Somerset Trough Project, is based in Nunavut, which is the northernmost and biggest territory of Canada and contains most of the Canadian Arctic. Here, James and Samuel are investigating signs of copper, zinc and silver mineralisation.

On rare occasions, pure copper can form naturally in rocks. However, most of the world's copper comes from copper minerals, which contain copper mixed with other elements, such as sulphur. These minerals are processed to extract the pure metal. "Copper is an indispensable metal for any application involving electricity and for applications like household plumbing, roofing and making alloys such as brass," explains James. "After iron, copper is the most valuable metal commodity. Worldwide use is expected to increase dramatically, while reserves are dwindling fast."

As a university professor, James is also supervising PhD student Karim El Ghawi who is looking for copper sources from a new perspective. "We need to broaden our view of what can be considered to be a metal ore," says Karim. "In the future, we can expect to find ourselves increasingly dependent on mining rocks currently regarded as subeconomic or merely as common rock."

The techniques of mineral exploration

James and Samuel identify possible sites using remote sensing tools, including satellite imagery and airborne geophysical surveys. "These collect detailed information about the Earth's surface and what lies under the ground," explains James. "Aircraft fly back and forth over the land, towing instruments through the air to collect data, such as the strength of the magnetic field and the gravitational field, or to detect the presence of electrical conductors under the ground." In collecting this geophysical data, the team makes images that overlay satellite images and geological field observations, making a detailed map of the subsurface geology.

Protecting a sensitive environment

The Canadian Arctic is home to fragile ecosystems including the tundra and permafrost, wildlife such as polar bears, seals and Arctic foxes, and glaciers and freshwater lakes. It is an environmentally sensitive region, where digging can release greenhouse gases, and cold temperatures mean recovery from any environmental damage can last longer than in other areas.

To ensure their work is environmentally sustainable, James and Samuel study requirements for working in the region carefully and submit proposals for their work which are reviewed by experts and through community consultation. "What happens in the field is always dictated by the need to leave as few traces of our passage as possible," says James. "Water is taken from approved water sources and disposed of responsibly to ensure it doesn't contaminate the groundwater or surface runoff. All waste is either incinerated or shipped back out, and when we leave a camp, nothing is left behind."

James and Samuel also respect local communities. "We want local people to benefit from our work and be supportive of what we do," says James. "We hope to contribute to the growth of new industries and jobs in the north, so that local communities can diversify their economies." The team thinks carefully about communicating with the community. "We do our best to make sure local communities are informed about the exploration we are conducting," says Samuel. "We engage through email, phone calls, community visits, Facebook – whatever is best to reach the people we need to reach."

What are the next steps?

"Our next step is to carefully go through all the data we've collated and design the work plan for future years," says James. "We will continue engaging with local communities, Inuit associations and the territorial government, explaining our aims and taking feedback." Ultimately, James and Samuel want to drill for samples, make 3D models of the subsurface geology and determine metal concentrations. They will model the economic feasibility of a mining operation and then seek permission to develop a mine.

The cook/office tent of the Somerset Trough project, 2023 © Samuel Robb

About *geology*

Geology is the science of understanding the planet we live on – studying rocks and mountains, volcanoes and earthquakes, and the minerals and metals that are used in phones, cars, buildings and more.

Geologists work to solve real-world problems, such as finding clean water, protecting the environment and building safe cities. "The history of the Earth remains cloaked in mystery and there are innumerable pathways young researchers can follow," says James. With an increasing urgency for the vast amounts of metals we need for our modern way of living and the technology that permeates that, geology research is becoming increasingly valued.

As well as being important, geology is highly rewarding. "Research in geology is fun and interesting because it combines all of the sciences, and offers opportunities to travel the world," says James. "In my research career, I've worked in laboratories measuring physical and chemical properties of melted rocks, climbed mountains and crossed tundra and forests searching for key rock outcrops, and developed computer models to simulate natural processes in volcanoes and mineral deposits – there is probably no other STEM field that allows one person to do such a variety of things."

Working in remote locations is fascinating – but it can also be challenging. "The Canadian Arctic land is sensitive to disturbances, so there are no trucks, or roads for that matter, and access requires the use of charter aircraft, helicopters and hiking," says Samuel. "Supplies, including fuel, are expensive and need to be flown in. We carry all our rock samples in large backpacks after we have been dropped into the area by a helicopter." During fieldwork, James and Samuel live in tents with diesel stoves for heat, diesel or gas generators for power, and an electric fence to repel wildlife like polar bears and wolves.

Alongside his work at Bronzite Exploration, James is Professor of Earth Sciences at Carleton University. Day to day, he spends his time formulating explanations for observations he has made, testing his ideas (in the lab and in the field), and writing and publishing research papers to share his findings. In addition, he mentors younger colleagues, like Karim. "Taking young geoscientists along on this journey of discovery and publication is especially rewarding," he says. "Seeing them prosper and build their own careers is always a thrill, especially when I bump into them somewhere else in the world and see what amazing things they have accomplished."

Meet *Samuel*

I stumbled into geology while I was trying to figure out what to major in at university. Once I discovered it, I realised it was the perfect combination of science and being able to spend time outdoors in some incredible, remote regions of Canada.

Working in remote regions, from the Arctic tundra in Nunavut, to the mountains in British Columbia, to the Canadian Shield, is amazing. Each time I have gone out into the field, I have learnt something new, made a new discovery, or seen a part of the world I never would have expected to see.

Geology is full of eureka moments. You can spend hours looking at data, making observations in the field and taking measurements, without any idea of what you're looking at! Then, you get an idea, figure out a way to test it, and everything suddenly fits into place (or it doesn't, and you go back to the drawing board). It's all part of the fun and natural process of working in geology.

The biggest challenge of running exploration is managing the uncertainty, whether geological, logistical or financial. Operating in remote areas means every decision matters, with success depending on preparation, adaptability and teamwork. Things often don't go the way you planned or expected!

The rewards include testing new ideas, being part of new discoveries and mentoring new geologists. Building exploration programmes from the ground up, with input from local communities, is also rewarding. We've worked hard to establish Bronzite Exploration as a credible northern explorer, building trust with Inuit organisations, and running safe, efficient field seasons in inhospitable environments – all fulfilling achievements.

My focus is to continue advancing our exploration work at our Somerset Trough Project in Nunavut. I believe we can demonstrate that mineral exploration can be conducted responsibly and provide benefit to local communities.

Samuel's *top tips*

1. Stay curious about the things you're interested in; ask questions and try to figure out the answers on your own. Your curiosity will keep you excited and show your enthusiasm to everyone around you.

2. Be adaptable. In geology and many other fields, technology is transformative and changing the way we work. It's important to stay on top of new methods and technologies available. That being said, don't ever lose sight of the field. No matter what technology changes, nothing replaces boots on the ground and spending time with rocks!

3. Find a mentor or mentors who will challenge you to think critically, give you guidance, and push you to learn things on your own.

Download the team's resources from **futurumcareers.com/mineral-exploration-future-proofing-the-availability-of-essential-metals**

Meet *James*

I have always had the desire to spend time in the wilderness, testing my body and my mind against nature. As a child, I often broke open rocks, curious to know what was inside. I also loved literature and enrolled in an English programme but switched to geology because that was where my heart really lay. My first year of studies and fieldwork cemented the choice, and I've never regretted the decision.

Eureka moments have often hit when observations haven't made sense. I've poked them in my mind the way you poke a sore tooth and then, suddenly, something has clicked. For example, I was mapping rocks in northern Quebec, and nothing was making sense in terms of where nickel mineralisation was being found – we had assumed it was only in lava flows, but this didn't match the data. One day, I realised the mineralised bodies were all part of one huge, intrusive, magmatic rock formation called a dike that cut across all the other rocks on the map. This gave us a tool to predict where the next discovery could be made. Once you step back and look at the whole picture, you wonder why it took you so long to understand!

Achievements that make me feel my time is well spent include: publishing papers that have changed how people think about scientific processes; making geological maps that have become go-to sources of knowledge about regions of northern Canada; and building an exploration company with Samuel that, in just three years, has become one of the most ambitiously funded exploration programmes in the country.

Lately, I'm very proud of the work I'm doing to create a fully online master's programme in mineral exploration and resource management. This programme will pull together my lifetime experience of working and teaching to give early career geoscientists a unique geoscience and business degree.

Although I'm approaching retirement age, I have no desire to stop being productive. Over the coming years, I hope to see our Somerset Trough Project selected by a major mining company for development. After we launch the master's programme, I look forward to seeing our graduates spreading out around the world and achieving success in exploration. On the research front, I plan to publish a paper re-evaluating the composition of the Earth's upper mantle. And, of course, I'm eager to see what Karim's work on unconventional resources will show us about our future as a metal-producing country.

James's *top tips*

Pour yourself into your work, doing it for the love of accomplishing something. Always give a little more than you were asked for and seek to constantly learn about subjects that might seem a little scary. As American physicist Richard Feynman said, when a new subject seems too complicated to understand, don't turn away from it – that is the moment when it starts to get exciting!

James (centre) in the field exploring for uranium in Nova Scotia, 1979

Q&A

Meet *Karim*

Karim El Ghawi, PhD student, Department of Earth Sciences, Carleton University, Canada

Fields of research: Geology; geometallurgy

Funder: Natural Sciences and Engineering Research Council of Canada (NSERC)

Glossary

Geometallurgy — the study of rocks to discover how useful metals can be found, extracted and processed from them

Leaching — a process where minerals are dissolved and removed from rock

Magnetic separation — a process using magnets to separate magnetic and non-magnetic materials

Ore — a rock containing a valuable mineral

Who or what motivated you to pursue geology?

I began my undergraduate studies in chemistry at the American University of Beirut in my home country, Lebanon. As part of this programme, I took a geology course that introduced me to the key minerals in rocks. I quickly became fascinated and decided to pursue a minor in geology. With encouragement from my professor, I chose to complete a full degree in geology, knowing I wanted to continue into research in the field. This led me to move to Canada where I completed my master's at Carleton University, and I am now pursuing my PhD in geology.

What did you study for your master's degree?

I focused my master's research on the Tamarack Intrusive Complex, a large underground rock formation in Minnesota in the US, because it is rich in essential metals like nickel, copper, platinum and palladium. These metals are critical for technologies such as batteries, electric cars, renewable energy and medical devices. Tamarack is especially important because it shows how magma carrying these metals interacted with surrounding rocks deep underground, concentrating them into ore deposits.

How did you use computer modelling for this research?

Computer modelling helps recreate conditions deep inside the Earth, such as temperature, pressure, and chemical reactions, without going there physically. Using software, we can predict how magma cools, minerals crystallise, and metals become concentrated into ores. In my master's research, I used models to test scenarios of how magma interacted with surrounding rocks or other magmas. This revealed which processes were most important for trapping valuable metals and forming ore deposits.

What were your key findings?

I studied how metal-rich sulphide minerals formed and found that different sulphide-mineral rock textures reflect how magma cooled and crystallised. Using computer models, I showed that even small amounts of surrounding rock or gases could trigger sulphide deposit formation, concentrating metals like nickel, copper, platinum and palladium. I also discovered that the unusual platinum and palladium enrichments were caused by magmatic processes – the movements and changes of magma as it forms, moves and cools – not by later, hot fluid activity.

How did your master's lead to your current PhD study?

My master's research prepared me for my PhD by strengthening my research skills and sparking my interest in where our metals come from. I learnt to design computer models and analyse mineral data, which gave me the confidence to take on a larger project.

What are you investigating for your PhD?

I am investigating metals in rocks that are usually not considered to be 'ore', which is rock that contains enough metal to make mining worthwhile. All rocks contain small amounts of valuable metals, but not enough to be mined with today's methods, which is why, when we consider how we could extract metals from them, they are called unconventional resources. They have potential because they are widespread and abundant. As demand for critical metals grows, these common rocks could one day become important, new sources of supply.

What research methods are you using?

I plan to use modern geometallurgical methods to study how metals are locked in rocks and how they can be extracted. This involves collecting rock samples, using imaging techniques like X-ray mapping using an electron microscope to see which minerals contain certain metals, and running lab tests like magnetic separation or leaching to see how easily the metals can be released. These methods help predict which unconventional rocks could become future sources of critical metals.

What are the next steps for your PhD?

I plan to collect rocks that represent many of the main rock types that make up Earth's crust. By studying these, I will be able to compare how important metals are distributed in different rock types and under different conditions – my aim is to come up with general rules that will allow us to predict the sites in any rock where metals are concentrated. The next steps will be detailed lab and computer analyses to understand how these metals could be extracted in the future.

How do you switch off from the pressures of studying?

Doing a PhD can be challenging at times, so I try make sure to balance my research with activities that help me recharge. Playing sports, especially soccer, is one of my main ways to switch off. It keeps me active and lets me focus on something completely different from my studies. Spending time with friends also helps me relax and stay connected outside of the academic world.

What are your proudest career achievements so far?

Presenting my research at several scientific conferences. These events bring together top academics and experts in this field from around the world, so they are great opportunities to share my work, have discussions, and receive feedback.

What are your goals for the future?

Looking ahead, my main goal is to complete my PhD and make a meaningful contribution to how we think about future metal resources. I am most excited about uncovering how valuable metals are stored in common rocks that have not been studied in detail before. By understanding this better, I hope my research can help guide new, sustainable ways of supplying the metals needed for technologies such as renewable energy. Ultimately, I want my work to play a role in supporting the transition to a greener, more sustainable future.

Karim's *top tips*

1. Stay curious and spend time exploring the world around you. Geology is all about asking questions: Why does this rock look this way? How did this landscape form?

2. Don't be afraid of the science; geology combines chemistry, physics and biology in exciting ways.

3. Most importantly, get outside when you can. The best lessons in geology happen in the field, not inside the classroom.

Aerospatiale AS350-B3 helicopter towing Xcalibur HeliTEM magnetometer and bedrock conductivity probe, Somerset Trough project, 2025 © James Mungall

Pathway from school to *geology*

Developing skills in maths and science at school, especially in calculus, algebra, chemistry, physics and biology, will help build a solid foundation for geology. Develop your written and verbal communication skills as these will help with report-writing and presenting.

At university, study Earth sciences or geology, or specialise in environmental geoscience or geophysics if you can.

"If you want to work as a geoscientist after you graduate, you will have to qualify for professional status in the same way as engineers do," says James. "This involves completing a four-year programme, followed by four years of work experience under the supervision of a professional geoscientist. You must then pass an examination of your ability to perform ethically and in compliance with the laws."

"Building leadership skills can be important, so look for opportunities in sports or other extracurricular activities," says Samuel. "Volunteering in the community can help build valuable leadership and people skills."

Explore careers in *geology*

Learn more about the work of James and his colleagues in the Department of Earth Sciences at Carleton University: **earthsci.carleton.ca**

The Geoscientists Canada website offers advice and information about careers in geoscience. It also provides links to local professional organisations in Canada which you could join and attend events through: **geoscientistscanada.ca**

Explore the website of the Mining Association of Canada which shares useful information about the mining industry and is a popular employer of geoscience graduates in Canada: **mining.ca**

The websites of the European Geosciences Union (**egu.eu**) and the Geological Society of America (**geosociety.org**) both contain a wealth of information about careers, the latest research and conferences networking events. You could even consider becoming a student member.

Can we predict where falling rocks will go?

Rockfalls can cause serious damage to people and infrastructure. To design useful protection measures, it is important to understand what happens during a rockfall and where any rocks might go. At **Boise State University** in the US, geotechnical engineer **Professor Nick Hudyma** and his team, including PhD student **Grant Goertzen**, are throwing rocks down slopes to initiate artificial rockfalls. These experiments will allow them to create computer simulations that model how real rockfalls might occur.

Professor Nick Hudyma

Grant Goertzen

Department of Civil Engineering,
Boise State University, USA

Fields of research
Civil engineering; geotechnical engineering

Research project
Creating artificial rockfalls to develop simulations of rockfall hazards

Funder
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PROFILES

Talk like a ...

geotechnical engineer

Coefficient of restitution — a measure of how elastic a collision is, showing how much energy a rock retains after hitting the ground

Freeze-thaw weathering — the mechanical process that breaks rocks when water seeps into cracks and then freezes and expands

Impact scar — a mark left on a slope after it has been hit by a rock

Lidar — a survey method that uses lasers to create high-resolution topographic maps

Rockfall — the movement of loose rocks down a slope

Rotational velocity — the speed at which an object rotates around an axis

Simulation — a digital recreation of a real-world event based on mathematical models that represent the behaviour of the system

Trajectory — the path a rock follows as it moves down a slope

If you have ever driven along a mountain road, you may have seen signs warning of falling rocks. These warnings exist for good reason. Rockfalls happen when pieces of rock break away from steep slopes or cliffs and travel downwards, often at high speeds. Rain, freeze-thaw weathering, earthquakes and even human activities like construction or rock climbing can set them in motion.

Why is it important to study rockfalls?

"Rockfalls pose a substantial danger to people and infrastructure, especially in mountainous and coastal regions," says Professor Nick Hudyma, a geotechnical engineer at Boise State University. Anchoring loose rocks can prevent rockfalls, but it is often expensive and impractical. Another option is to let rocks fall naturally while limiting their damage by installing protections such as nets, ditches and barriers. "To place these protections wisely, we need to know where any falling rocks may travel," explains Nick.

To determine this, Nick and his team create artificial rockfalls which allow them to develop computer simulations that can be used to model how real rockfalls may occur. "Our artificially induced rockfalls help us better understand rock movement, enabling us to protect people and infrastructure," he says.

Team members set up the internal sensors and high speed cameras at the top of the test slope before a rockfall experiment.

How did the team create artificial rockfalls?

In reality, an artificial rockfall simply involves throwing a rock down a slope! But there was a lot more scientific work that went into the team's experiments, which were carried out in gravel pits. A single day in the field takes weeks of preparation. In addition to organising transport, equipment and safety gear, the team also conducted preliminary mapping and simulations. This involved flying drones equipped with lidar to create high-resolution topographic maps of each site and using these maps to model where the rocks were likely to go. This was critical so that the team knew where to place cameras and sensors to collect data during the rockfalls.

"On the day of testing, we arrived just before sunrise because there was a lot of preliminary set-up and testing to do before we could drop our first block," says PhD student Grant Goertzen. The team used artificial concrete blocks rather than real rocks which gave them greater control and allowed them to study how rock shape affects rockfall behaviour. The blocks were painted bright pink and came as spheres, cubes, cylinders and rectangular prisms. Each weighed between 35 kg and 135 kg and had a tube leading to the centre where a sensor was placed to track the block's motion. "These blocks were too heavy to just pick up and toss off the slope!" says Nick. "So, we also had to design and build a moveable hoist system to lift and safely release them."

"It was so exciting to see the first block travel downslope!" says Grant. "After it came to rest, we were all cheering! Then, after those celebrations, the real work began." The team spent the day releasing block after block down slopes of different length, gradient and material (sand, gravel and cobbles). For each rockfall, the team measured the block's progress down the slope using high-speed cameras, drones and the internal motion sensors. After recording where the blocks came to rest, they had to be transported back up to the top of the slope using the hoist system so they could be released again. Once all the tests were done, the slope was rescanned with lidar to capture the impact scars carved into the surface. "Finally, we had to pack everything up and head home," says Grant. "It was a long and exhausting day, but also so much fun!"

> ***"Our work will better inform geotechnical engineers about the role of soil and slope properties in rockfalls."***

What did the rockfall experiments reveal?

"There are many factors that influence the trajectory of a block, including its size and shape, and the stiffness and angle of the slope," explains Nick. The team discovered that shape plays a huge role in how a block travels downslope and where it comes to rest. Spheres travelled the fastest and farthest, rolling smoothly over obstacles, while cubes and rectangular prisms were more affected by the terrain and travelled less far. As more blocks were released, impact scars formed on the slope and some rectangular prisms even became trapped in these grooves. One unexpected observation was the behaviour of the cubes – their sharp faces acted like lever arms and caused sudden changes in rotational velocity each time they hit the ground.

How will these artificial rockfalls help geotechnical engineers?

The team is now analysing the large dataset collected in the field, including lidar maps of slope surface features before and after the rockfalls, soil measurements, motion sensor readings, videos of each rockfall and the final resting place of each block. They will study the photos and video footage to understand how each block moved downslope and, by synchronising the videos and sensor data, they will calculate the coefficient of restitution – a key property that controls how a rock bounces each time it impacts the ground during a rockfall.

Using these insights, the team will run new computer simulations to try to digitally recreate the experiments. "Our hope is that we can successfully simulate our field tests to provide confidence in our future simulations," says Nick. "Our work will better inform geotechnical engineers about the role of soil and slope properties in rockfalls and their influence on how rocks move downslope and where they will eventually come to rest. This information can be used to design better rockfall protection systems."

The team conducted their rockfall experiments in gravel pits owned by the Idaho Transportation Department.

About *geotechnical engineering*

Geotechnical engineering is the branch of civil engineering that focuses on the ground beneath our feet. While civil engineers design, build and maintain infrastructure like bridges, roads, buildings and pipelines, geotechnical engineers ensure these structures are safe and stable by studying the properties of the soils and rocks they are built on or in. Every building, tunnel, bridge and road depends on solid understanding of the ground that supports it.

"Geotechnical engineers determine the properties of soils and rocks for construction," says Nick. "They also design foundations (for buildings and bridges), subsurface systems (such as pipelines and tunnels) and slopes (along highways and railroads). And they are responsible for assessing, predicting and repairing damage caused by geological hazards, such as earthquakes, landslides and rockfalls."

Careers in geotechnical engineering are varied and exciting. Some engineers work in the lab or field, testing soils and rocks to understand their strength, while others analyse data and run computer simulations to model how the ground will behave during construction. "You should be excited to pursue a career in geotechnical engineering because it offers a variety of experiences," says Grant. You will get to enjoy a mix of outdoor teamwork, technical problem-solving and collaboration with multidisciplinary teams. "Most importantly, you will be part of a profession that prioritises the well-being of society and the environment in your design, construction and maintenance decisions," says Nick. "Geotechnical engineers are driven by a dedication to serving the public and improving communities."

Pathway from school to *geotechnical engineering*

At high school, study science and mathematics. "It is important that aspiring geotechnical engineers have a good understanding of math, statistics, physics and chemistry, as these are the background of all engineering," says Nick.

At university, study an undergraduate degree in civil engineering and take courses in geotechnical or geological engineering. These will cover topics such as soil and rock mechanics, slope stability, and computer simulations. You can then study a postgraduate degree in geotechnical engineering.

"All engineers are problem solvers, but geotechnical engineers are also naturally curious about the world around them," says Grant. "Most of us have an interest in geology or Earth sciences, and we use those interests to help us solve practical infrastructure problems."

Explore careers in *geotechnical engineering*

"If you like solving problems, are interested in geology or the natural world, and would like to design and construct infrastructure, then geotechnical engineering may be for you!" says Grant.

Careers in geotechnical engineering range from designing foundations for buildings to studying natural hazards.

Explore organisations such as the Geo-Institute of the American Society of Civil Engineers (**geoinstitute.org**), the International Society for Soil Mechanics and Geotechnical Engineering (**issmge.org**) and the British Geotechnical Association (**britishgeotech.org**) to find information about research and careers in the field.

Prospects provides information about what a career in geotechnical engineering could involve, the qualifications you will need and the salary you can expect (**prospects.ac.uk/job-profiles/geotechnical-engineer**)

"At Bosie State University, we host outreach events to inform students about civil engineering and the cool things we do," says Nick. "If you are ever in Boise, I would love to show you our laboratory facilities and talk about the exciting projects our students are working on!"

Download the team's resources from **futurumcareers.com/can-we-predict-where-falling-rocks-will-go**

Meet *Nick*

I was fortunate to grow up in an area surrounded by nature, and I was always curious about how the landscapes I could see came into being. When I was young, I was fascinated by earth-moving equipment. As a teenager, I enjoyed playing sports, writing computer programs and riding my bike around town.

There are no engineers in my family. But I was good at math and science so, when I went to university, I decided to study engineering. I was fortunate to have the opportunity to study geological engineering, which focused heavily on understanding the properties of natural materials. It was a wonderful combination of my interests in engineering and geology.

When I became a professor, I wanted to study geological hazards so I could continue to combine my interests in engineering and geology. In Florida, I focused on sinkholes. When I moved to Boise in Idaho, I was excited to study rock-related hazards such as rockfalls.

I am so happy that, as a geotechnical engineer, I get to work outside as part of my job. My favourite experiences are working with students who share my passion and want to understand how natural materials behave. Fieldwork is very important in geotechnical engineering, but not everyone enjoys that sort of work. During our recent fieldwork, I was so impressed by how well the rockfall team performed and worked together to accomplish our goals. Seeing the first drop test is something I will never forget.

In my free time, I like to play ice hockey and hang out with my dog, Asta. But my favourite thing is long weekend bike rides along the Boise Greenbelt where I can be alone and think about the next cool project.

Nick's *top tip*

Try different things to find your passion. Who knows? That passion may become a cool hobby or even your career. If you are really interested in something, it is easy to work hard and be dedicated to it.

Meet *Grant*

As a teenager, I loved being outside and being active. I had a lot of hobbies like fishing, hiking and cliff jumping, but my primary interest was rock climbing.

I come from a family of civil engineers, so I grew up loving math and construction. My dad and both my grandpas were civil engineers – one of whom is still practising at nearly 80 years old! During junior year of my civil engineering undergraduate degree, it was Dr Hudyma and the other geotechnical professors at Boise State University who motivated me to choose geotechnical engineering as my area of interest.

The best part of studying rockfalls is the surprises! Research is all about exploring and understanding new concepts, so when experiments lead to unexpected outcomes, it's exciting. The real challenge (and reward) comes from figuring out why those surprises happened.

Fieldwork can be hard work – it turns out, lifting the 15,000th pound of rock in a day is not as easy as the first pound! By the end of the day, we were exhausted! Before a field day, we do lots of planning to determine all the testing procedures. During our fieldwork, we made a change to one of our procedures, but we didn't adequately assess the impact of this change. This resulted in one of our sensors recording no data for the day! Thankfully the test site is only 15 minutes away from campus so we can easily go back and collect additional data from the site.

In my free time, I love being active outdoors. I love rock climbing, both indoors and outdoors, which fits perfectly given my research! I also enjoy running, hiking, mountaineering, cliff jumping, fishing, and playing sports like basketball, football and volleyball.

Grant's *top tips*

Work hard at whatever you are doing (but that doesn't mean work all the time!). And put your best effort into the task at hand. Building good habits of focus and effort will carry you a long way.

How are mathematical models helping wildlife management?

Humans deliberately manage wildlife populations for a variety of reasons, such as sustainable harvesting or to prevent overpopulation, the spread of disease or risks to domestic animals. But sometimes, management measures can have unexpected results. This is why conservation must be based on scientific evidence. At the **University of Alberta** in Canada, **Professor Mark Boyce** and his students, including **Kathryn Vaughan** and **Gillian Power**, are modelling wildlife populations to help inform management decisions.

Professor Mark Boyce

Boyce Lab, Department of Biological Sciences, University of Alberta, Canada

Research project
Modelling wildlife population dynamics to inform management strategies

Kathryn Vaughan

Master's student (now graduated)

Research project
Developing a winter severity index to help manage white-tailed deer populations

Gillian Power

PhD student

Research project
Tracking bighorn sheep movement to prevent the spread of disease from livestock to bighorn sheep

Fields of research
Conservation ecology; wildlife management

PROFILES

Talk like a ...

conservation ecologist

Game species — animals hunted by humans

Mortality — the number of deaths in a population

Snow water equivalent — the amount of water produced when a given volume of snow is melted (i.e., a measure of the density of the volume of snow)

Statistical modelling — applying statistical analyses to a dataset to find patterns and relationships among variables

Sustainable harvesting — hunting animals to manage their population

Winter severity index — a metric to quantify the harshness of a winter season

Funders
Natural Sciences and Engineering Research Council of Canada (NSREC); Alberta Conservation Association (ACA)

Website
grad.biology.ualberta.ca/boyce

doi: 10.33424/FUTURUM660

From grizzly bears roaming the Rocky Mountains to herds of bison grazing the Prairies, Canada is home to an incredible diversity of wildlife. But despite their 'wild' nature, many of these species are closely managed by humans. "Game species (e.g., deer, elk, moose) are managed for hunters," explains Professor Mark Boyce, a conservation ecologist at the University of Alberta. "Other species are managed to reduce risks to livestock (e.g., wolves) or crops (e.g., boar), or for their own protection (e.g., grizzly bears in Alberta)."

However, knowing the best method for managing wildlife is

Members of the Boyce Lab have found that populations of elk are thriving in Alberta, despite an increase in predator species such as wolves, grizzly bears and cougars. © Mark Boyce

not straightforward. "Often, wildlife management decisions are made with insufficient evidence because it's expensive to accurately monitor populations," says Mark. "Or political interference can mean decisions are based on public opinion rather than advice from scientists." For example, people in urban areas generally favour wolf protection, while people in wolf-inhabited areas generally favour wolf hunting to protect their livestock and pets.

Population management: follow the science

Wildlife populations change size according to their rates of reproduction and mortality, which are influenced by numerous factors such as availability of food, predator and prey interactions, weather conditions, disease and hunting. Complex mathematical equations can incorporate these variables into models that predict how populations will change over time. In the Boyce Lab, Mark and his team develop such models to investigate how wildlife populations will respond to different management strategies.

There are many forms of wildlife management, including direct management (killing or protecting animals), or indirect management (managing habitats, e.g., planting native species or removing vegetation through controlled burning). But before making management decisions, it is important to have a robust understanding of their likely effects. History is littered with stories of when wildlife management went wrong. A famous example is the introduction of cane toads to Australia – they were introduced to control crop pests but soon became invasive and had catastrophic effects on native species. Wildlife management strategies can have unanticipated outcomes, which is why Mark is a strong advocate for science-based management built on real-world data and mathematical models.

Surprising population changes

Population ecology models have revealed counterintuitive phenomena which mathematically explain why some management strategies fail. The Hydra Effect is named after the many-headed monster in Greek mythology – each time a head was cut off, two more grew in its place. "For certain populations, we find that low to moderate levels of hunting can actually result in increased abundance of the species," says Mark.

The Hydra Effect occurs because surviving individuals have less competition for resources, leading to a 'baby boom' and increased population. This has significant implications for wildlife management. "For game species, the increased abundance caused by low to moderate hunting is good news for hunters," says Mark. "On the other hand, for species in conflict with humans, hunting can be counterproductive." For example, hunting wild boar in an attempt to stop them damaging crops actually leads to increased boar populations and greater crop damage.

Another counterintuitive effect is the Volterra Principle. "When both predator and prey species have an increase in mortality, the prey species then increases while the predator species decreases," explains Mark. "This has implications for how we manage predator and prey populations as it calls into question the use of predator control to manage game species." For instance, a wildlife manager may want to kill wolves to increase the deer population for hunters, but according to the Volterra Principle, both predator and prey should be targeted.

Winter is coming

Canada is a country of seasonal extremes, where winters can be very harsh. This has a significant impact on white-tailed deer populations, a species that provides over $35 million to the Albertan economy through the hunting industry. Kathryn Vaughan, a master's student in the Boyce Lab, developed a winter severity index to help manage deer populations. "A winter severity index is a tool to measure the harshness of a winter season, based on factors like temperature and snow conditions," she explains. "Colder weather means deer use more energy to stay warm, and deeper snow makes it harder for them to move around to find food and shelter."

Wildlife managers need to understand the effects of winter on deer populations to decide how to manage them, but traditional winter severity indices are overly simplified. "To make a more accurate and flexible index, I used 20 years' worth of satellite data of temperature and snow water equivalent," says Kathryn. "Snow water equivalent is a measure of how dense the snow is, which gives us a better understanding of the amount of energy deer use to move through it."

Kathryn used her new winter severity index to explore whether sustainable harvesting could help with white-tailed deer management to prevent population crashes after severe winters. "Interestingly, I found that areas with more hunting tended to have more stable and even slightly higher average abundance," says Kathryn. "This suggests that consistent hunting may help prevent overpopulation, by decreasing competition for food and shelter when they are limited during tough winters."

Preventing sheep disease

Preventing the spread of diseases between domestic and wild animal populations is a key part of wildlife management. Gillian Power, a PhD student in the Boyce Lab, is exploring disease transmission to wild bighorn sheep, a species famous for dramatic head-butting dominance displays. "Domestic sheep and goats carry a bacterium that can cause pneumonia in bighorn sheep," Gillian explains. If wild bighorn sheep come into contact with domestic animals, pneumonia outbreaks can devastate their populations, which take generations to recover.

It is essential to understand how these outbreaks occur to effectively manage and protect wild populations. "We are placing radio collars on bighorn sheep, which allow us to track and analyse their movements," explains Gillian. "I will use statistical modelling and machine learning simulations to understand the patterns within their movements." She will supplement these data with real-life observations, spending time in the field to document the behaviours and interactions of wild bighorn sheep.

Gillian hopes to identify priority locations for surveillance, so wildlife managers can prevent contact between wild bighorn sheep and domestic animals. "Due to the severity of this disease, our best chance for maintaining healthy bighorn sheep populations is by preventing it from entering wild populations in the first place," says Gillian. "I hope this project brings together people with passions for wildlife and domestic animals – by working together, we can make a bigger impact."

As Mark, Kathryn and Gillian's work highlights, conservation ecologists are essential for providing the scientific evidence required for making effective wildlife management decisions.

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Pathway from school to *conservation ecology and wildlife management*

At school, get a good grounding in biology to learn about animals, ecology and populations, and mathematics and statistics to develop quantitative skills that are important for analysing data. "I also recommend learning coding and data analysis early on," advises Kathryn. Look for courses to learn R, Python and GIS.

At university, a degree in biology, ecology or conservation would provide a direct route into the field, but other pathways also exist. Kathryn studied a degree in general biology, where modules in population ecology and animal behaviour convinced her to pursue a career in ecology. Gillian studied agriculture, livestock epidemiology and veterinary science before joining the Boyce Lab.

Mark notes that certain professional certifications, such as Certified Wildlife Biologist (e.g., **wildlife.org/certification-programs**) or Certified Ecologist (e.g., **esa.org/certification**), are often desired or required by employers. Pay attention to certification requirements in your region to ensure your qualifications will be recognised.

"There are many paths into conservation, and it can feel overwhelming at first, but remember that there's a place for everyone," says Kathryn. "Reach out and talk to people – you can learn so much from hearing different people's career stories."

Explore careers in *conservation ecology and wildlife management*

If you love the idea of working with animals, then conservation ecology and wildlife management could be the career for you. "Going into the mountains to watch sheep is a big perk," says Gillian. "How often can you go hiking and camping as part of your job?"

"Most of my students get jobs working for government agencies, which hire wildlife biologists with strong quantitative skills," says Mark. "There are also jobs in industry or consulting which involve mitigating the consequences of industrial development on wildlife. And some of my students stay in academic research."

"With so many species and ecosystems to study, there are endless opportunities to make a difference!" says Kathryn. "No matter what animals or habitats interest you, there's likely someone studying them, and you could be part of that work."

Kathryn and Gillian recommend getting involved in local clubs or organisations to meet like-minded people, find volunteer opportunities and assess whether the field is right for you. For example, The Wildlife Society (**wildlife.org**) has local-level groups across North America and advertises jobs, internships and graduate research opportunities.

Meet *the team*

Download the team's resources from **futurumcareers.com/how-are-mathematical-models-helping-wildlife-management**

Meet *Mark*

In high school, I was an avid hunter and angler, which motivated me to study conservation. During a summer field course in my third year of undergraduate studies, I saw the lifestyle associated with a career in outdoor research. This motivated me to gear my life towards wildlife ecology research.

I love working with students – seeing them grow and go on to be successful professionals makes me very proud. And I love working with wildlife – every species that I've studied has been uniquely rewarding.

It's motivating to see our research influence conservation and management decisions. I believe that science informs the best decisions, so it's discouraging when politics and economics interfere. I sincerely hope that science will prevail in policy and government.

There is no better life than working in wild places with wildlife! This is a fantasy for many young people, and you can have these opportunities if you pursue this path with dedication.

Meet *Kathryn*

It was the TV show *Zoboomafoo* that first interested me in ecology. It sparked my love for animals and inspired me to want to help them. As I got older, I wanted to do that for others – spark curiosity, compassion and excitement for wildlife. Because as important as research is, we also need advocacy and education.

Progress in science doesn't always mean everything goes according to plan; moments of confusion or failure have taught me the most. Wildlife research is highly collaborative, and working with experts in wildlife biology, mathematics and policy has taught me the importance of effective communication.

There are many moments I'm proud of throughout this research, but one of my proudest moments was finishing and presenting my master's thesis. After I presented my winter severity index at a wildlife conservation conference, someone told me it was exactly what they needed. That moment made me realise my work truly had real value and that I had contributed something useful to wildlife management.

Humans have caused a lot of harm to wildlife and the environment, but we also have the power to make a positive difference. I want future generations to have the same wildlife experiences that I cherished growing up, like watching monarch butterflies outside my window and bird watching in the park. I hope to inspire others to pursue a career in conservation to make that happen.

Meet *Gillian*

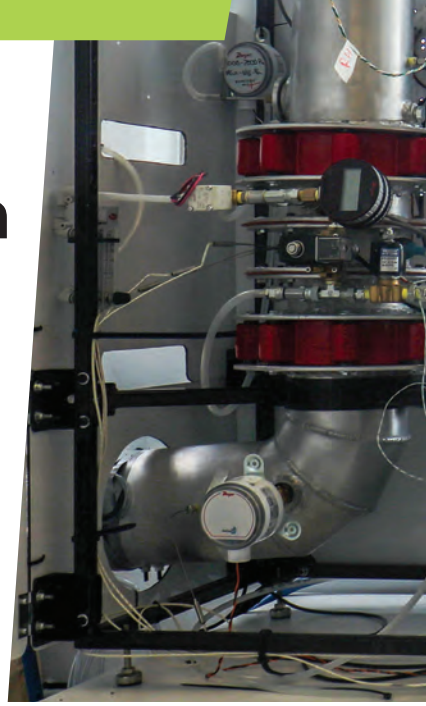
My interest in wildlife was also piqued by watching *Zoboomafoo!* Growing up in a big city, I thought my only job options were zookeeper or veterinarian. Then, during my studies in agriculture, I learnt about other career options.

I am a strong proponent of the One Health approach. It focuses on the interconnected nature of health between the environment, humans and animals. Conservation is key to human and animal health, and we need to find ways to support wildlife and domestic animals.

I have just joined the Boyce Lab, and I'm looking forward to doing fieldwork with bighorn sheep. After my PhD, I hope to continue researching interactions between wildlife and livestock because humans and domestic animals keep encroaching on wild areas.

My favourite fact about bighorn sheep is that males experience such great forces when they head-butt each other that scientists are designing human concussion mitigation strategies by looking at the composition and structure of their skulls!

How can we transform carbon dioxide from a greenhouse gas into a valuable resource?



Most climate change mitigation strategies focus on reducing our emissions of carbon dioxide (CO_2). However, direct air capture tackles the problem from a different angle: by removing carbon dioxide directly from the atmosphere. At the **RECARB Hub**, hosted by **Monash University** in Australia, **Evangeline Leong, Maksis Darzins** and **Dr Aaron Guo** have created a new direct air capture system that can supply various industries with CO_2, including the biomanufacturing industry which can use this CO_2 to create valuable bioproducts.

Evangeline Leong

Industry PhD Candidate

Field of research
Chemical engineering

Maksis Darzins

Industry PhD Candidate

Field of research
Mechanical engineering

Dr Aaron Guo

Research Fellow

Field of research
Chemical engineering

Monash University, Australia

Research project
Developing a direct air capture system that captures carbon dioxide from the air for carbon reduction and utilisation

Funders
RECARB Hub; Woodside Monash Energy Partnership; Australia Economic Accelerator

doi: 10.33424/FUTURUM659

Talk like a ...

direct air capture developer

Adsorbent — a material that attracts and holds molecules to its surface (not to be confused with absorption, which involves molecules being taken into a material)

Bioreactor — a piece of industrial equipment within which a biological process or reaction takes place

Circular carbon economy — an economic model that aims to keep carbon in circulation, rather than treating it as a waste product

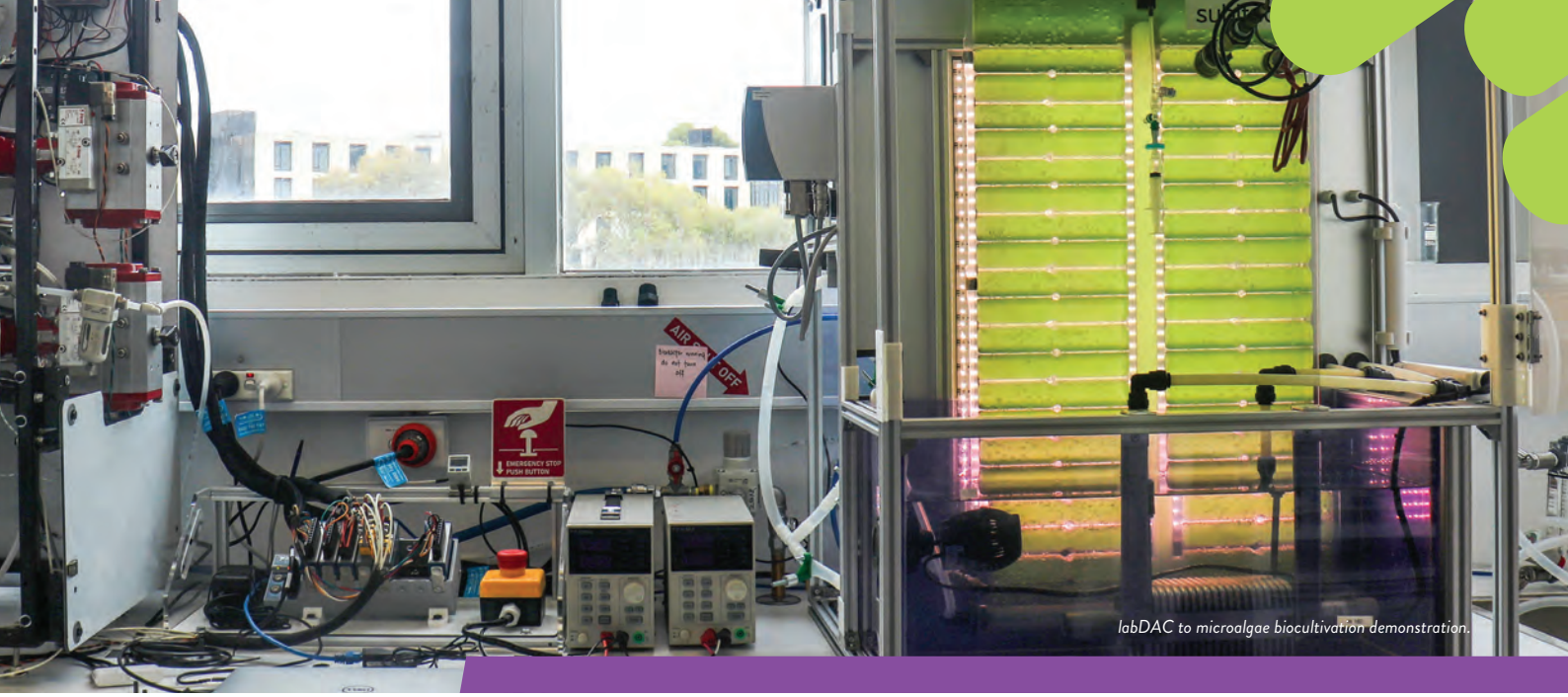
Direct air capture (DAC) — technology that pulls carbon dioxide from the air

Climate change is already having measurable impacts on the environment, ecosystems and human networks around the world. "Carbon dioxide (CO_2) in our atmosphere acts as a blanket around the Earth, creating the greenhouse effect that heats our planet," explains Maksis Darzins from the ARC Research Hub for Carbon Utilisation and Recycling (RECARB Hub) at Monash University. "Human activities have contributed to rising CO_2 levels, influencing climate patterns and environmental conditions."

Mitigating, and ideally reversing, climate change is crucial, and direct air capture (DAC) is likely to be an essential tool in this process as it filters CO_2 from the atmosphere. "As well as directly removing surplus CO_2 from the atmosphere, DAC can also drive a sustainable future by putting this captured CO_2 to good use," says Maksis. "DAC has the potential to replace fossil fuels and create a circular carbon economy with a neutral carbon footprint."

Direct air capture

Sucking CO_2 from the air is nothing new. Plants and other photosynthetic lifeforms have been doing it for billions of years. However, it is unlikely that these organisms alone can absorb enough CO_2 to fully address climate change. This is where new technologies come in. "The technology that we are researching uses a solid adsorbent to capture CO_2 molecules," explains Maksis. "Once the adsorbent is saturated with CO_2, similar to a sponge becoming saturated with



labDAC to microalgae biocultivation demonstration.

water, we heat the adsorbent so it releases the CO_2, which we collect using a vacuum system." The adsorbents can then be reused to capture more CO_2.

Interestingly, the team's system does not rely on one specific adsorbent material. "We are tackling the mechanics of our design first, while remaining open about the materials we use," says Maksis. "This flips the standard DAC design process, allowing us to tackle the issues facing other DAC systems – in particular, energy efficiency and cost – without being too preoccupied with adsorbent design and synthesis." This means that the system can use whichever adsorbent is most effective in any particular context, without needing to redesign the entire system. "This modular package gives us the ability to scale up and work with new contractors and industries, increasing the productivity of our system," says Maksis.

Miraculous microbes

The next stage of the process is figuring out what to do with the captured CO_2. "The CO_2 produced through DAC technology has a negative carbon footprint (it reduces the amount of CO_2 in the atmosphere), so it has potential to be a valuable resource," says Maksis. "CO_2 is already used in various applications, such as carbonating drinks or increasing plant growth in greenhouses." This CO_2 is conventionally produced through fossil fuel combustion, so DAC offers a much greener approach.

Some DAC systems inject and store the CO2 in rocks underground; however, the team's DAC2BIO programme takes a different approach. "We are developing systems that feed captured CO_2 into bioreactors to grow microbes," says Evangeline Leong, the primary investigator of DAC2BIO. "These microbes utilise the CO_2, alongside hydrogen and other gases, to make specific chemicals, proteins or biomaterials." This process (known as bioconversion) is often used in biomanufacturing industries to convert waste materials into valuable products. "By integrating DAC with biomanufacturing pathways, we are showing how innovative methods can help industries be both climate-positive and resource-efficient," says Evangeline.

Given that carbon forms the backbone of all organic molecules, the range of potential products derived from CO_2 is large and diverse. "CO_2 is increasingly used to produce synthetic fuels and chemicals that would otherwise be made from fossil fuels," says Evangeline. "And through biotechnology, we can use microbes to convert carbon dioxide into proteins, bioplastics or other sustainable materials."

Industry partnerships: from research to reality

The team is working with a number of industry partners, bringing together different facilities, resources and expertise. "For instance, Woodside Energy provides engineering expertise and facilities for large-scale integration, helping us understand how DAC can work within real industrial environments," says Evangeline. "Local manufacturing companies, such as KDR Compressors and Rudimental, contribute to the development of the post-capture gas purification and compression systems while global industry partners, such as WesCEF, BASF, and Agilent, support the team in other ways."

Such partnerships also bring challenges. Research and industry tend to work on different timescales, there are differences in the way technical terms are used, and systems have to be established for sharing intellectual property. "But the benefits far outweigh the challenges," says Evangeline. "Together, we're building not just a technology, but a whole ecosystem capable of transforming atmospheric CO_2 into real-world products."

To date, the team has piloted a small-scale DAC system, which captures CO_2 at concentrations suitable for use in a bioreactor. They have also developed a bioprocess that can make biomaterials such as biodegradable plastics. "The next step is to integrate the DAC system with the bioreactor," says Dr Aaron Guo, another member of the team. "Our aim is to demonstrate a small integrated DAC2BIO prototype that shows the complete production line from carbon capture through to bioconversion." The long-term aspiration is to scale up the technology so it can make a tangible difference – both in terms of tackling climate change and supporting carbon-positive industries. "We hope our work will contribute to a circular carbon economy, where atmospheric carbon becomes a renewable resource rather than a waste product," says Aaron.

labDAC to bacterial fermentation demonstration.

About *direct air capture*

Given the critical need to find and implement solutions to climate change, direct air capture (DAC) is a rapidly growing field of study and development. "There are a multitude of interesting design challenges that must be solved for the technology to have a tangible impact on climate change," says Maksis. "Innovative solutions to these problems require creative thinking, which makes the field extremely appealing to work in." The work is highly rewarding; after all, it is helping solve what many consider the greatest challenge of our time.

DAC is a highly collaborative field, combining skills from many different disciplines. "No individual can solve complex problems like DAC alone," says Evangeline. "Progress happens when engineers, scientists and innovators learn to communicate across disciplines." In particular, DAC involves engineers of every type. "Throughout the design process of the pilot system, the team has consulted colleagues in every branch of engineering, including chemical, mechanical, aerospace, electrical, and civil, and each discipline brought their own insights," says Maksis.

Perhaps the biggest challenge of DAC is working out how to capture CO_2 efficiently. "Even though atmospheric CO_2 concentrations are much higher than they should be, they are still very low relative to other gases," says Aaron. "This low concentration makes it difficult to capture CO_2 while ignoring other gas molecules, and also means that an enormous volume of air must be processed."

Download the team's resources from **futurumcareers.com/how-can-we-transform-carbon-dioxide-from-a-greenhouse-gas-into-a-valuable-resource**

Pathway from school to *direct air capture*

At school, get a good grounding in mathematics, physics and chemistry.

At university, Maksis suggests pursuing engineering for the most direct route to DAC research and development. "Chemical engineering and mechanical engineering are the most common, though all engineering fields are relevant," he says.

Vocational careers can also directly contribute to DAC. "All types of practical professions are needed to support the building and development of DAC plants, as well as management and business professionals to support and help scale the emerging technologies," says Maksis.

Explore careers in *direct air capture*

Getting experience in the field is a great way to learn about DAC and whether it could be a good fit for you. Engineers Australia hosts a huge range of resources covering work experience, internships, mentoring and more: **engineersaustralia.org.au/resources/early-career-resources**

Monash University has a number of outreach programmes for high schools. For instance, Monash Engineering Girls is an engagement programme for high school girls to learn more about engineering careers: **monash.edu/engineering/meg**

Meet *Evangeline*

I've always been fascinated by how things work and how they are created. As a teenager, I couldn't decide which area of science I liked best, so I ended up studying all of them at university through a double degree in chemical engineering and biomedical science. Over time, I was drawn to the practicality of engineering, but my biomedical background has also proven incredibly valuable for my current work.

I lead the DAC2BIO programme. My goal is to ensure that the CO_2 we capture doesn't just get pumped underground, but is transformed into useful products. I joined the project because I saw its enormous potential to create technologies that benefit people and the planet. Working with a world-class team of researchers and industry experts is a privilege.

Problem-solving and creativity are essential skills in this line of work. DAC and biomanufacturing are emerging areas, so we often encounter challenges that no one has faced before.

I love being surrounded by brilliant, curious minds. This includes mentors, peers and students. The trust and autonomy that I've been granted by my supervisors have allowed me to explore bold ideas and grow as an innovator and leader.

Outside of work, I enjoy quiet time alone or with family. Simple, restful things help me recharge. I'm an introvert who has learnt to be a professional extrovert when needed; so, when my social battery runs out, I return to calm spaces to reset and find balance.

Evangeline's *top tips*

1. Develop your interpersonal skills. Get involved in group projects, science fairs or student innovation challenges to practise teamwork and creative problem-solving.
2. Pair your scientific curiosity with empathy and purpose. You will find yourself helping to build a cleaner, more sustainable world.

Meet *Maksis*

I have always enjoyed building and creating. When I was young, I spent my weekends making custom skateboards that I used to explore the neighbourhood. This passion progressed to a double degree in mechanical engineering and industrial design, which satisfied the creative and academic parts of my brain.

My true passion for mechanical design was uncovered by an extracurricular activity at university. Monash Motorsport is a student team which engineers, designs and builds race cars to compete in student competitions. This experience honed my engineering abilities and taught me hands-on skills such as welding and machining.

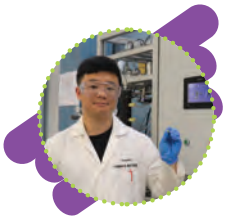
I am the lead mechanical engineer on the DAC project. This involves designing, building, testing and continuously improving the DAC system. This lets me use my skills to create a large positive social and environmental impact.

Our supervisor, Professor Paul Webley, has supported us throughout this project. He is not only passionate about DAC but also dedicated to mentoring and nurturing the next generation of researchers.

Outside of work, I enjoy cycling. Riding in all forms, from the commute to work or long-distance weekend rides, gives me the opportunity to disconnect from the rush of working life and regain balance.

Maksis' *top tips*

1. Be open-minded and willing to learn. What we need more than anything is young, bright people to solve current and future challenges.
2. Research is never straightforward. It's a journey towards innovation, and requires resilience and persistence. Turn your setbacks into motivation.



Meet *Aaron*

I enjoyed physics more than chemistry when I was young. I've since learnt that there are many connections between different fields – and drawing on these connections is vital for solving real-world problems. My bachelor's degree was in mechanical engineering, my master's was in thermodynamics, and my PhD was in chemical engineering. All have come together to serve me in my work today.

I am the leader of material development and the lead chemical engineer on the DAC project. Soon after starting the job, my first son was born. It made me reflect deeply on the kind of world we are leaving for the next generation. I started to feel a personal responsibility to help create a more promising future. DAC is one technology that can help make this vision a reality.

The DAC project requires an understanding of materials and process design. But problem-solving skills and persistence are equally important. Research often brings unexpected challenges, so being able to adapt and keep learning is essential.

I love working with an amazing team. Everyone has a can-do attitude and a willingness to solve problems together. Being part of a supportive team makes the work exciting.

Outside of work, I enjoy fitness and hiking. Exercise helps me release pressure, while spending time in nature helps me recharge and come back to work feeling refreshed.

Aaron's *top tips*

1. Stay curious and keep learning. Explore new ideas, follow the latest research and don't be afraid to try new things.
2. Develop problem-solving, creativity and persistence, because research always comes with challenges.

How can we use blockchain and AI to revolutionise supply chains?

Blockchain technology has taken off in recent years, and is helping to streamline and secure supply chains like never before. However, organisations need to change their strategies, capabilities and mindsets to fully embrace this revolutionary technology. This transition can be supported by artificial intelligence (AI), so **Dr Aravindh Sekar** from **Dakota State University** in the US has developed a unique framework to help organisations effectively integrate AI-augmented blockchain into their supply chains.

Dr Aravindh Sekar

Dakota State University, USA

Field of research
Information systems

Research paper
Integrating AI and Blockchain in Supply Chains: An SDRT-Based Resilience Framework.
Sekar, A., et al. (2025)
doi: 10.20944/preprints202512.0845.v1

Website
scholar.google.com/citations?user=2nk8dJEAAAAJ&hl=en

doi: 10.33424/FUTURUM671

PROFILE

Talk like an ... information systems researcher

Artificial intelligence (AI) — software that can perform tasks that normally require human intelligence

Blockchain — a shared, decentralised, tamper-resistant digital ledger that records transactions in 'blocks'

Decentralised — the transfer of powers, responsibilities or resources from a central authority to a wider group

Supply chain — the system that produces, processes and distributes a product or service – including people, organisations, information, activities and resources

Transparency — being open to public scrutiny, without secret or confidential information

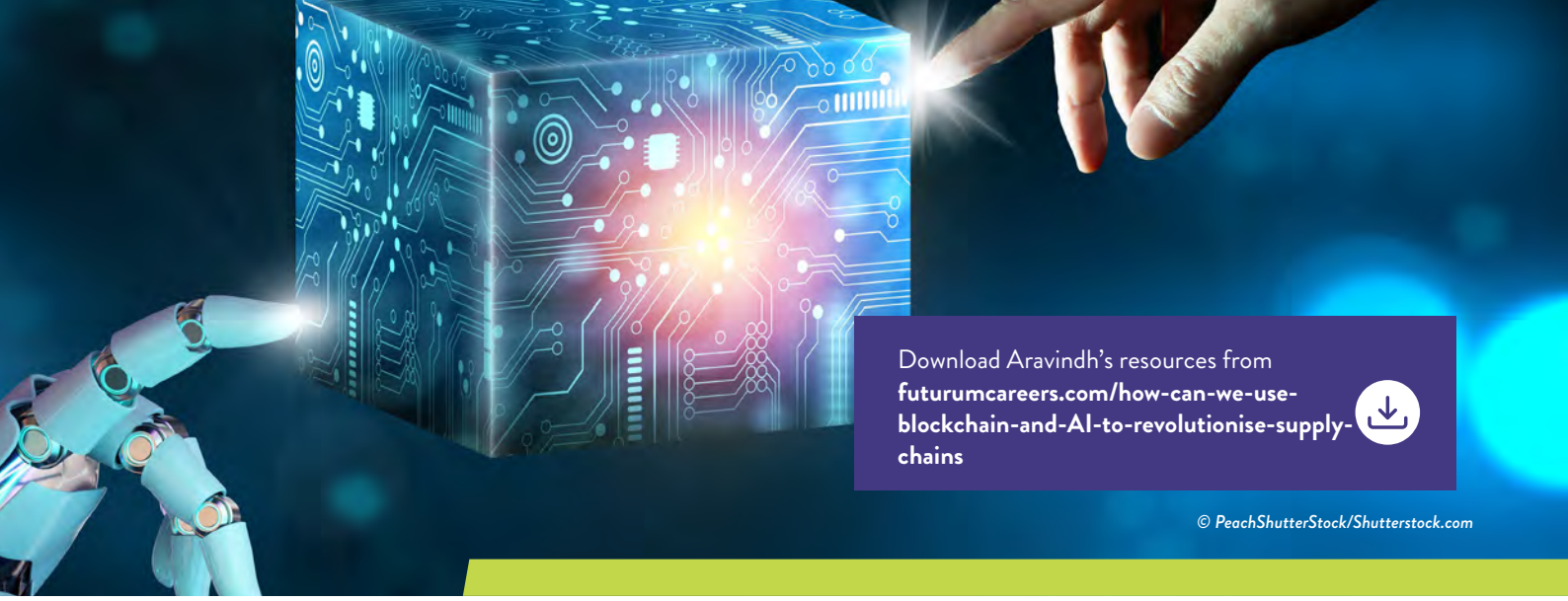
Supply chains make the world go round. They link the production, processing and distribution of any product that you can think of — but making them work efficiently is no easy task. "Having worked in the supply chain industry for many years, I have seen first-hand how easily information breaks down between companies," says Dr Aravindh Sekar from Dakota State University. "Delays, mistakes and mistrust usually happen not because people are careless, but because different systems cannot talk to each other."

If each company within a supply chain has a different way of storing, processing and sharing information, it can be difficult to hold all the information about the supply chain in one place — especially given that this place needs to be secure and tamper-proof. "Data can be delayed, incomplete or inconsistent," says Aravindh. "This leads to problems such as lost shipments, slow decision-making and higher operating costs." Blockchain may hold the key to these problems, and Aravindh believes we are on the cusp of rolling it out across supply chains worldwide.

What is blockchain?

You have probably heard the term 'blockchain' being used on the news or social media, perhaps in relation to cryptocurrency; but it's often tricky to get a handle on what it actually means. "Blockchain is a digital technology that records information in a shared, secure and tamper-proof way," explains Aravindh. "Once data is added to the blockchain, everyone involved can trust it without needing a central authority."

Blockchain is essentially a shared database that is unique through its use of 'blocks' to store and share data. These blocks are all linked to each other in a 'chain', and once made, a block's data cannot be changed. "This helps supply chains become more resilient by improving transparency and reducing errors," says Aravindh. "It also supports sustainability by cutting inefficiency and enabling



Download Aravindh's resources from **futurumcareers.com/how-can-we-use-blockchain-and-AI-to-revolutionise-supply-chains**

accurate tracking of materials, allowing companies and consumers to verify where products come from and if they are made responsibly and ethically."

Transparency is especially important for supply chains, but is tricky to establish. "When organisations can see real-time data on inventory, shipments, delays or disruptions, they can respond faster and make better decisions," says Aravindh. "Problems are identified and resolved earlier, and trust is built among partners, which leads to better cooperation during emergencies."

Blockchain implementation

Aravindh studies how blockchain can be best implemented in organisations. "To me, this research is important because it helps companies work together more smoothly and honestly," he says. "For society, it supports safer products, more reliable supply chains and systems that are better prepared for disruption." Aravindh has developed a framework called Strategic-Decentralised Resilience Theory (SDRT) that lays out how organisations can successfully adopt blockchain technology. "Blockchain implementation is not just a technical project," he says. "It requires the right strategy, organisational capabilities and decentralised mindset."

SDRT comprises three connected pillars of resilience. The first is strategic resilience: the vision and commitment of leaders to use blockchain effectively. The second is organisational resilience: the ability of companies to upskill their workforce and develop processes to use blockchain effectively. "The third is decentralised resilience," says Aravindh. "Organisations need to embrace blockchain's unique strengths: shared control, secure data, distributed decision-making and trust built through technology rather than hierarchy." This is a very different approach to the centralised culture that many organisations are accustomed to — which is why it's important to study how to make it happen.

> ***"This field is just beginning. There is enormous potential for meaningful impact."***

Enter AI

Pushing for strategic, organisational and cultural change in any company can be a headache, but Aravindh believes that artificial intelligence (AI) can help ease the process. "Blockchain can be slow or expensive if not designed correctly, and partners may hesitate to share information openly," says Aravindh. "Moreover, employees may be unsure how to use the technology, and may not have the skills to redesign processes around decentralised data." AI can potentially overcome these issues: it can analyse large volumes of data, predict disruptions before they happen and automate many decisions. Aravindh has updated his framework to include AI as a powerful enabler. "The SDRT-Agentic AI framework expands the original SDRT by adding AI systems that can sense problems, make recommendations and take autonomous actions," he says. "This helps supply chains become not just transparent and secure, but adaptive, predictive and self-correcting."

Nonetheless, this is a big step for organisations — they need to identify the problems they want to solve, have reliable and accessible data, build internal skillsets, and establish governance rules for data management and decision-making. "The SDRT-Agentic AI framework guides organisations through these steps by aligning strategy, technology and people," says Aravindh. "My hope is that it can help organisations understand how to implement blockchain successfully."

The future is now

Aravindh is currently testing and refining his framework in real organisational settings. "I am working on simulation models and case studies to show how blockchain and AI interact," he says. "I am also developing projects that explore blockchain in project management, AI-driven privacy controls and decentralised governance in digital organisations."

These efforts are creating fertile ground for the next generation of information systems researchers. "They will explore how AI, blockchain and data analytics reshape decision-making, resilience, sustainability and the future of work," says Aravindh. "This field is just beginning. There is enormous potential for meaningful impact."

Combining textile technology with healthcare entrepreneurship for human dignity

When we think of health, we tend to think about the physical aspects – being free from pain, illness or injury. However, there is also experiential health – how we feel about and experience our own health. One aspect of experiential health is dignity, which can be a problem for women with low resources around the world when it comes to menstrual hygiene. **Dr Karin Högberg** and **Nils Lindh** of the **University of Borås**, Sweden, have designed an innovative new sanitary pad designed to be durable, hygienic and easy to clean, providing dignity for women and girls who desperately need it.

Dr Karin Högberg

Senior Lecturer, Department of Textile Technology, Faculty of Textiles, Engineering and Business

Nils Lindh

Sustainability Coordinator

University of Borås, Sweden

PROFILES

Fields of research
Healthcare; textile technology

Funder
Swedish Governmental Agency for Innovation Systems (Vinnova)

Website
spacerpad.org/en

doi: 10.33424/FUTURUM666

Talk like a ...

healthcare entrepreneur

3D encapsulation — a method of trapping liquid inside a three-dimensional network of small pockets instead of absorbing it into fibres

Biocide — a substance that kills or controls harmful organisms such as bacteria

Experiential health — how an individual experiences their own physical and mental health

Filament fibre — a long, continuous strand of fibre that can run for many metres without breaking

Hydrophobic — something, such as a fabric, that repels water and, therefore, does not get wet easily

Incontinence — lack of bladder control

Menstruation — often referred to as a 'period', the regular discharge of the uterus lining (and blood and tissue) through the vagina

Patented — legally protected so that only the inventor or company which owns the patent has the right to make or use the invention

Staple fibre — a short fibre, up to only a few centimetres long, that is spun with other staple fibres to produce a longer thread

WASH — water, sanitation and private spaces

From mood changes to cramping, fatigue and aches, having a period can be mentally and physically challenging. In addition, many women and girls have limited financial resources available for sanitary products, making periods difficult to cope with. To compound matters, menstruation is stigmatised in many parts of the world, leading to lack of knowledge and support, feelings of shame and humiliation, and the use of rags or fabric scraps instead of hygienic and purposefully designed sanitary products. For the many women worldwide who lack clean running water, sanitation or private spaces (collectively known as WASH), menstruation is incredibly difficult to manage.

To tackle this, Dr Karin Högberg and Nils Lindh with colleagues at the University of Borås created Spacerpad, a reusable, sustainable sanitary pad, designed to be effective in low-resource environments. "We believe in everyone's equal right to a dignified life," says Karin. "In all cultures, sanitary hygiene is expected to be done in private, which is difficult

By balancing hydrophobic and hydrophilic yarns in different thicknesses, the movement of liquids can be controlled. © Spacerpad

for the millions of women worldwide who lack the right conditions. Being able to discreetly take care of your most private hygiene is important for feeling decent and dignified. The opposite is shame, which is one of the most humiliating things a human can experience."

Karin and Nils' work is guided by the United Nations 2030 Agenda for Sustainable Development, which includes goals such as Clean Water and Sanitation, and Reduced Inequalities. Nils says, "We are primarily targeting the 88% of the world's fertile women who do not have an abundance of financial resources, and women who lack safe access to water or sanitation solutions."

What is Spacerpad, and how is it made?

"Spacerpad is a high-tech, hygienic and durable sanitary pad that holds liquid using 3D encapsulation instead of absorption," explains Karin. In traditional pads, the liquid is either absorbed into the fibres themselves or into highly absorbent disposable materials. In Spacerpad, menstrual fluid is captured inside tiny three-dimensional pockets formed by hydrophobic filaments, and a patented barrier stops it from leaking.

The pads are made from filament fibres, which are long, continuous strands of material, rather than from staple fibres which are incredibly short fibres that are spun together to create a continuous thread. "Filament fibres are stronger, smoother and less likely to retain particles than staple fibres," explains Karin. "The liquid-holding core of Spacerpad consists of 100% polyester filament structures, making it quick-drying, easy to clean, and hygienic for repeated use."

This innovative approach makes Spacerpad durable, lightweight, breathable and capable of holding large amounts of fluid. "The pads are easy to clean with a small amount of water and soap, and dry quickly because water isn't trapped," says Karin. "The small water residues can be manually squeezed away with a piece of fabric, preferably made from staple fibres of natural materials as these absorb water effectively." This means that only two to four pads are needed for a full period, and with careful use, a pad can last several years, making each Spacerpad very cost-effective.

How is Spacerpad overcoming the limitations that many of todays' sanitary products have?

Reusable sanitary products exist, but they often leak, smell, or are difficult to clean and dry. To prevent odour, Spacerpad includes a silica spray. Karin explains, "Silicon dioxide, or silica, is one of the most common minerals on Earth. It exists naturally in forms like quartz, and it's safe for people and the environment."

Another key concern is safety. "A lot of reusable sanitary products are treated with biocides, such as silver ions, copper zeolite and zinc oxide, which are harmful to the environment and to wildlife. Some are even hormone-disrupting for humans," says Karin. "Our alternative to antibacterial additives is to eliminate the basis for what can become a bacterial growth, by offering a product that is truly easy to clean with only a small amount of water and soap or detergent, and which dries quickly, minimising the risk of moisture during reuse."

What challenges did the development of Spacerpad involve?

Karin and her colleagues set themselves an ambitious target – to create a pad that worked like a menstrual cup. "One moment it should hold liquid, and the next moment it should release it, two contradictory properties which are tricky to combine," says Karin. "The solution involves considering the materials and how they are constructed – that is, the production of the pad."

Beyond the creation of Spacerpad, there was the challenge of how to get Spacerpad to the target group – women with the fewest resources. These women do not have money to spend on expensive products, but technological innovation is not cheap. So, Karin and Nils created ways to remove this financial barrier. "We have worked extensively with different business models to make Spacerpad accessible to more people," explains Nils. "These include a 'buy one, give one' concept, enabling those who can afford it to donate a Spacerpad to someone who cannot, and facilitating local production in low-income areas."

What's next for Spacerpad?

The next exciting step is getting Spacerpad out to the women who particularly need it. Karin and Nils hope Spacerpad will be available in India and parts of East Africa in early 2026. Beyond that, Nils says, "One can always continue to research and develop, but we must choose how best to use our resources. Instead of product development, I think we will look more at how we can build local production and distribution in a sustainable way."

A Spacerpad storage tub containing pads and soap.
© Spacerpad

About *healthcare entrepreneurship*

Karin and Nils' work in healthcare entrepreneurship and textile technology requires skills such as creativity, problem-solving, perseverance and business sense, as well as specific knowledge about a field. Karin says, "I have a research brain and a heart for development that benefits the people at the bottom of the economic pyramid."

Karin and Nils are passionate about supporting dignity. Karin says, "Health has a physical dimension, but experienced health goes further than that – the deepest depths of human experience, where issues like dignity become central."

Bringing their vision for Spacerpad to life has required practical innovation. Spacerpad holds fluid rather than absorbs it, needing heat-and-pressure assembly without squashing, so they created a specialised machine for this process. Smart solutions, such as moving production to the areas where the product is needed, will help get Spacerpad to low-income women and support local economies while still covering production costs. "Local manufacturing enables ownership and job opportunities," says Nils.

Karin and Nils have also devised 'Spacerpad It Forward' (SPIF). "SPIF is a social innovation with a simple core idea: 'Buy a pad, pay for a pad for a sister'," explains Nils. "Each purchase funds a Spacerpad for a woman who cannot afford one, and in high-income regions like Europe, buyers pay more to support women in low-income countries. SPIF aims to transform menstrual health access into a shared responsibility, bridging gaps between economic classes and empowering women worldwide."

Healthcare solutions are needed in different areas of personal hygiene. "Activism around the phenomenon of menstruation has been very positive and has broken down many taboos," says Karin. "However, incontinence, especially in a resource-poor settings, needs similar solutions – discreet, affordable products, safe washing and drying facilities, and respect for dignity. Addressing this requires entrepreneurial vision."

Download the team's resources from **futurumcareers.com/combining-textile-technology-with-healthcare-entrepreneurship-for-human-dignity**

Pathway from school to *healthcare entrepreneurship*

At school, make sure you develop a good foundation in the sciences, to understand technology and people's physical needs, and humanities, to understand people and societies.

To develop products similar to Spacerpad you may want to study textile technology at university.

"If you want to work on developing menstrual hygiene solutions, or how people can be lifted out of poverty, there are many entrances and, therefore, a huge range of educational opportunities," says Karin. "You may be more drawn to natural sciences or social sciences. Either way, it is of great value if you can collaborate across both areas."

Explore careers in *healthcare entrepreneurship*

You can learn more about the work of Karin, Nils and their colleagues at the University of Borås in Sweden here: **hb.se/en/the-swedish-school-of-textiles**

"The Swedish School of Textiles (**hb.se/en/the-swedish-school-of-textiles/about-the-swedish-school-of-textiles**), part of the University of Borås, hosts open house events and provides online guidance sessions," says Karin. "For international audiences, the Swedish School of Textiles offers webinars and digital resources about studying in Sweden."

The Textile Institute (**textileinstitute.org**) is an international professional organisation for people working in the textile industry. Its website provides courses as well as all the latest news and information about the field. You could even consider becoming a student member which would get you access to resources, career support and events.

Spacerpad is a reusable, sustainable sanitary pad, designed to be effective in low-resource environments. © Spacerpad

Meet *Karin*

I was inspired to pursue nursing by the desire to make a tangible difference for people who really are in need of support.

You can develop ideas based on technical possibilities or based on human needs. The need I have based my work on is existential – the human need for dignity.

My strongest driving force is a 'moral ambition', something the Dutch historian Rutger Bregman writes about in his book with the same name. He argues that people should use their talents not just for personal gain but to tackle the world's problems, and I encourage others to embrace this same ambition. It is possible to shift from "someone should..." to "I will do it...".

My proudest career achievement is not giving up on the idea of simplifying life for those who almost always end up last in priority – women and girls living in poverty.

We have not yet reached our goal of having the smartest products reach those with the greatest actual need. So, it will remain!

Karin's *top tips*

1. If the issue you focus on is ethically significant, for humanity, society or the environment, then I believe you can have more energy and can manage to do and achieve more. It is also easier to get others interested in what you are doing, which is important so that you can build a team.

2. Working in a team is important because you need different skills, but also because it allows you to find enjoyment and stay motivated.

Meet *Nils*

I grew up in Kenya, spending 10 of my first 16 years there. Experiencing its nature, cultures and challenges sparked my interest in sustainability and led me to study environmental sciences and business. After working for environmental authorities, I joined a small development organisation where I shaped partnerships in Africa, expanded projects and developed strategies.

My eureka moment came when I realised that aid often creates dependency, while learning empowers change. This insight drove us to design strategies focused on learning processes, entrepreneurship and local ownership – while embracing patience and clear communication. These principles continue to guide my work, including in the Spacerpad project.

My proudest achievement is realising the transformative power of learning and building strategies around it – creating approaches that foster ownership, entrepreneurship and sustainable impact.

My aim is to see Spacerpad succeed and improve the lives of underserved women and girls globally.

Nils' *top tips*

1. Understand that sustainability is complex, so keep an open mind and practise patience.

2. Focus on people. Recognise that we all have needs and biases, and prioritise learning as a way to move forward together.

Say YES to youth empowerment: how increasing agency can reduce violence

Many young people feel like they have little control over their lives, and this feeling, along with the emotions it can trigger, can lead to violent behaviours. In response to this issue, **Professor Marc Zimmerman** from the **University of Michigan** co-founded the YES programme, which supports and empowers young people through community engagement. Marc works with YES Project Manager, **Kate Taelman**, and teachers like **Alicia Harris-Goodwin** to empower young people in America and around the world.

Professor Marc Zimmerman

Marshall H. Becker Collegiate Professor, Co-Director of the Institute for Firearm Injury Prevention, Faculty Member of the School of Public Health, University of Michigan, USA

Kate Taelman

Research Area Specialist, YES Project Manager, University of Michigan, USA

Alicia Harris-Goodwin

Middle School English Language Arts Teacher, Grandport Academy in Ecorse Public Schools, USA

Fields of research

Community psychology; developmental psychology; public health; adolescent and child health; school health; violence prevention

Research project

Youth Empowerment Solutions (YES): centring youth in community violence prevention

doi: 10.33424/FUTURUM668

PROFILES

Talk like a ...

youth empowerment worker

Agency — the ability to make your own choices and take actions that have a positive impact on your life

Comparison group — a group of people in a study not receiving treatment, allowing researchers to explore whether an intervention has made a difference or not

Empowerment theory — a framework explaining the process by which individuals gain the necessary skills, experiences and knowledge to feel empowered and create change in their community

Facilitator — a person who takes a neutral role and guides a group to work well together and achieve a common goal, rather than taking a position of authority or imparting knowledge

Funders

The YES programme and resources were made possible by grants from the US National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC) and the John Mohme Foundation

How much control do you feel you have over your life? Young people often feel like their voices are not heard and that adults make all the decisions. This lack of agency can be frustrating and lead to negative behaviours and poor mental health.

To help young people reclaim their agency, Professor Marc Zimmerman from the University of Michigan co-founded the Youth Empowerment Solutions (YES) programme. Driven by a desire to reduce youth violence, he realised that the most important factor was for young people to take the lead and be at the heart of creating solutions. "One of the most consistent findings in psychological research is that agency is related to our level of mental and physical health," says Marc. "So, we created YES to help put youth on the path to gaining that sense of control — in essence, to be empowered."

What is the YES programme?

YES is based on empowerment theory, which focuses on two questions: how do people become empowered, and how do we know when someone is empowered? "The answer to both questions lies in the

Youth and adults working together to create a peace garden as part of their YES Community Project in Flint, Michigan.

idea of having control over the things in life that matter to you," explains Marc. "It might be doing well in school, getting a good job, doing well at sports or influencing decisions that matter to you, like school policies."

YES is currently designed for 10- to 13-year-olds. "The main goal of YES is to instil in students the ability to promote positivity while discouraging negativity and violence," says Alicia Harris-Goodwin, a teacher who leads the latest iteration of YES. Participants in the programme start with team building and leadership activities, then use creative practices, such as photography, to identify problems in the community and potential resources that could help solve the problems.

Once a community issue has been identified, participants design and implement a project. "The project could be a physical change, such as creating a mural, community garden or reading space in school, or a social event, such as a community celebration or a school health fair," says Marc. "The curriculum is designed to help youth think critically about their lives and community, develop confidence, decision-making and problem-solving skills, and recognise that they can create change."

Each YES group is guided by trained adult facilitators who support rather than control their participants. "The role of a facilitator is to help youth realise and reach their potential," says Marc. "They need to be a sideline coach, not a lecturing teacher, and the responsibility is given to the youth."

How has the YES programme been evaluated?

"It is important that we pay attention to the conversations between facilitators and participants, as both groups are likely to have personal, related experiences or curiosities around the topics being discussed," says Kate Taelman, project manager of YES. Accordingly, the team have carried out evaluations of both the implementation and the outcomes of the programme. The implementation evaluation, where groups were observed and feedback was taken from the youth and the facilitators, has led to changes such as more formal training and support for facilitators.

In terms of outcomes, the team monitored the progress of regular attendees three months after the programme and one year later, compared to a comparison group of young people who did not participate or attend many sessions. "We found that youth in the programme felt more empowered, improved their problem-solving skills and took more actions to exert control in their lives," says Marc. "This led to more positive behaviours, such as school engagement and participation in extracurricular activities, and fewer problem behaviours, such as alcohol use, crime and violence, compared to youth who did not participate in the programme."

Testimonials from participants highlight the programme's positive impacts. "One youth interviewed several years later noted that the YES experience was transformational and helped him appreciate his community and that there was more to the world than his own perspective and experience," says Marc.

Facilitators note that participants form friendships, connect with trusted adults, gain confidence to speak in front of a group and learn to communicate respectfully, even when they disagree. "This is important because we want them to be able to know how to engage with people from different backgrounds or points of view while valuing each other and demonstrating respect," explains Kate.

What are the wider impacts of the YES programme?

The team found a reduction in violent crime around murals and gardens created by participants. "We found that the effect was stronger closer to the project, and then slowly decreased further away from the site," says Marc. "This led to a whole new programme of research on greening and reclaiming vacant properties, which we have consistently found to result in less community violence."

"Youth-led projects have also addressed other needs within their school communities," says Kate. "Some have created food pantries or emergency clothing banks, while others have installed buddy benches, promoted school pride, and hosted events to destigmatise and raise awareness of mental health."

What is next for the YES programme?

The team are improving YES by providing free online access to all programme materials and low-cost, self-paced facilitator training. They hope to expand YES to high school students, including a focus on employment skills for older students and graduates. "We are currently evaluating YES to see whether it can improve tolerance for differences and build solidarity between youth, regardless of race, sexual identity, gender and (dis)ability," says Marc.

Youth and adults working together to create a peace garden in Flint, Michigan.

About *youth empowerment*

Childhood, adolescence and early adulthood are full of excitements, frustrations and mistakes, and are key to the development of our personality and sense of self. Working in youth empowerment provides unique opportunities to sit alongside young people as they work through these experiences, and to enable them to grow in confidence, develop leadership skills and become agents of change. "Youth empowerment is exciting because you see thought processes change over time," says Alicia. "We often see quiet students who join YES and find a voice they didn't know they had."

There are challenges, such as convincing young people (and adults) to engage with the work. "Some youth find it hard not to think critically about their community and to recognise that they have power to make change," says Kate. "Apathy is rampant and there are lots of distractions, such as social media, that make it easy to tune out."

"Another challenge is helping students understand that there are people who live their lives differently from them yet have some of the same experiences," says Alicia. "It is important to help students understand that the stereotypes and stigmas they have seen and heard about through the media don't represent a single group of people."

These challenges can be overcome by listening deeply to the needs and concerns of young people. "Centring youth voice and experience is key," says Kate. "They need opportunities to practice using their voice, making decisions and planning for shared goals." Patience and acceptance are also important. "Keep an open mind," says Alicia. "Be willing to accept people as they are and know that there's always room for growth."

Pathway from school to *youth empowerment*

At school, build a foundation in psychology, sociology and statistics. At university or college, focus on topics such as community psychology, developmental psychology and public health. Exploring courses which cover service learning, organisational studies, group processes and active learning will also be helpful.

"If you are interested in youth related research or youth empowerment, be sure to gain experience working directly with youth or with professionals who work with them in any capacity," says Kate. "You can learn a lot about the needs and experiences of youth through roles like coaching, camp counselling or assisting teachers."

Explore careers in *youth empowerment*

Careers in youth empowerment can include working as a researcher in universities or other organisations such as charities and policy research units, or working directly with young people in settings such as schools, hospitals, prisons and community centres.

The American Psychological Association (**apa.org**) and the British Psychological Society (**bps.org.uk**) both have useful websites full of information, resources and volunteering opportunities. You could even consider becoming a student member, which gives you access to additional resources as well as meetings, conferences and other opportunities to meet professionals working in the field.

You can learn more about the research being carried out by Marc, Kate and their colleagues in the School of Public Health at the University of Michigan on their website: **sph.umich.edu/research-education/index.html**

Download the team's resources from **futurumcareers.com/say-yes-to-youth-empowerment**

Meet *the team*

Meet *Marc*

I grew up during the civil and women's rights movements of the 1960's, so I was influenced by how those movements made change by organising and making their voices heard in mostly non-violent ways. When our college administrators started to cancel all bi-lingual, women's and African-American studies programmes, I worked with my fellow students to save them. We succeeded, but I learnt that those in power had all the information. This led me to a career in research because I wanted to develop the skills to gather data and inform policy, and to have the power of the data and information that I generated.

I enjoy working with my colleagues and community partners to use the research process to improve lives, especially among those who are less advantaged than me. It was not easy, but I now get to use research to make a difference in the lives of individuals, families and communities – helping to create safe and healthy futures.

I'm motivated by helping youth find a path to positive development instead of the slippery slope of problem behaviours which can lead to all sorts of bad outcomes like alcohol and drug addiction, crime, injury, and even death. I am also driven by helping the next generation of learners take what I have learnt to new heights and make positive change in the world.

Marc's *top tips*

1. Believe in yourself, and be a positive force in the world.
2. Be open-minded, listen to others' ideas and include them in your plans to make positive change happen.
3. Think outside the box, be creative and do not let the ordinary get in the way of the extraordinary.

Meet *Kate*

My own teenage years were very challenging. I became a social studies teacher to help students who were facing similar challenges, and to instil the belief that people have power to make change within themselves and their community. As a teacher, I saw the effects of structural racism and policy failures that contribute to violence, poverty and poor health outcomes at a population level. After more than a decade in various education roles, I began my career in public health research. I wanted to better understand what 'we' can do about these large issues facing communities, and to do something about it.

What I love most about my job is the people! I enjoy working with my colleagues and connecting with the YES teachers and youth involved in the programme. I also love that my role helps others work towards creating a better world. I love being a project manager because no two days are the same and I'm able to use my planning, organisational and problem-solving skills in meaningful ways.

I am motivated by the beliefs that people have power and youth are our future. This means preparing them and making sure they understand that their power is vital. We do not need to normalise or accept violence as an inevitable outcome. Adults and youth can't become complacent in that. We can do better.

Kate's *top tips*

1. Make connections with all kinds of people. Let them teach or inform you about their lives, experiences and expertise.
2. Go through open doors – they may lead you to something you hadn't thought of or planned to do, but more often than not, it'll be better than you expected.

Meet *Alicia*

As a teenager, I was interested in the typical activities – going out with friends, reading and listening to music. In high school, I was a member of the marching band and symphony band.

During my undergraduate years, I was involved in many teaching and mentoring roles with a variety of groups. This helped me determine which ages I wanted to teach, and promoting youth empowerment was an added bonus. As a teacher, I give my students the necessary tools to be their best selves, especially how to give and receive respect.

I love hearing student-led discussions. I'll pose a question based on the given topic, and they'll keep the conversation going. In those moments, I am more of a moderator than a facilitator. It's an amazing thing to see, hear and feel. It gives me an understanding of what their points of view are and answers the 'why' of what they think and feel.

I am motivated by students who are excited to participate. They show up eager to hear about and discuss the given topic. Their commitment to the YES programme inspires me to keep working with the programme as well.

Alicia's *top tip*

Start small and take part in volunteer work with youth to determine your level of commitment.

Staying on track: how do teenage athletes choose what to eat?

In Canadian high schools, around 30% of teenagers participate in school sports. However, there are limited resources available to help these teen athletes decide what they should be eating to keep themselves healthy and improve their performance. At the **University of British Columbia** in Canada, **Dr Tamara Cohen** and her PhD student **Alysha Deslippe** are developing an app that helps teenage athletes improve their understanding of nutrition so that they can make better decisions about what to eat.

Dr Tamara Cohen

Associate Professor in Human Nutrition, Director of Dietetics Programs

Funders
Canadian Institute of Health Research; University of British Columbia; The Canadian Foundation for Innovation; Canadian Institute of Health Research Planning and Dissemination Grant

Alysha Deslippe

PhD Candidate in Human Nutrition

Funders
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University of British Columbia, Canada

Fields of research
Dietetics; nutrition; dietary behaviours

Research project
Developing an app to support nutrition and food literacy in teen athletes

doi: 10.33424/FUTURUM667

PROFILES

Talk like a ... dietitian

Dietetics — the scientific study of food and its effect on people's health

Eating behaviours — a person's patterns and habits of how they choose and consume food

Food literacy — the ability to make informed choices about food and consider its impact on health, the environment and the economy

What do you think about when you choose what to have for lunch? Perhaps you consider which meals are easy and quick to make, which ingredients are most affordable, or which foods have the most protein or energy. Maybe you think about which meals taste the best or have the lowest environmental impact. Whatever you prioritise, understanding the food we put in our bodies — and how it impacts our lives and well-being — is an important part of becoming food literate.

At the University of British Columbia, Dr Tamara Cohen and her PhD student Alysha Deslippe are working to improve the food literacy of teenagers. Food literacy affects many aspects of our lives, and it is much more complex than being able to tell the difference between healthy and unhealthy foods. Instead, food literacy also includes having the skills to cook different meals, knowing which foods are sustainable and affordable, and understanding how food can affect our mental health. "What we eat affects everything — energy, growth, mental health and even how well we recover from illness," says Alysha.

How can we improve our food literacy?

Most people first learn about food by cooking with family members or attending cooking classes at school. However, food-based TV shows, nutritional content online or on social media, and talking to dietitians are also great ways to get more information.

"Once you know what food your body needs, becoming more food literate is all about practice," says Alysha. "This

includes trying out new foods and learning to cook new meals. Anything that allows you to really think about what you need to eat, as well as where and how you can get it, are great ways to start building your food literacy."

What are Tamara and Alysha studying?

While it is important to develop food literacy at any age, Tamara and Alysha are promoting this knowledge amongst teenagers and young people. "Food literacy is incredibly important for teens because it can help them make choices about when, what and how to eat, in ways that support their physical health and mental well-being," says Alysha.

With the overwhelming amount of content and misinformation online, as well as harmful messaging around body image and dieting advice on social media, it is now more important than ever for teenagers to have trusted and reliable sources that can help them make healthy choices around food.

Focusing in: teenage athletes

In their current research, Tamara and Alysha are working specifically with teenage athletes, as their relationship with food plays a huge role in their ability to compete and perform well in their sport. "If a teenager doesn't get enough nutrients for their level of activity, they can be more likely to get injured, feel sluggish and fail to grow to their full potential," says Alysha. "In extreme cases, a teen who doesn't get enough nutrients might not be able to keep playing their sport."

> ***"Once you know what food your body needs, becoming more food literate is all about practice."***

Tamara and Alysha have been working to understand current levels of food literacy in teenage athletes and areas in which they might need help. Their initial research has shown that while most teenagers are comfortable cooking and understand how food affects their physical health, a lot of them do not understand the impact of food on their mental well-being, social connections or the health of the planet. "What this means is that we have more work to do to make sure teens can make informed choices that aren't just based on whether a food is healthy or not," says Alysha. "It's much more complex than that!"

Research project: PLAYTE

To help teenage athletes improve their food literacy, Tamara and Alysha have developed an app called PLAYTE, which aims to help teenage athletes develop the skills and knowledge they need to cook high-nutrient meals and make food-based decisions that will help their performance. Instead of a one-size-fits-all approach, PLAYTE helps users develop personalised dietary habits that work for them and support both their physical and mental health. "For example, PLAYTE uses portion sizes instead of rigid numbers when helping users figure out what nutrients they need," says Alysha. "The app also includes meal tracking, sport nutrition videos and a recipe library, and we have incorporated specific safety measures to make sure PLAYTE does not cause an athlete to feel worse about themselves or their body by thinking about what they eat while using the app."

To measure the impact of PLAYTE, the research team has created a study with 80 high school athletes who are using the app for a full school year. "We send out online surveys to participants before and after using PLAYTE, which lets us measure changes in their dietary habits and receive feedback," says Alysha. "So far, teen athletes have found PLAYTE fun, useful and simple to use." The team's next steps are to collate the feedback and adapt the app accordingly. "For example, we're adding in a goal-setting feature based on feedback that this would make the app feel more personal," continues Alysha.

If your school is based in the Greater Vancouver area, ask your teacher if your school can start using the PLAYTE app. Alysha and Tamara are also partnering with national organisations to get the app promoted further afield too, so keep an eye out to see if PLAYTE makes its way towards you!

About *dietetics*

Dietetics is the scientific study of food and the practice of helping people make the best decisions about what to eat. Within the field of dietetics, there are a huge range of different career options, as dietitians can work in hospitals, medical research groups, sports teams, community projects or within the pharmaceuticals industry. "Regardless of which area they are working in, dietitians are regulated health professionals who assess, diagnose and treat nutrition-related problems," says Tamara.

"Dietetics is all about using food and nutrition to keep people healthy and prevent disease," adds Tamara. "Dietitians help individuals make better choices and also shape public health programmes, like school lunch guidelines or hospital nutrition plans. By improving nutrition, dietitians can help reduce the risk of chronic diseases like diabetes, heart disease and obesity, which benefits society as a whole."

Dietitian or nutritionist?

The words dietitian and nutritionist are often used interchangeably, but they mean very different things. "A dietitian is a legally protected title in Canada, and dietitians must meet strict education and licensing requirements," says Tamara. "They can work in clinical settings and provide medical nutrition therapy." On the other hand, being a nutritionist is not a protected title, meaning anyone can call themselves a nutritionist — even without formal training.

What are the rewards and challenges of working in dietetics?

The positive real-world impact of working in dietetics is one of the main reasons people are drawn to this field. "You get to make a real difference in people's lives — helping someone feel better, recover faster or build healthy habits that last a lifetime," says Tamara.

"Food is something that everyone interacts with every day, and it has a huge impact on health and quality of life," adds Tamara. "Dietetics allows me to use science to solve problems and change lives — whether it's helping someone manage a chronic condition or influencing national nutrition guidelines. Seeing research translate into real-world improvements is incredibly fulfilling."

However, one of the challenges that Alysha and Tamara face is combatting the misinformation and incorrect nutrition advice that people often find online, which is only getting worse. "Another challenge is working with people who are struggling to change their eating habits," says Tamara. "Understanding people's challenges and supporting them without judgment is key." By becoming a dietitian, you could help find solutions to these challenges!

Pathway from school to *dietetics*

"Focus on biology, chemistry and math in high school," says Tamara. "These subjects are the building blocks for understanding nutrition."

Next, study a bachelor's degree in human nutrition or dietetics. "After that, you have to complete supervised practical training and pass a licensing exam to become a dietitian," says Tamara.

"Take additional courses in physiology, biochemistry and food science," advises Tamara. Once you have completed an undergraduate degree, you will need to pursue a master's degree if you want to work in research.

Explore careers in *dietetics*

"Careers in dietetics include clinical dietitians (in a hospital), community nutritionists, sports dietitians, food industry consultants, academic researchers and educators," says Tamara.

"A dietitian's day can vary a lot depending on their job," says Tamara. "Some work in hospitals, helping patients with special diets. Others work in sports, planning meals for athletes, or in research, studying how food affects health."

Try to get hands-on experience in healthcare and food-related settings. "Volunteer at hospitals, community health programmes or food banks," says Tamara. "Speak with researchers or PhD students in the area you are interested in. Most researchers and students are happy to talk about what they do, and this can be a great way to get some inside knowledge about what the role is like and what to expect."

Learn more about becoming a dietitian from the Dietitians of Canada: **dietitians.ca/Become-a-Dietitian/Education-and-Training**

Read about the variety of interesting career paths that are open to nutrition and dietetics students: **landfood.ubc.ca/alumni/alumni-profiles**

Download the team's resources from **futurumcareers.com/staying-on-track-how-do-teenage-athletes-choose-what-to-eat**

Meet *Tamara*

As a teenager, I was always very active — I loved exercising and staying fit, and I also loved baking. I thought I wanted to become a medical doctor, but over time, I realised that dietetics offered something unique: flexibility, creativity and the chance to talk about food all day!

I love the creative nature of my job and the flexibility to explore research questions that truly interest me. Every day feels different because I can design studies, analyse data and develop new tools to help people improve their health. I also love working with others — collaborating with professors, students and health professionals makes projects exciting and rewarding.

What really drives me is the opportunity to make a difference. Nutrition can prevent illness, support recovery and even influence public health policies. Knowing that my work can improve lives on both an individual and community level keeps me passionate about this field.

As the Director of Dietetics at the University of British Columbia, I'm also motivated by the chance to shape the future of the profession. I get to design programmes that train the next generation of dietitians and ensure they have the skills to meet today's health challenges.

To unwind from work, I run — and I run a lot! Staying active is my way of clearing my head and recharging. My mantra is simple: eat, sleep and work out. Whether it's a long run or just a walk around the block, moving my body helps me stay focused and manage stress. Exercise gives me time to think, reset and come back to work with fresh energy.

Tamara's *top tips*

1. Develop your communication skills! Dietitians work with patients, students and other health professionals every day, so being able to clearly explain complex ideas is key.

2. Stay curious and open-minded. Nutrition science is always changing. Be ready to learn and adapt.

Meet *Alysha*

As a teenager, I was diagnosed with irritable bowel syndrome (IBS) and had to make a lot of changes to what I was eating to support my health. While I was going through this process, I became really interested in all the information that was out there about nutrition and, importantly, how often it's actually untrue. I wanted to pursue a career where I could help to tackle this misinformation and help other people figure out what to eat in ways that support their health.

Although I am a behavioural scientist rather than a dietitian, I am thoroughly trained in nutritional needs, the reasons behind dietary habits, human anatomy and other key topics dietitians need to know.

My experiences dealing with IBS, competing as a former athlete and working as a coach for over 10 years have all helped shape my PhD. I can tie experiences from my life into my research and this often makes it feel more meaningful to me — I can see how my work can be useful for others in the real world.

I'd love to see more work on how high school coaches of teen athletes can be better supported in their roles. Being a high school coach in Canada is often a volunteer position and doesn't come with much training. Getting a better understanding of what support coaches may need could help improve sport experiences for everyone involved.

After work, I like to get outside to move my body, whether that's running, skiing, playing beach volleyball or going for a walk. Right now, I am doing a lot of unwinding by walking with my young pup Marvin and watching Netflix with him.

Alysha's *top tips*

1. Try out research early, as it can look very different depending on the field, country, project or team.

2. When choosing a career, think about whether what you would be doing on a day-to-day basis is what you really want.

The wisdom of young carers

Motivated by her own experience as a young carer, **Rebekah Gold**, Co-Founder and Director, leads the **Young Caregiver Council of Canada (YCCC)**. Amplifying carers' stories and fostering a supportive community, the YCCC is proud to celebrate young carers as leaders and change makers.

What defines a young carer?

Young carers (also called young caregivers) are generally young people who support a family member or friend living with chronic illness, disability, mental health challenge, substance use, parental absence, ageing needs, and/or other social or cultural factors (such as language barriers).

You might be a young carer if you do any of the following things for a parent, grandparent, sibling, other family member or friend:

- manage someone's medicine and medical supplies
- accompany or drive someone to appointments, social gatherings, grocery shopping, etc.
- help to emotionally regulate someone, de-escalate someone or a situation, call emergency services to support someone, protect and keep someone safe, navigate someone's mental health crises
- assist someone with toileting, clothing, showering, moving around, etc.
- help someone communicate with others, advocate for their rights, manage their finances, navigate health and social services.

This is by no means an exhaustive list.

What is the YCCC, and what motivated you to establish it?

The Young Caregiver Council of Canada (YCCC) is a group of dedicated young carers (aged between 14 and 30) with diverse care experiences (past and/or present). Our aim is to represent and mobilise the stories and wisdom of young carers across Canada.

Co-founded with the Young Caregivers Association® and initially supported by Petro-Canada CareMakers Foundation National Grant, I have worked alongside brilliant young carers to build the YCCC from the ground up since 2023. Drawing on my experiences as a young carer and critical participatory researcher, I worked to ensure the YCCC was created by young carers for young carers, prioritising community, mentorship, shared decision-making and meaningful partnerships. Our group fosters community through shared care experiences and collaboration on efforts, events and projects. In addition to participating in community nights, young carers engage in initiatives including media creation, conference presentations, panel speaking events, research projects, stakeholder meetings, networking, council projects and outreach activities. The YCCC has now become its own advocacy entity and a powerful space for community among young carers.

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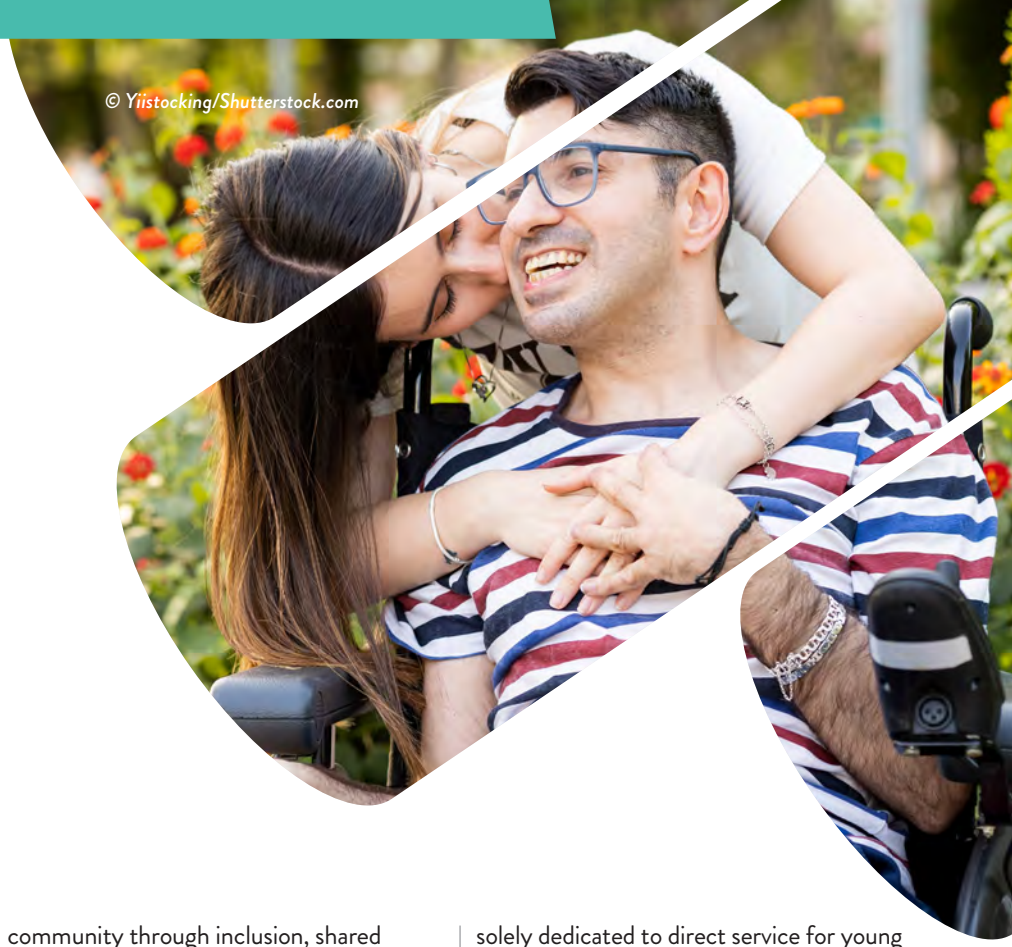

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What are the YCCC's goals?

Our mission is to represent carers' stories and experiences, and to support the engagement of young carers in research, practice, decision-making and national policy in Canada.

We want young carers to be recognised, supported and valued. And we want to create a space grounded in connection and co-creation, where we design our own projects, share our lived wisdom and work alongside professionals and policymakers to transform the systems that shape our lives.

We uphold three important pillars:

Value Our Stories: We advocate for ownership over our own stories through direct involvement in the decisions that impact our lives. Our stories belong to us. Our stories matter.

Support Community: We prioritise community through inclusion, shared understanding, mentorship and a genuine interest in each other's well-being.

Advocate for Change: We engage in initiatives, events and projects in collaboration with professionals, researchers, organisations and institutions that build awareness, support and resources for young carers and families.

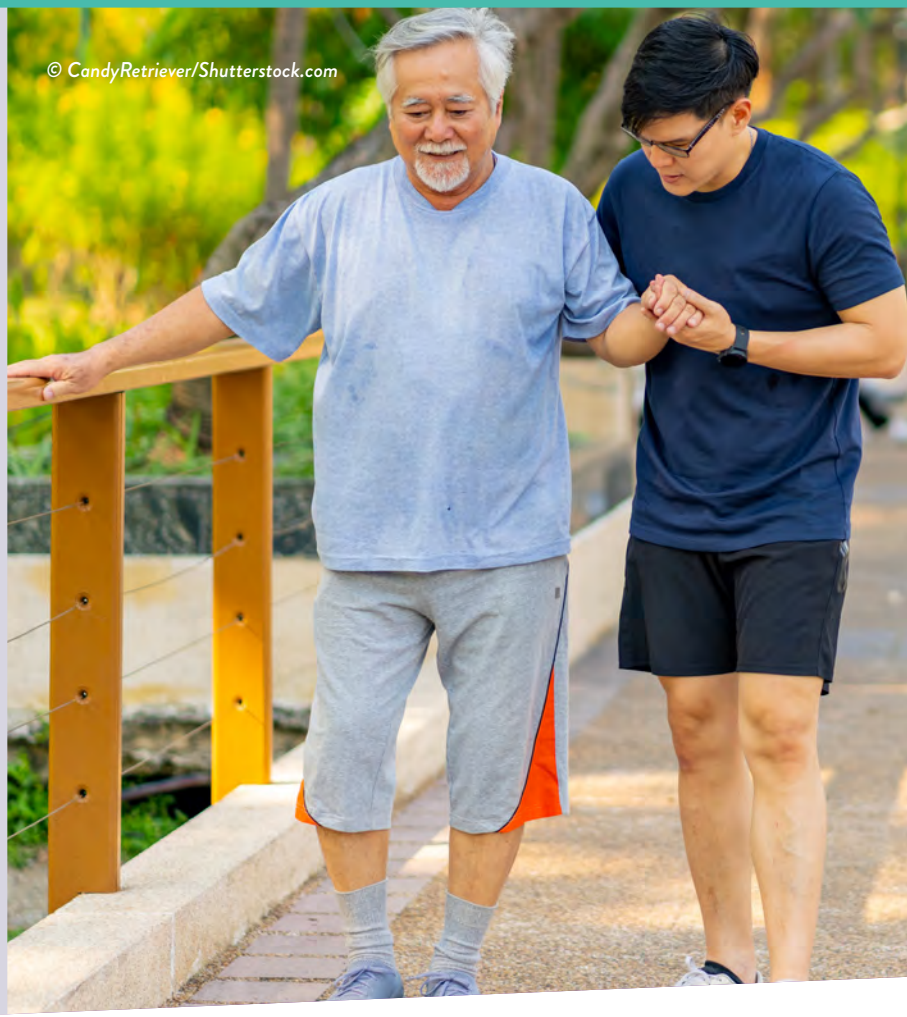
Why is the YCCC needed?

There is an overwhelming lack of awareness, recognition and support for young carers across Canada. With only one organisation solely dedicated to direct service for young carers (Young Caregivers Association®) and a handful of programmes across Canada (AMI-Quebec, Starlings Community, BC Children's Hospital Sauder Sibling Centre), the YCCC makes up the first national space dedicated to community and advocacy for young carers. The YCCC lifts up young carers as leaders, wisdom-holders, advocates, storytellers and change-makers across Canada. Too often, decisions about young carers are made without including those of us who take up care work every day. The YCCC is here to change that.

> **"We want young carers to be recognised, supported and valued."**

Original artwork by YCCC member, Melodie LePage, '34 Moberly'. Watercolour and pen on paper 12 x 9in © Melodie LePage

> **The YCCC lifts up young carers as leaders, wisdom-holders, advocates, storytellers and change-makers across Canada.**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Awareness of young carers matters because it is the first step toward change. When people know we exist, they can begin to create policies, programmes and practices that support us.

What are the challenges of being a young carer?

There is substantial research that references the short and long-term challenges experienced by young carers, which impact them academically, socially and professionally[i]. According to the Young Caregivers Association®, young carers express experiencing stress, loneliness, isolation, depression, anxiety, low self-esteem and difficulties relating to peers. In a research study[ii], 68% of young carers reported fearing they will do poorly in school because of their care work. Despite the responsibilities they shoulder, young carers remain one of the most overlooked and underserved groups in the country. Many don't even realise that the support they provide is caregiving, let alone that they have a right to accessible, quality resources and support[iii].

Our three pillars acknowledge the power of community in combatting the isolation that many young carers experience. We want young carers to know that they are not alone, and that their stories and care work matter.

What positive impact can being a carer have on a young person?

As young people with care experiences, we hold wisdom about the challenges that come with supporting a family member and/or friend. Most of us have navigated caring for someone without any formal support and became aware of the term 'young carer' later in our youth. We hold valuable knowledge about disability and illness, we recognise and experience stigma and injustices that lead to silence and isolation, and we feel deep empathy for young carers and families across Canada who have also been left unsupported. Through caring for someone, we have learnt important life skills that help us support our family, friends and community.

How are YCCC members using their wisdom to advocate for change?

We use our collective wisdom to amplify the voices and stories of young carers and inform policy initiatives across Canada. Our **Young Caregiver Blog** features important knowledge and stories from young carer Council members. Our blog offers opportunities for guest contributions from young carers who would like to share their stories anonymously and perspectives from researchers and professionals working to understand and support young carers in policy, healthcare and education.

Most recently, we have created the first **National Young Caregiver Support List**, which is a centralised list of support, including resources specifically designed for young carers. This collection brings together national programmes, information hubs, resources available in each province and territory, and youth mental-health services. In addition, we created a **Young Caregiver Library**, which recommends podcasts, videos, toolkits, zines and books. Our website is the first digital space in Canada to bring together almost every relevant support for young carers.

What collaborations is the YCCC benefitting from?

The YCCC collaborates with organisations, institutions, service professionals and

researchers on projects that are novel, meaningful and lead to actionable change for young carers. Some examples of our organisation and academic partners and collaborators can be found on our website. We have been fortunate to collaborate with incredible professionals and researchers, leading to presentations, webinars, co-created research projects, workshops and resources.

How can people get involved with the YCCC?

We invite educators and young people to connect with us, share our message, and take action in your own communities. Explore our website to learn more about what we do, listen to young carers' stories, and join this growing movement to build a future where young carers feel safe, respected, informed, involved and supported.

Whether you are a young carer, organisation, service professional or researcher, we would love to hear from you! We are always open to new collaborations.

What advice do you have for young carers?

Many young people may not see themselves as a carer, but if you support someone in your life or have a close family member/friend that experiences challenges, you might be taking on care work without even knowing it. We encourage you to watch our **YCCC: A Window into Care** video to see how different young people describe their care work.

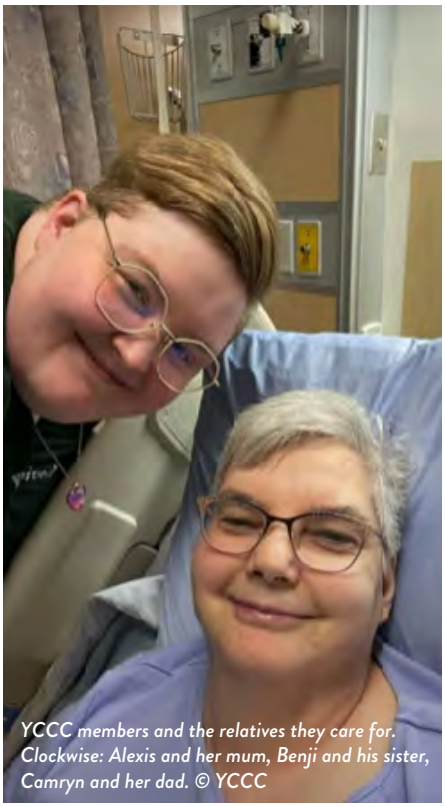
You have the wisdom to get through this. We see the work you are doing, and it matters. If you do not have access to support, please explore our website. If you are located in the UK, we recommend contacting Carers Trust for more localised support.

What does the year ahead look like for the YCCC?

We are extremely proud of the community we have been able to build, the meaningful partnerships we have developed, and the important resources we have curated.
In the year ahead, we will continue to prioritise community and advocacy work by and for young carers. This year will focus on the YCCC's growth and some very exciting partnerships and projects. We are in the process of building our first YCCC project of 2026, featuring a series of digital arts-based workshops. Please stay connected by following us on Instagram and keeping up with our **Upcoming Events**.

> ***"We are extremely proud of the community we have been able to build, the meaningful partnerships we have developed, and the important resources we have curated."***

[i] *Stamatopoulos, V. (2018)*
[ii] *Lakman, Y., Chalmers, H. & Sexton, C. (2017)*
[iii] *Joseph, S., Sempik, J., Leu, A., & Becker, S. (2019); Norman, R. A. (2024)*



YCCC members and the relatives they care for. Clockwise: Alexis and her mum, Benji and his sister, Camryn and her dad. © YCCC

Connect with YCCC

youngcaregivercouncil.ca

meet the YCCC team:
youngcaregivercouncil.ca/about-us

instagram.com/canadayoungcaregivers

youtube.com/watch?v=ifMZVMWWPh8&t

The rise of feminism in Egypt: colonialism and cultural progress

The late 19th to early 20th century was a tumultuous time for the Muslim world. The British Empire had become a colonial force, and the Ottoman Empire was waning. Two Egyptian women, 'A'isha Taymur and Malak Hifni Nasif, explored the role of women within their nation and contributed to emerging debates. They assessed how colonialism impacted cultural identity, and how foreign and local patriarchal systems hampered women's rights granted by Islam. **Dr Maha F. Habib** explores their work.

Dr Maha F. Habib

Arab and Islamic Studies, University of Exeter, UK

PROFILE

Fields of research
Arab and Muslim culture, thought and literature; Eastern feminism; decolonisation and indigeneity; East-West dialogues

Research paper
An eastern feminist perspective on the 'woman question': the activity, thought and writing of 'A'isha Taymur & Malak Hifni Nasif. Habib M.F. (2024)
doi: 10.1080/09612025.2024.2334092

doi: 10.33424/FUTURUM657

Talk like a ...

culture and literature researcher

Colonialism — the practice of exerting political, economic, social and cultural domination over a territory and its people by a foreign power

Feminism — the belief that men and women should have equal rights and opportunities, and the advocacy for societal change to fulfil this

Imperialism — the maintaining and extending of power over foreign nations (but, unlike colonialism, not always through occupation)

Indigenous — describing the original people who lived in a land before the arrival of colonists, and their socio-cultural systems. 'Indigeneity' is the cultural systems, identity and ancestral connection to the land, as well as the act of being that is maintained despite colonisation

Islam — a monotheistic religion, Islam holds the belief in one God, Allah. It is based on the Holy book the Qur'an and the teachings of the Prophet and leader Muhammad

'New Woman' — a woman of a new age, who pushed for radical societal change and rights

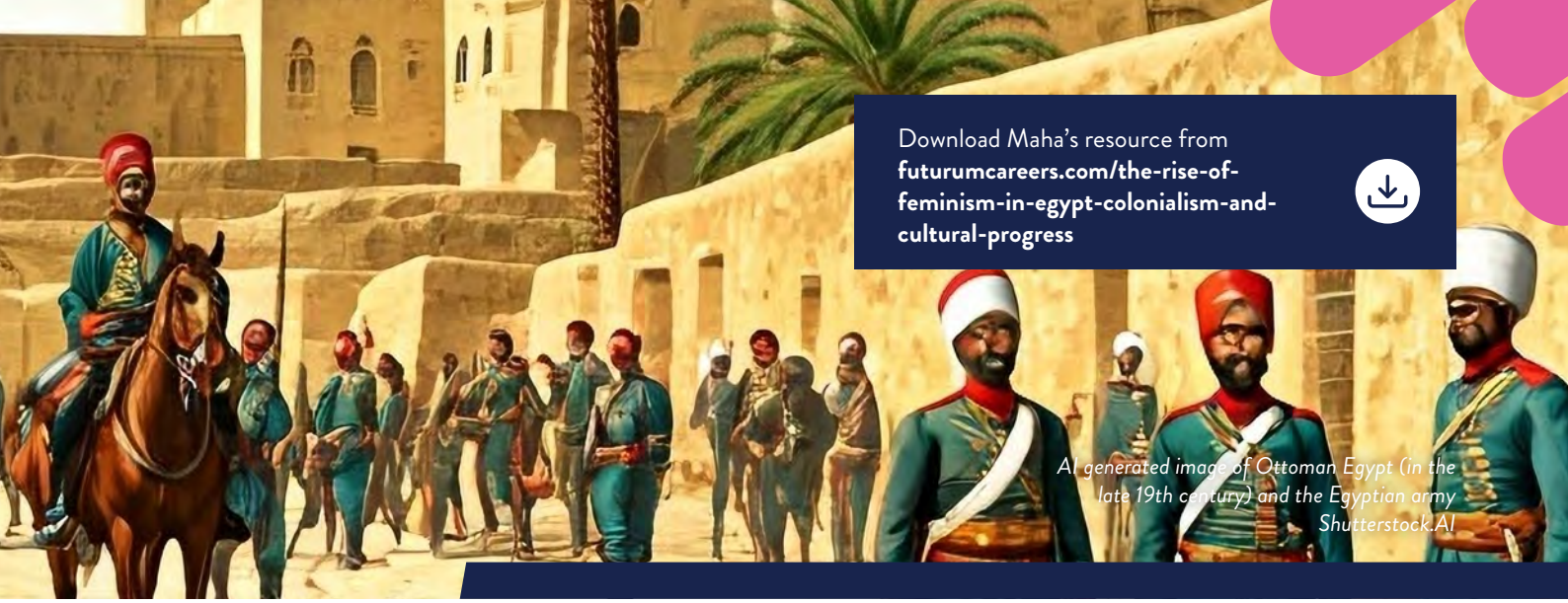
Ottoman Empire — a vast empire founded in the early 13th century. The empire spread across three continents and included parts of modern-day Middle East, southeastern Europe and North Africa until it was dissolved after World War I

Patriarchal — describing a system/society controlled by men

There are various types of feminism, each with different approaches to addressing gender-based concerns within different contexts. Colonialism and colonial feminism impacted perceptions of Eastern societies and their treatment of women. However, Western feminist ideals are not always aligned with Eastern feminist ideals. To address this, Dr Maha F. Habib explores indigenous feminist perspectives on the shaping of their own cultures and futures, in their own contexts. She demonstrates how they counteracted the effects of colonial feminist ideals and addressed local gender-based concerns – issues still critical today.

Feminism in Egypt

"'A'isha Taymur and Malak Hifni Nasif were critical to the early formation of the feminist movement in Egypt," says Maha. "They contributed to Egypt's cultural and literary scene and led debates on the roles and rights of women." The Ottoman Empire had governed vast regions of the Muslim world, but by the mid-18th century, it was in serious decline. British colonialism attempted to influence cultural transformation and establish what it considered 'superior' societal and cultural values. "These values prompted debates within Egypt on the most appropriate means to enact cultural transformation and progress, given the Eastern and Islamic heritage of the region," explains Maha. The perspective and contribution of women was an important part of these debates.



Download Maha's resource from **futurumcareers.com/the-rise-of-feminism-in-egypt-colonialism-and-cultural-progress**

AI generated image of Ottoman Egypt (in the late 19th century) and the Egyptian army Shutterstock.AI

Taymur and Nasif lived in a changing world and were part of a new generation of women. "They were educated, remained faithful to Islam and traditional ethics, and were active participants in change," says Maha. "I wanted to study their work to explore the historical realities of the time, the challenges that women faced and emerging feminist perspectives." Maha gathered, interpreted and analysed the written works of Taymur and Nasif, being careful to set them within their historical context, acknowledging the impact of colonialism and the influence of European attitudes.

European ideas

In the 19th century, European colonialism was at its height and held set ideas about society. "A key idea about the evolution of society was 'social Darwinism', which argued that Europeans were the most evolved people, superior to other civilisations," explains Maha. "Any other model for civilisation was compared to Europe and devalued in relation to it." This Euro-centric thinking considered Islam as a 'primitive' form of human development. "Muslim women, especially, were considered oppressed, subdued and immoral," says Maha.

British feminism emerged in the mid-19th century and developed its own set of debates about the role of women in society. By the late 19th century, the concept of the 'New Woman' was conceived. "In Britain, the 'New Woman' challenged Christian ideals, scientific theories and cultural traditions that devalued women," says Maha. But the social norms that British feminists were trying to overthrow were not the same as those in Eastern society. Taymur and Nasif provided narratives relevant to their own societal concerns. "Their narratives were set in a context of debates and competing discourses, local and foreign, that raised questions over women's nature, their participation and visibility in public life, and their right to education. They explored ideas enabling of rights for women and national progress, and contested ideas that imposed different types of control over women," explains Maha. For Taymur and Nasif, "these questions were critical to addressing the challenges of colonialism and local culture alike."

Modernising Egypt

The world was changing fast – not only because of colonialism, but also the Industrial Revolution and new technologies that would change daily life forever. The 'modern age' was emerging, and Taymur and Nasif knew that this new era presented opportunities for the advancement of women's rights, and for "the critical shaping of a 'New Woman', and new cultures and societies."

"Taymur and Nasif asked critical questions about cultural authenticity, the foundations of modernity and what true progress meant," says Maha. "They produced an Eastern feminist perspective that spoke to the needs of their society." In particular, their perspective on feminism acknowledged the central role of religion and culture for defining cultural identity and cultural progress. They were in favour of a cultural transformation – but one that spoke to their culture's rich heritage and "presented an alternative that did not submit to colonialist perspectives on Islam, the Westernisation of their culture and local patriarchal demands," explains Maha.

"Colonial visions for Eastern nations were directed by an interest to control and subdue other societies and cultures, including their women," says Maha. "Taymur and Nasif rejected this colonial framing and moved beyond the ideas used by local figures, which often reflected political and ideological conflicts. They offered a more critical approach to realising rights and progress."

Islamic principles for women's rights

Central to Taymur and Nasif's vision of Eastern feminism was the role of Islam. "They argued that Islam was critical for countering the negative effects of modernity in Egypt, correcting misunderstandings of women in Islam, and enabling enlightenment and progress," says Maha. "Drawing on central Islamic texts, they argued that women and men are of equal worth in Islam, and that both Islamic femininity and masculinity are defined by religious obedience, strong ethical principles and social responsibility." In line with these values, Taymur and Nasif argued for opportunities for women to contribute to Egypt's culture and development. "This helped set in motion the broadening of feminist consciousness, opening avenues for women's education, activism and participation in public life."

To this day, there are challenges that women face and misconceptions about the status and role of women in Islam. Maha is motivated to explore and communicate the work of these two important Egyptian feminists to reveal historically overshadowed Eastern women's perspectives on cultural meaning and transformation. "Bringing to light anti-colonial, anti-racist, indigenous perspectives is important to assessing historical change and understanding historical roots of modern debates," says Maha. "Particularly as colonialism and imperialism still persist today and are contributing to agenda-setting and rising Islamophobia."

The history of science and culture through the medieval lens of alchemy

Alchemists believed that, if their mind, body and spirit were pure, they could create the Philosophers' Stone – a substance that could heal people from illness and turn base metals into gold. At **McGill University** in Canada, **Dr Matteo Soranzo** is analysing medieval manuscripts written by the 15th century alchemist Cristoforo da Parigi. Matteo's work is highlighting how culture shaped, and continues to shape, scientific ideas and priorities.

Dr Matteo Soranzo

Department of Languages, Literatures and Cultures, McGill University, Canada

PROFILE

Fields of research
Italian studies; literature studies; cultural history

Research project
Analysing texts written by the medieval alchemist Cristoforo da Parigi

Funder
Social Sciences and Humanities Research Council of Canada (SSHRC)

doi: 10.33424/FUTURUM650

Talk like an ...

Italian studies researcher

Alchemist — someone who practises alchemy

Alchemy — the medieval discipline concerned with creating the Philosophers' Stone, which combined philosophy, early understanding of chemistry and ideas about magic

Base metal — a non-precious metal, such as copper, tin or lead

Medieval — the period in European history from the 5th to 15th centuries

Philosophers' Stone — a mythical substance capable of curing illness and turning base metals into gold

Textual criticism — the academic process of determining the most accurate version of an original text by comparing all available existing versions

Transmission — how a text has evolved over time as it has been copied

Transmutation — the process of transforming one substance into another, such as base metals into gold

Cristoforo da Parigi was a mysterious man – an alchemist passionate about using knowledge to help the poor and to address social and economic injustices. "The identity of Cristoforo is still shrouded in mystery," says Dr Matteo Soranzo, a professor of Italian studies at McGill University. "My research suggests that he might have been a pharmacist, writing letters from Paris in the 1400s to a man named Andrea Ognibene back in Cristoforo's hometown of Venice."

What were alchemists trying to achieve?

The medieval discipline of alchemy focused on two key aims. "First, there were practical concerns of making the Philosophers' Stone – a substance believed to be capable of turning base metals into gold, as well as healing humans from various ailments," says Matteo. "There was also an emphasis on reaching the spiritual and mental mindset necessary for the alchemist to succeed in this very difficult operation."

Alchemists believed that purity of both body and soul were needed to successfully create the Philosophers' Stone. While Matteo has not yet identified Cristoforo in historical records, he is learning about him, his peers and the culture in which they lived through the letters Cristoforo wrote. For example, Matteo has discovered that Andrea (the recipient of Cristoforo's letters) belonged to a religious order that encouraged its members to whip themselves to seek forgiveness for sins. "Elements of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this harsh spirituality appear in Cristoforo's letters as necessary steps to achieve the alchemical transmutation," explains Matteo.

How is Matteo analysing Cristoforo's texts?

First, Matteo must find copies of Cristoforo's works. "I travel to libraries and archives throughout Europe and North America," he says. "It is remarkable how many 15th century manuscripts crafted in Italy ended up in other countries." Then, he transcribes and translates the manuscripts and uses digital tools to help him annotate the sources so he can compare different copies of the same text.

Matteo is interested in the transmission of Cristoforo's texts – how his original letters were reproduced and shared. "Manuscripts appear to have been copied by amateur scribes, driven by interest in Cristoforo's alchemical knowledge," he says. Analysing ancient manuscript sources in this way is called textual criticism, a cutting-edge historical method for recreating old texts. "This involves reconstructing the transmission of a text and establishing a critical edition (an accurate version of the original text) by comparing all the existing copies available and formulating a hypothesis about their mutual relationships," explains Matteo.

Matteo has two main aims for his work. "At a basic level, I want to bring back to life a very prolific, yet largely forgotten, writer and sharer of alchemical ideas who used the everyday Italian of the time, rather than Latin, as his language of choice," he says. "At a more ambitious level, I want to build a bridge between textual criticism and the history of science, showing how these disciplines can benefit from each other." Matteo's work enables him to explore the cultural history of late medieval Italy, and to make contributions to our understanding of the history of science. "My research explores how scientific knowledge and ideas were embedded in and influenced by broader culture," he explains. "My work examines how scientific concepts were communicated and understood by the public."

What stories does Cristoforo tell?

By translating Cristoforo's letters, Matteo has uncovered fascinating details about how beliefs in alchemy were embedded in everyday medieval life. For example, Cristoforo tells Andrea about finding an urn in an ancient Roman tomb which he said was filled with quintessence – the pure 'fifth element' that was believed to fill the heavens. "According to Cristoforo, thanks to this remarkable substance the urn was still emanating a pleasant scent centuries after its construction," says Matteo.

One letter tells of a glassmaker on the island of Murano in Venice who was creating the glass tools that alchemists used to try and create the Philosophers' Stone. Today, Murano is famous for producing beautiful hand-blown glass, but Cristoforo's writing shows that in medieval times, its artisans were investing their glassmaking skills in alchemical pursuits.

"Finally, there is Cristoforo's emphasis on the alchemist's spirituality, necessary to achieve the much-sought-after transmutation of base metals into gold," says Matteo. "His letters include detailed instructions on how to achieve this state of spiritual perfection."

How does culture impact scientific ideas?

Perhaps most importantly, Matteo has learnt how Cristoforo's motives were influenced by the culture of the time. "Building on medieval ideas, Cristoforo wanted to use alchemy to correct socio-economic injustices," says Matteo. "He addresses his teachings to Andrea, a man who is struggling to feed his children. Cristoforo wishes the Philosophers' Stone is used only by poor people who are well-intentioned and spiritually sound. At the time, a capitalist economy was becoming the norm in Italy and Europe, and it looks like Cristoforo wanted to correct the excesses of this new economic system and its impact on society."

Matteo's work helps us to explore how scientists are influenced by the culture of their time. "Some scientists today isolate their pursuits and discoveries from their culture," says Matteo. "However, research questions and methods do not come about in a vacuum but are shaped by the surrounding culture. An emphasis on technology and financial profit reflects a Western capitalist culture and practices like 'extractivism' – exploiting resources for economic gain. These focuses often marginalise alternative approaches driven by ancient beliefs that nature is a living being that needs to be protected. Looking at the past helps us look at the present as a possible answer, but not the only answer, to questions that are as old as humankind."

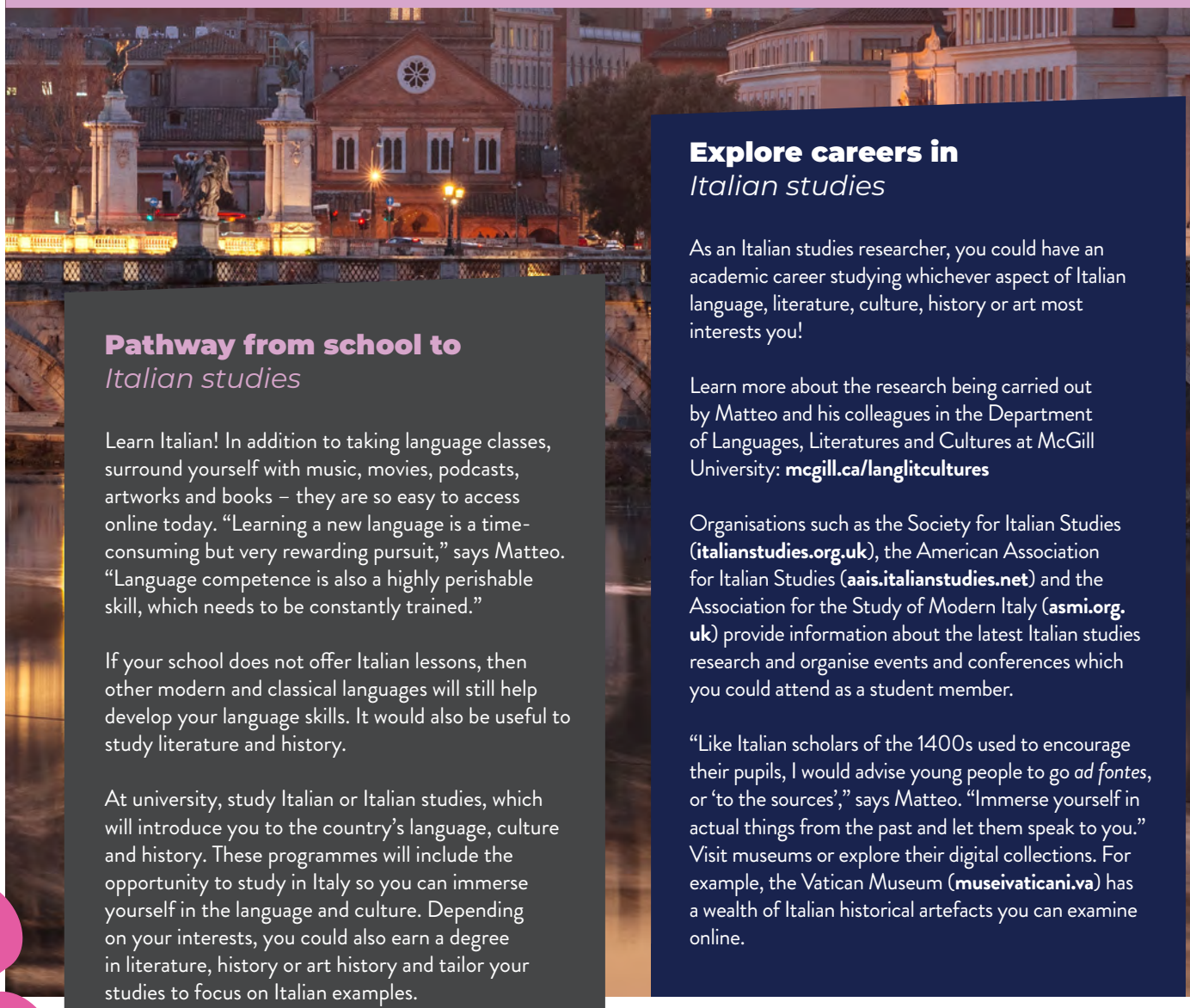
About *Italian studies*

The field of Italian studies covers everything from ancient Roman history to modern-day Italian fashion. It is the exploration of Italy's language, art, literature, history and culture, and how it maintains a distinct identity while taking inspiration from and inspiring the rest of the world.

Matteo focuses on Italian literature studies and cultural history. "I have always been interested in how literature reflects ideas from philosophy, astrology and alchemy," he says. "Literary texts are often seen as 'just fiction' but, on closer inspection, they build on knowledge structures that their authors and readers considered facts. Looking at a text as weaving together multiple ways of thinking allows me to grapple with historical worldviews often very different from our own."

The importance of language skills

Having a deep understanding of the Italian language, including how it developed from Latin and regional variations, is essential, challenging and incredibly rewarding. "Somebody who wants to investigate pre-modern Italian culture should learn Italian, but with an open mind," says Matteo. "Late medieval and Renaissance (14th to 17th century) Italian is quite different from that used in Italy today." Similarly, having a good understanding of Latin and Greek is important, but equally full of surprises; the Latin used by medieval writers can seem rather strange and confusing for students and scholars more familiar with standard classical languages. "If I could go back in time, I would also study Arabic," says Matteo. "Medieval culture was shaped by Greek texts that arrived in Europe in Arabic translations, which were eventually translated into Latin."



Pathway from school to *Italian studies*

Learn Italian! In addition to taking language classes, surround yourself with music, movies, podcasts, artworks and books – they are so easy to access online today. "Learning a new language is a time-consuming but very rewarding pursuit," says Matteo. "Language competence is also a highly perishable skill, which needs to be constantly trained."

If your school does not offer Italian lessons, then other modern and classical languages will still help develop your language skills. It would also be useful to study literature and history.

At university, study Italian or Italian studies, which will introduce you to the country's language, culture and history. These programmes will include the opportunity to study in Italy so you can immerse yourself in the language and culture. Depending on your interests, you could also earn a degree in literature, history or art history and tailor your studies to focus on Italian examples.

Explore careers in *Italian studies*

As an Italian studies researcher, you could have an academic career studying whichever aspect of Italian language, literature, culture, history or art most interests you!

Learn more about the research being carried out by Matteo and his colleagues in the Department of Languages, Literatures and Cultures at McGill University: **mcgill.ca/langlitcultures**

Organisations such as the Society for Italian Studies (**italianstudies.org.uk**), the American Association for Italian Studies (**aais.italianstudies.net**) and the Association for the Study of Modern Italy (**asmi.org.uk**) provide information about the latest Italian studies research and organise events and conferences which you could attend as a student member.

"Like Italian scholars of the 1400s used to encourage their pupils, I would advise young people to go *ad fontes*, or 'to the sources'," says Matteo. "Immerse yourself in actual things from the past and let them speak to you." Visit museums or explore their digital collections. For example, the Vatican Museum (**museivaticani.va**) has a wealth of Italian historical artefacts you can examine online.

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Download Matteo's resources from **futurumcareers.com/the-history-of-science-and-culture-through-the-medieval-lens-of-alchemy**

Meet *Matteo*

I've always loved learning languages and travelling. Growing up in Europe, it was much easier to experience cultural differences without spending hours on an airplane, so I consider myself lucky on that front. As a teenager, I also liked hiking and biking in the mountains as a slow-paced way to experience the landscape that felt very much like learning.

I decided to dedicate my studies to culture and literature after reading S.T. Coleridge's *The Rime of the Ancient Mariner* (1798). I know mine is not a standard interpretation of this poem, but when I read it, it felt like it gave shape to the thrills, fears, depressive states and sudden moments of euphoria that characterise – at least for me – the intellectual journey. So, I embarked on my studies as if I was going a lifelong journey that keeps sailing on, so to speak.

I was motivated to study discarded forms of knowledge, such as alchemy and astrology, due to my frustration with literary studies and their tendency to interpret anything in literary texts as 'fiction'. However, to make sense, a poem or a novel must build on a knowledge structure that authors and readers accept as factually true. If a medieval poem states that the planet Saturn is the cause of a character's melancholic state or that a devil takes on a solid body and physically harms people, this is not fiction. In medieval times, knowledge from astrology and demonology explained these phenomena as facts. But modern ideas have stigmatised these beliefs and made these forms of knowledge obsolete. Reading outside of the 'literary' canon offers modern readers a point of entry into a different mentality.

For my research, I work with texts that are not available in modern editions, so first I must transcribe and collate all the manuscripts I find. These tasks are challenging because they are demanding and time-consuming, but they lead to intellectually stimulating research.

In my free time, I like travelling with my family, running, working out and gardening.

Matteo's *top tip*

Try to ask yourself why certain things interest you while others do not. External pressure and expectation are only going to take you so far, so be true to what genuinely interests and inspires you.

Changing the narrative: how does colonialism affect healthcare research?

Whose health is studied for scientific research, whose opinions get published, and how is healthcare impacted if some people are not included? In an ideal world, scientific research would be fair and equally applicable to everyone. At **The City University of New York** in the US, **Dr Justine McGovern** and **Dr Lisa Fusco** are looking at how colonial attitudes have impacted scientific research and techniques, and how rethinking healthcare research and practices could improve public health for everyone.

Dr Justine McGovern

Department Chair, Associate Professor, Health Promotion and Nutrition Sciences, Institute for Health Equity

Dr Lisa Fusco

Doctoral Lecturer, Graduate Program Director, Health Promotion and Nutrition Sciences

Lehman College, The City University of New York (CUNY), USA

Fields of research
Health promotion; health education; gerontology; epistemic disobedience

Research project
Investigating how healthcare research and promotion can challenge colonial practices

doi: 10.33424/FUTURUM673

PROFILES

Talk like a ...

health educator and promoter

Colonialism — the practice of a powerful nation exerting control over another territory and its people, including their histories

Epistemic disobedience – the concept of challenging dominant forms of knowledge and thinking

Health promotion – the process of enabling people to increase control over and improve their health

Lived experience – first-hand knowledge and understanding that individuals gain through their personal circumstances

Public health – the large-scale practice of improving the health of whole populations or communities, rather than just individuals

Qualitative – research that is descriptive and does not include numbers, such as interview responses and observations

Quantitative – research that is based on numerical and statistical evidence

When a researcher conducts a study, they make multiple choices along the way – all of which can affect their research findings and how their research is applied to wider society. Alongside preconceptions that the researcher brings to the project, decisions include which research methods are used and which participants are included. Once the work is ready to be shared, scientific journals also impact the research outcomes by choosing whose opinions should be valued and what the barriers to publishing will be.

At The City University of New York, Dr Justine McGovern and Dr Lisa Fusco are analysing the way healthcare research is conducted. One of the main aspects of health they are focusing on is promoting epistemic disobedience. "Epistemic disobedience refers to dismantling the dynamics of power and privilege promoted by colonialism," explains Justine. "It offers new ways of developing and disseminating knowledge that focus on different branches of knowledge." This means considering health from a wider range of perspectives, experiences and research methods.

"At a basic level, epistemic disobedience might challenge the primacy of pharmaceutical medicine over traditional medicine," adds Lisa. "It might also amplify community-based healthcare wisdom over scientific and medical beliefs." Whatever form it takes, the

goal of bringing in epistemic disobedience is to decolonise healthcare and challenge colonial structures and systems that have dominated healthcare research up till now.

Why is change needed?

Currently, most scientific research is conducted through a colonial lens, which means that certain experiences are not considered, certain research methods are overlooked and some solutions are not found. This has also led to huge health disparities between different groups. "Power structures in healthcare lead to discrimination, which results in health disparities based on social determinants of health, such as race, education, employment history, immigration status and financial resources," explains Justine. "In order to have a fairer system where the health of all people is valued and taken seriously, we need to rethink who holds the power in research and learning in healthcare."

Rethinking healthcare

One of the impacts of colonialism in healthcare research is that the default approach is to use quantitative methods over qualitative methods. "In quantitative research, individuals' contributions are calculated rather than interpreted and are translated into numbers, graphs, etc. to assess significance rather than to capture personal experiences," says Lisa.

While quantitative data can give numerical answers that seem clear, straightforward and objective, this data can also be misleading as it is not able to represent the full story of someone's health. Instead of focusing on objectivity, rethinking healthcare research through a decolonial perspective would instead centre subjectivity, highlight different perspectives and validate the personal experiences of people within studies. Qualitative research techniques that give detailed descriptions of situations would change the nature of scientific research, making the work more able to encompass a broader range of perspectives.

Power within language

Another way of applying the practices of epistemic disobedience to healthcare is through changing the language used within studies. "In qualitative research, the participant or citizen scientist – who has historically been referred to as a research 'subject' in quantitative methods – is recognised as the expert," explains Justine.

This shift in language – from 'subject' to 'expert' – changes the power dynamic and grants more importance to the person bringing their personal experience to the study, rather than the person running the study. While it seems like a small change, this wording completely reframes the power dynamic between study participants and study leaders.

A similar approach comes across through the change of the word 'results' in quantitative research to the word 'findings' in qualitative research. "In contrast to unquestionable 'results', 'findings' leave room for a range of interpretations and, importantly, revisions," says Lisa. The wording changes the nature of the conclusion, with 'findings' leaving the outcome of the study more open for discussion and further understanding.

Power within publishing

Even once research has taken place, there are still various ways in which colonial perspectives shape how work is shared with the wider healthcare community. One of these is through language. "The de facto language of science is English, which excludes any number of potential contributors and readers and falsely elevates one language over others," says Justine.

As well as language barriers, getting work published in scientific journals is often expensive. This means many researchers cannot afford to share their work through 'high ranking' journals where it will be read by the wider community.

Finally, getting work peer-reviewed by other researchers who have credentials (such as university degrees and a publication record) is a crucial part of getting work published. "According to the decolonial perspective, non-academics engaged in knowledge development need to also be recognised as the experts," explains Lisa. "Their credentials may not consist of expensive degrees but rather of lived experiences and community-based recognition."

Rethinking healthcare in practice

Justine and Lisa's work highlights how colonial attitudes have impacted which research methods and ways of thinking have dominated healthcare research. By understanding where these decisions have come from, challenging them and applying the principles of epistemic disobedience, healthcare research has the potential to become more empathetic, inclusive and, ultimately, promote better healthcare outcomes for everyone.

About *health education and promotion*

Health education and promotion involves promoting global public health and enabling people to have more control over their own health. Rather than working reactively and treating the symptoms of health problems, the work of health educators and promoters is often proactive and involves focusing on preventative measures. "Health education and promotion aims to equip individuals with essential tools and resources to support longevity and well-being," says Lisa. "It represents an expanding discipline where students learn and understand the dimensions of health and implement them in both their own lives and those of others."

Health educators and promoters can work in a variety of roles, including positions in non-government organisations (NGOs) or government departments influencing health policy, running workshops in schools or community settings, or interacting one-on-one with individuals to help them improve their health in personalised ways. Regardless of the specific aspects of the role, working in health education and promotion will involve connecting with, listening to and working alongside others to help people lead healthier lives.

"There is a strong sense of purpose in knowing that our work not only expands understanding in the field but also has a tangible and positive impact on people's health and well-being," says Lisa. "By empowering individuals and communities, health educators contribute to reducing health disparities and improving public health outcomes on a larger scale."

The world of health education and promotion is swayed by current events and news, so it is important to keep up to date with what is happening around the globe. "These events shape the public's interest and their need for education on a personal level," says Lisa. "For example, there has been a noticeable reduction in the stigma associated with mental illness. This positive shift is creating new opportunities for mental health education and promotion, allowing these topics to be addressed more openly and effectively within communities."

Pathway from school to *health education and promotion*

Health education is crucial for your own health as well as for preparing you to work in healthcare. "Whether it is a basic health education course that focuses on dimensions of health or a health content course that dives deeper into a specific topic like substance abuse or human sexuality, make the most of any health education courses available to you at school," says Lisa.

Being able to communicate well and relate to others are essential skills in this field, so taking any additional classes in humanities and communication courses will be useful. "For anyone interested in a career in health education and promotion, having proper education and training is crucial. Health educators need to be experts in their field, as well as in all dimensions of health, from physical to emotional to social health," says Justine.

After high school, a straightforward way to enter this field is to pursue a bachelor's degree in a health-related field such as public health, health education or social work. You will then need to complete a doctorate if you want to become a researcher like Justine and Lisa.

Try to get some hands-on experience in social work or a healthcare setting. Contact your local medical practice or university researchers whose work you are interested in to see if they have any volunteering or shadowing opportunities.

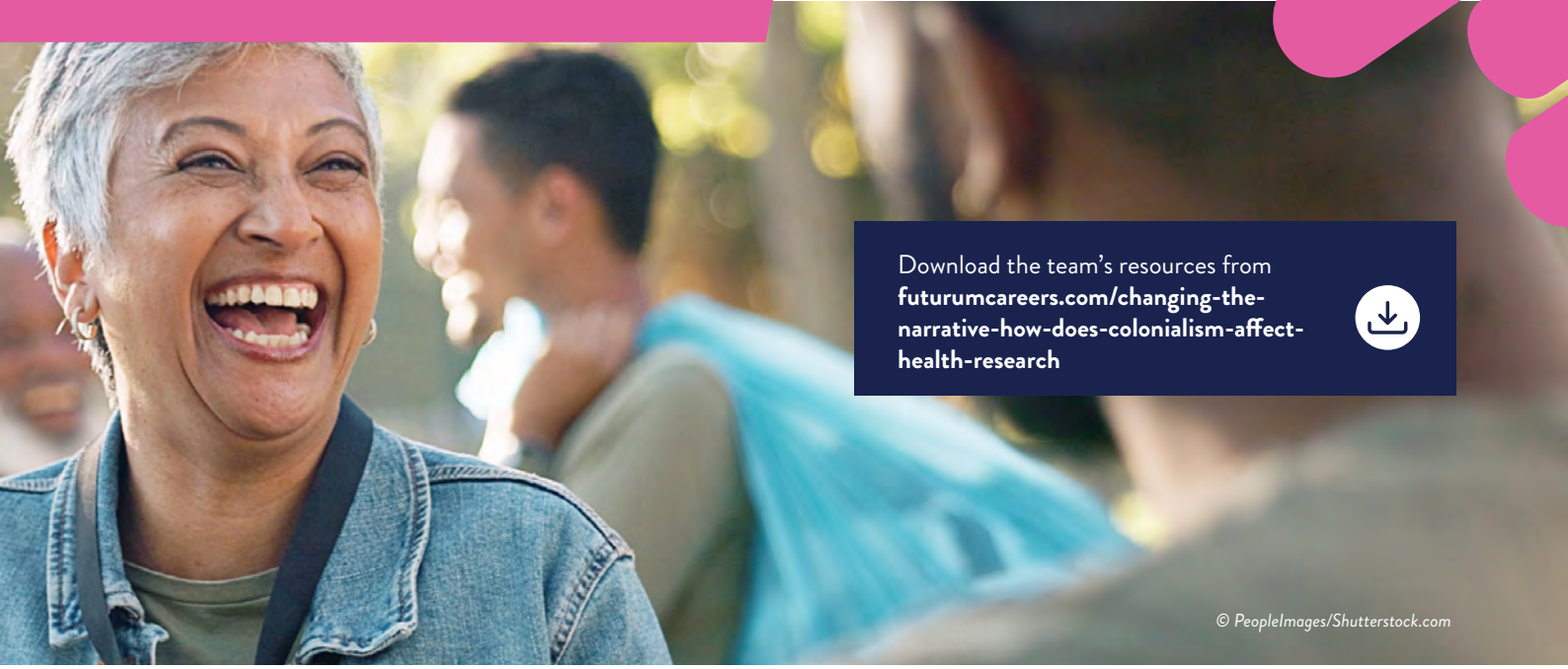
Explore careers in *health education and promotion*

"Pursuing studies in health education and promotion can lead to diverse career paths, including roles in schools, hospitals, community organisations and public health agencies," says Lisa. "Professionals in this field work to design effective programmes, influence health policy, and foster environments that encourage healthy choices."

Lisa recommends looking at the websites of health education and promotion professional organisations to get more information. "The Society of Public Health Educators (**sophe.org**), the American Public Health Association (**apha.org**), and the US Centers for Disease Control and Prevention (**cdc.gov**) are trusted and valued resources in the field," she says.

The 'Focus Areas' page of the Society for Public Health Education website has some great information to help you learn more about a variety of healthcare topics that careers in healthcare education and promotion can touch on, from nutrition to COVID-19: **sophe.org/focus-areas**

This video from health educators explains what they enjoy about working in the profession: **youtube.com/watch?v=0nrgpnx8Tgl**



Download the team's resources from **futurumcareers.com/changing-the-narrative-how-does-colonialism-affect-health-research**

Meet *Justine*

I was inspired to pursue social work because I wanted to find solutions to the problems I was learning about as an American Studies major at Yale University. I began working in child welfare, and, eventually, I became more intent on promoting well-being among older adults. When my mother died of Alzheimer's disease, I narrowed my focus to supporting persons living with cognitive impairment, and their carers.

When I started my PhD, I knew I wanted to deepen my understanding of dementia experiences. Ever since, I have focused on older adulthood and the vast diversity of ageing experiences.

I have several proud moments that stand out as a practitioner in gerontology (the study of ageing) and as an educator. These include producing award-winning intergenerational programming and providing innovative experiential learning opportunities for college students.

In the future, I hope to continue to extend the reach of knowledge-building, by focusing on whose voices and experiences matter, what sources of knowledge are considered valid, and how knowledge is shared.

Justine's *top tip*

Don't limit yourself by always colouring within the lines!

Meet *Lisa*

After I graduated from university, I was offered a teaching position at an all-girls, private high school. I found this deeply rewarding as I felt that I was genuinely making a difference in the students' lives.

Because health education touches on so many personal topics, there have been many times that I have had to teach something I was dealing with personally. Early in my career, I was diagnosed with breast cancer, and I spent that year teaching and developing a full cancer unit for my students.

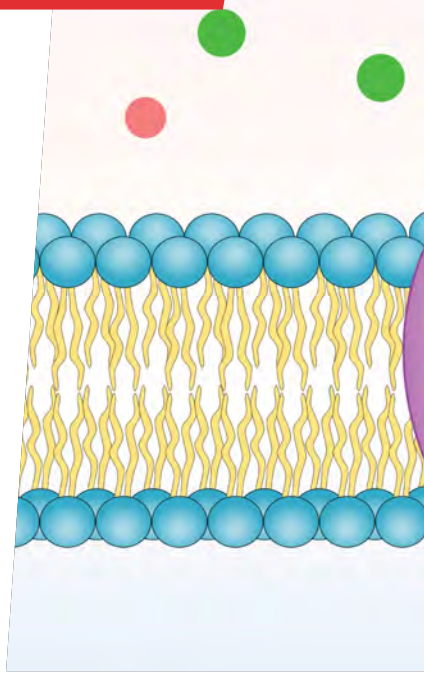
I find great satisfaction in crafting lessons and materials that engage and inspire my students, allowing me to draw upon my imagination and experience to create meaningful learning opportunities. This creative process is not only professionally fulfilling but also personally rewarding, as it provides a space for innovation and reflection.

My proudest moment to date is earning my doctoral degree. In the four years I was working on this, I was pregnant, became a mom to my first two children and started at Lehman College. I am so proud I was able to juggle it all, stay on course and achieve my goal.

Lisa's *top tip*

Find what you love and what you are passionate about and focus on working toward it. Connecting with specific topics is so important. If you find what you love, your work will continue to be exciting and rewarding.

Orphan membrane transporters: mapping functions of the unknown



Every cell in the body depends on transporters – proteins that move molecules in and out of the cell. While many are well understood, hundreds remain unknown. **Dr Kathy Giacomini**, Dean of the **School of Pharmacy** at the **University of California San Francisco** in the US, is investigating these orphan membrane transporters to reveal their roles in human evolution, normal physiology and the genetic reasons why people react differently to the same medicines.

Dr Kathy Giacomini

School of Pharmacy,
University of California San Francisco, USA

PROFILE

Field of research
Pharmacology

Research project
Deorphaning membrane transporters

Funder
US National Institutes of Health (NIH)

doi: 10.33424/FUTURUM667

You might think that scientists already understand how every gene in our genome works. Surprisingly, around 20% of human genes are still orphans – meaning we do not know what they do. Some of these genes encode membrane transporters – proteins that move nutrients, drugs and waste products across cell membranes.

These transporters are vital for life. Without them, cells cannot absorb nutrients, remove toxins or respond to medicines. But for many transporters, their function remains unknown. "An orphan membrane transporter in the Solute Carrier (SLC) family is presumed to be a transporter, to transport molecules across the membrane, but its exact substrate or substrates have not been identified in humans or in any other species," explains Dr Kathy Giacomini, Dean and Professor at the University of California San Francisco.

Talk like a ... pharmacologist

Androsterone glucuronide — a natural waste product consisting of sex hormones that is filtered and sometimes reabsorbed by the kidney

Blood–brain barrier — a selective barrier of cells that prevents many substances from entering the brain from the blood, while allowing essential nutrients to enter

Confocal microscopy — a high-resolution imaging technique used to see the precise location of proteins within cells or tissues

Conjugate — a protein attached to a non-protein component, like carbohydrates or lipids

Deorphan — the process of discovering the function of an orphan gene or transporter whose role is unknown

Hominid — a member of the great ape family, which includes humans, chimpanzees, gorillas, orangutans, and their ancestors

Metabolite — substance produced through the chemical process of metabolism (which breaks down food, drugs or tissues for energy)

Orphan gene — a gene whose function is currently unknown

Solute Carrier (SLC) family — a large family of transport proteins that move a wide range of molecules across cell membranes

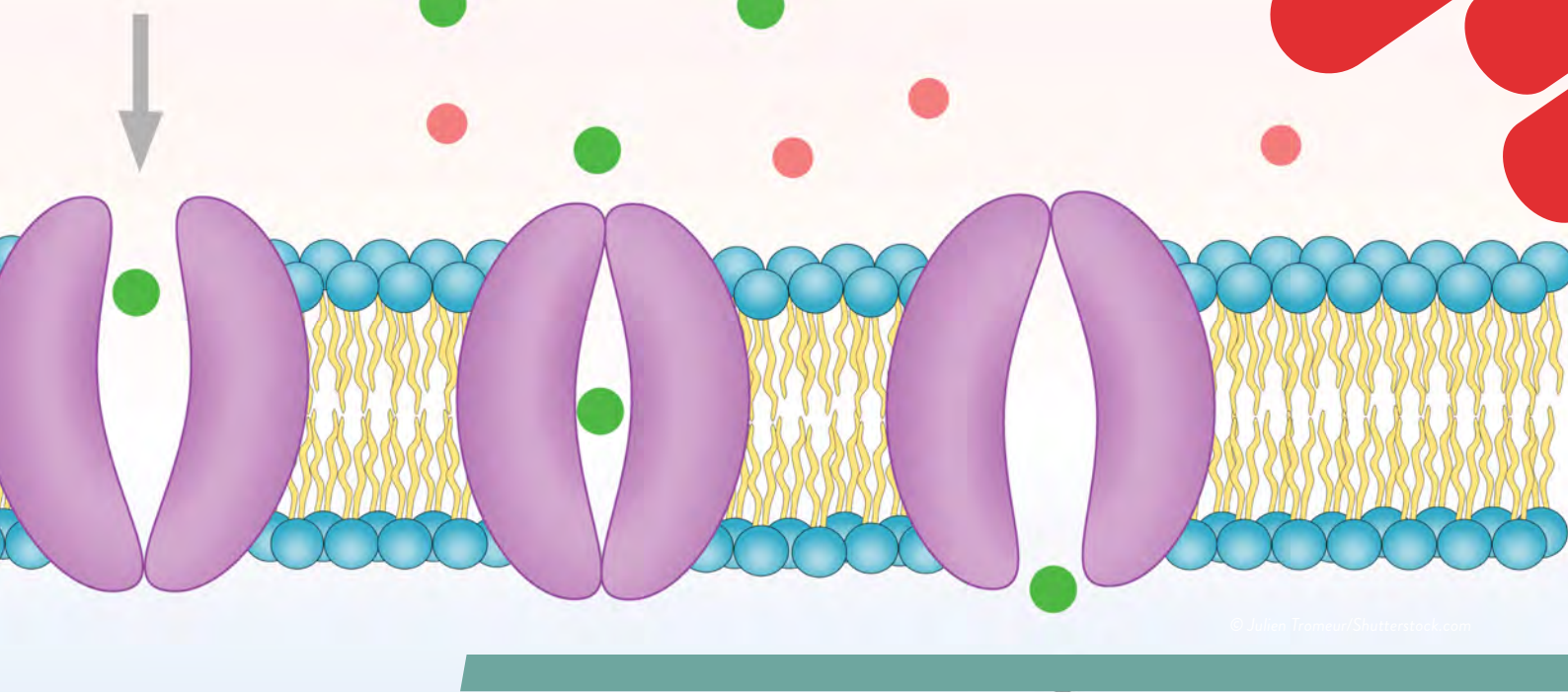
Stop-codon variant — a genetic change that causes the protein-coding sequence to stop prematurely, often producing a nonfunctional protein

Substrate — the specific molecule on which a functional protein acts

Zwitterion — a molecule that carries both a positive and a negative charge but is, overall, electrically neutral

What is the Solute Carrier 22 family, and why study its orphan transporters?

"The transporters in the SLC22 family are fascinating because most of them are highly promiscuous, interacting and transporting a wide range of substrates," says Kathy. Unlike highly specific transporters – such as the dopamine transporter, which handles almost exclusively dopamine – most SLC22 proteins can transport



many different compounds. Because they recognise charge rather than a single defined molecule, they are known as the organic ion transporter family. Within this group are organic anion transporters, which move negatively charged molecules, and organic cation transporters (OCTs), which move positively charged ones. These transporters handle normal metabolites, environmental toxins, and many medicines, including penicillins and antiviral drugs.

How do scientists deorphan a transporter?

"The fun of deorphaning, the process of discovering a transporter's function, is that there is no typical day," says Kathy. Her team uses a wide range of techniques, from molecular biology to clinical studies. They may:

- tag a transporter with a fluorescent marker and use microscopy to see where it sits in the cell
- use metabolomic genome-wide association studies to see if genetic variants affect metabolite levels
- overexpress transporters in cells and measure which molecules are taken up more than in normal cells
- search public databases, including single-cell expression data, to find where transporters are present in the body
- analyse genome-wide association studies of traits or diseases to gain clues about a transporter's role
- use confocal microscopy to locate transporters in specific tissues or in subcellular structures with high precision
- study the evolution of transporters across species, including ancient humans and other hominids.

Kathy's team has also carried out clinical studies to see how transporter variants affect the body. Using genetic analyses, they identified people who carry a stop-codon in the orphan transporter SLC22A24, which prevents the protein from forming normally. They then compared urine and blood samples from these individuals with samples from people who have a functional transporter. "By analysing these samples, we tested whether people with the stop-codon variant cannot reabsorb androsterone glucuronide in the kidney and, therefore, eliminate more of it in their urine," explains Kathy.

What has Kathy's team discovered so far?

One of the team's first discoveries in the orphan transporter area was the function of SLC22A15. They found that it transports zwitterions and shows a strong preference for ergothioneine, a powerful antioxidant that humans must obtain from food. Before this, only one human transporter – OCTN1 – was known to move ergothioneine. Yet OCTN1 is not present at the blood-brain barrier, even though ergothioneine is found in the brain. "Because SLC22A15 is located there, it may explain how this compound enters brain tissue," says Kathy.

Kathy has also deorphaned SLC22A24, a transporter that moves sex-steroid conjugates such as androsterone glucuronide. Kathy's team found that this transporter sits in the kidney, where it normally reabsorbs these molecules so they can be converted back into hormones like testosterone. However, many humans carry a common stop-codon variant that disrupts its function, and other primates are also gradually losing this transporter through evolution.

Finally, Kathy's lab discovered that SLC22A10 works in chimpanzees but not in humans. In humans and ancient hominids such as Neanderthals, a single amino acid change destabilised the protein, preventing it from reaching the cell surface. When Kathy's team studied the chimp version, they found it transported sex-steroid conjugates, hinting at a biological role that humans have lost over time.

Why does Kathy's research matter?

Kathy's team will continue to explore the SLC22 family, focusing on how the kidney reabsorbs steroid conjugates and recycles them back into active compounds. They are investigating how evolution has shaped these transporters, including why some have been lost in humans, and how this affects biological pathways.

"Ultimately, these studies will increase our knowledge of the genetic basis underlying drug response and will contribute to advancing the era of personalised medicine," says Kathy. "Furthermore, our studies will explain the genetic mechanisms of decreased drug response and, ultimately, contribute to improving drug design for safe and effective treatments of subgroups of patients who do not respond to standard treatments."

About *pharmacology*

Pharmacology is the study of how drugs interact with the body, including how they are absorbed, transported, metabolised and eliminated. Pharmacology studies help us understand why medicines work for some people but not others and how the body handles substances from food, the environment, or the microbiome. "Deorphaning a transporter, knowing that your research led to new knowledge of biology, is extremely rewarding," says Kathy. "How can we understand human biology if we do not know what each individual gene does? Through this work, I feel I have contributed to an understanding of biology and, in particular, human biology."

A major focus in pharmacology is pharmacogenomics, which studies how genetic differences affect drug response. Kathy's research highlights how transporter genes influence the effectiveness of common medicines. For example, metformin, the first-line treatment for type 2 diabetes, is taken up by transporters in the liver called OCT1, OCT2 and OCT3. Studies in 10,000 patients showed that response to metformin was linked to a variant in a glucose transporter, SLC2A2, which controls how sugar is moved in and out of liver cells – rather than the SLC22 transporters. Meanwhile, allopurinol, used to treat gout, is converted in the body to an active form called oxypurinol, which relies on a transporter called ABCG2. A common genetic variant in ABCG2 affects how well the drug works, influencing both oxypurinol and uric acid levels. "All of these studies have important implications for precision medicine," says Kathy. "With genotyping, one may be able to dose the drugs more precisely or to prescribe different drugs."

The next generation of pharmacologists will have exciting opportunities, especially with new technologies. Computational methods, AI and advanced laboratory tools will help researchers study transporters in greater detail. "Learning how transporters interact with other proteins and the pathways that they form will be the subject of the next generation of transporter biologists," says Kathy. "New methods to study transporters will also be developed, providing more research opportunities."

Download Kathy's resources from **futurumcareers.com/orphan-membrane-transporters-mapping-functions-of-the-unknown**

Pathway from school to *pharmacology*

In high school, build a strong foundation in the core science subjects of biology, chemistry, mathematics and physics.

"At university, take courses in biochemistry, physiology, pharmacology and genetics," advises Kathy. "It is also useful to understand computational sciences, such as how to program, as well as statistics."

Look out for outreach opportunities provided by universities near you. "For example, we have many outreach schemes for high school students in the San Francisco Bay Area, most notably the University of California San Francisco Science and Education Partnership," says Kathy. Learn more: **sep.ucsf.edu**

Explore careers in *pharmacology*

"Join various societies such as the American Society for Pharmacology and Experimental Therapeutics (**aspet.org**), the International Society for the Study of Xenobiotics (**issx.org**), or the British Pharmacological Society (**bps.ac.uk**)," says Kathy. These organisations provide educational resources, career guidance, webinars, and networking opportunities for students and early-career researchers.

Q&A

Meet *Kathy*

Who or what inspired you to become a pharmacologist?

I was strongly influenced by my parents. My father was a geophysicist who loved science, and I gained a strong love of science from him. My mother was a Filipina who had a strong interest in health professions. I became a pharmacist but was drawn to the sciences that form the underpinnings of the profession. So, I went back to school to get my PhD in pharmacology.

What experiences have shaped your career? Have there been any eureka moments along the way?

People have helped me along the way. My parents, my PHD advisor Dr Gerhard Levy, my postdoc advisor Dr Terrence Blaschke, who was open to me exploring various avenues of research, and my peer mentors at UCSF: Ira Herskowitz, Neil Risch and David Agard. Of course, my supportive husband, John, and family have been critical.

A eureka moment was when I realised that I had to learn molecular biology and went on a sabbatical in Dr Heini Murer's laboratory to learn expression cloning of transporters. And a second was when I knew I had to learn more genetics and worked in the laboratory of Dr Yusuke Nakamura at the University of Tokyo in Japan. These two sabbaticals helped me change direction and refine my focus.

How do you switch off from the pressures of your work?

Research is an oasis and a love of mine. If I get a moment free from my very busy schedule as dean, I find my way to reading some interesting research. I am also an avid gardener and love growing vegetables. I love to crochet, read, play pickle ball and ski. I spend time with my three grown kids and have five grandkids, with another on the way!

What are your proudest career achievements so far?

I'm proud of many achievements. These include: cloning the first human organic cation transporter and the first human transporter in the SLC22 family, cloning the first human purine nucleoside transporter, CNT2, and deorphaning three transporters in SLC22 family. I am proud to have led the International Transporter Consortium, which has made excellent recommendations on transporter-mediated drug-drug interaction studies to the FDA and other regulatory bodies. My large genome-wide association studies in pharmacogenomics have yielded highly reproducible results, which has been very rewarding. I am proud of the many students and trainees I have mentored, who have gone on to have stellar careers in academia, industry and in drug regulatory agencies. And by no means least, I am proud of being dean of the number one school of pharmacy in the world!

What are your aims for the future?

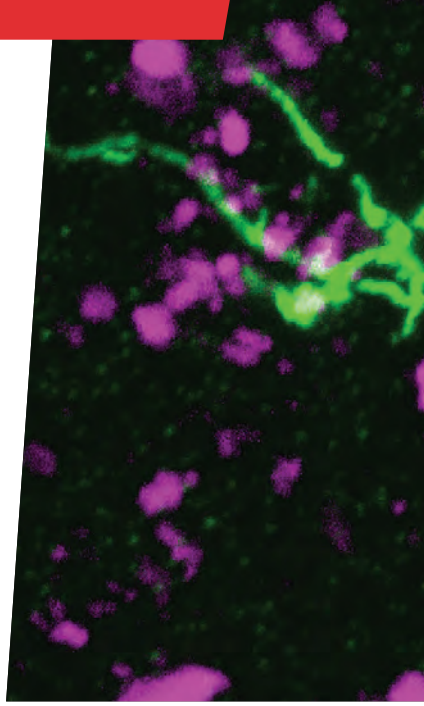
My research continues! I am learning about the transporters I have already deorphaned, and I am deorphaning others. I would also like to explore the biological pathways of renal reabsorption and recycling for drug conjugates.

Pharmacy has a rich educational remit yet tends to only train pharmacists. I would like to lead the expansion of education programmes in schools and colleges of pharmacy. With others, I have already developed a new AI and Computational Drug Discovery and Development Master's Degree programme and would like to do more.

Kathy's *top tips*

1. Don't follow in anyone's footsteps.
2. Explore, enjoy and indulge your curiosity.
3. Have fun!

Could the brain's over-eager 'pruning shears' be causing schizophrenia?



Schizophrenia is still a very poorly understood psychiatric disease. Uncovering the factors that lead to schizophrenia is no easy task – but neurobiologists are on the case. At the **Broad Institute** in the US, **Dr Matthew Johnson**, **Dr Beth Stevens** and their team are investigating whether schizophrenia occurs when brain development goes wrong, causing too many connections between neurons to be destroyed. Their findings could help the development of treatments to prevent and manage this serious disease.

Dr Matthew Johnson

Stanley Center for Psychiatric Research, Broad Institute, USA

Dr Beth Stevens

Broad Institute; Boston Children's Hospital; Howard Hughes Medical Institute, USA

Talk like a ... neurobiologist

C4A — a protein that tags synapses to be engulfed

Microglia — immune cells in the brain responsible for synaptic pruning

Schizophrenia — a severe, chronic brain disorder that affects cognition, emotions and behaviour

Synapse — the connection between neurons that allows information to be transmitted through the brain

Synaptic pruning — the process by which microglia engulf unnecessary synapses

Field of research
Neurobiology

Research project
Investigating whether excessive synaptic pruning during adolescence causes schizophrenia

Funders
US National Institutes of Health (NIH); Stanley Center for Psychiatric Research; Howard Hughes Medical Institute

Websites
stevenslab.org
broadinstitute.org/stanley-center-for-psychiatric-research

doi: 10.33424/FUTURUM670

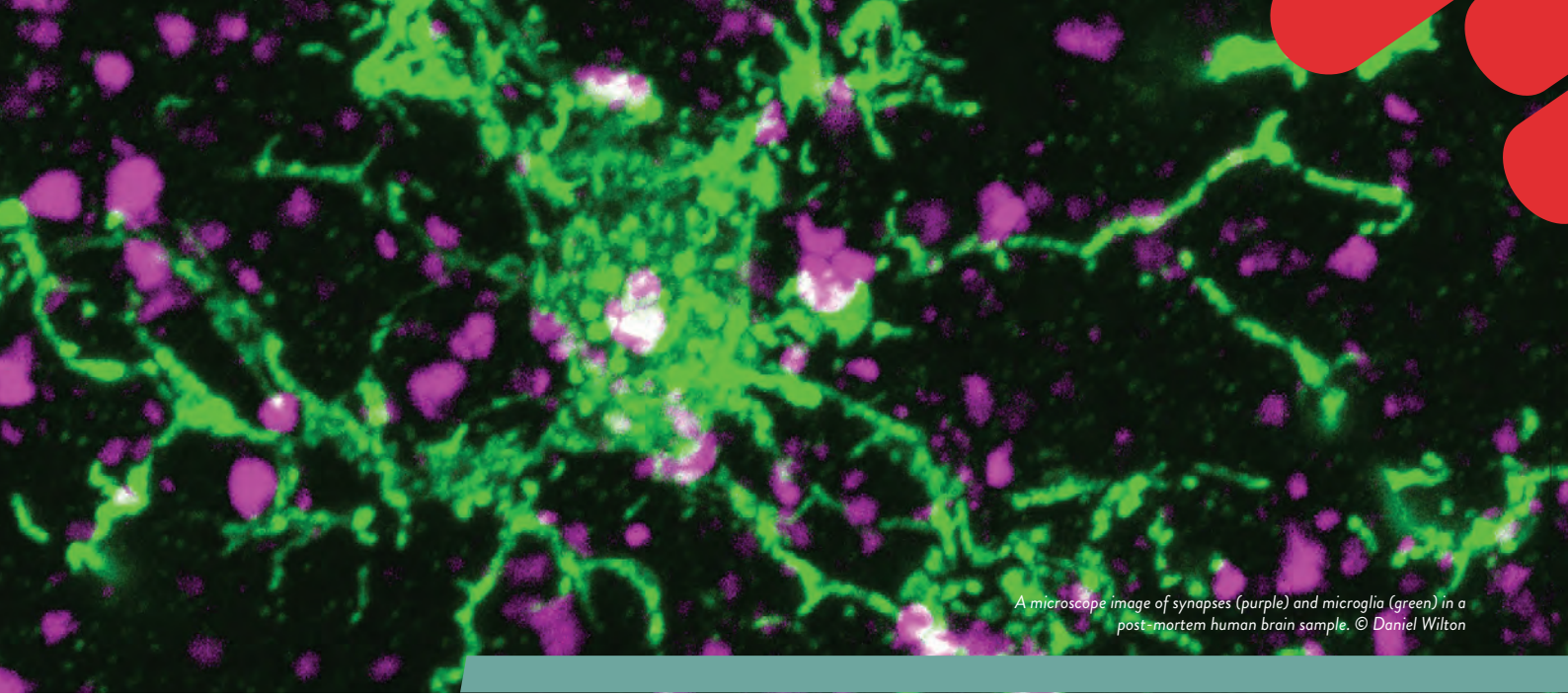
PROFILES

Schizophrenia is a serious mental illness, affecting about 1 in 300 people, or 23 million people around the world. "Symptoms include hallucinations and delusions, social withdrawal, difficulty with language and other cognitive impairments," says Dr Matthew Johnson, a neurobiologist at the Broad Institute. His colleague, Dr Beth Stevens, continues, "Schizophrenia tends to develop during adolescence, and we still don't fully understand why."

Synaptic pruning

Matthew and Beth's team is focusing on synaptic pruning and its relationship with schizophrenia. "Synapses are the connections between neurons that allow these cells to transmit information," says Matthew. "This is how we learn, form memories and control our actions." While we are developing during childhood, the brain makes excess synapses, to enable as much learning as possible. Later, once it is clearer which synapses are useful and which are less so, the body tidies up. During adolescence, unnecessary synapses are removed via synaptic pruning. These synapses get tagged by special molecules, which instruct immune cells called microglia to 'eat' them. "We are testing the hypothesis that too much synaptic pruning by microglia during adolescence is one (of many) causes of schizophrenia," says Beth.

The team is studying the molecules that tag synapses to instruct the microglia to destroy them. "The C4A protein is one of these molecular



A microscope image of synapses (purple) and microglia (green) in a post-mortem human brain sample. © Daniel Wilton

signals," explains Matthew. "Genetic studies have revealed that people with more C4A in their brain have a higher risk for schizophrenia." The team used mouse models to test the link between C4A and schizophrenia. "We studied genetically modified mice that express human C4A," says Beth. "Our findings show that these mice do indeed have increased synaptic pruning and show changes in social behaviour."

Teen troubles

Given that schizophrenia typically emerges during adolescence, it is likely that the disease is linked to developmental processes that happen during this time. "Synaptic pruning is especially active during critical development periods such as adolescence," says Matthew. To build on previous experiments, the team genetically modified new mice where extra C4A was only 'turned on' during adulthood, rather than being present from birth. "Our hypothesis is that mice with extra C4A-induced pruning during adolescence will perform worse at complex decision-making tasks compared to those where extra C4A expression is only during adulthood," explains Beth.

The team is also assessing how environmental factors might contribute to the risk of schizophrenia. "Stress induces immune system responses, so could potentially exacerbate synaptic pruning by microglia," says Matthew. "For example, stress might cause microglia to be more responsive to C4A tags." The team is testing this by observing how mice respond to chronic stress and if that affects the rate of synaptic pruning and their behaviour.

Mouse brains

So, how does the team measure rates of synaptic pruning? "Conventionally, synaptic pruning is measured by cutting mouse brains into super-thin slices, staining the microglia and synaptic proteins, and imaging them under a microscope," says Beth. "However, this method is slow and not well-suited to the complex brain circuits we're interested in." To address this, the team has developed better methods. "In one method, we purify the microglia from a mouse brain, stain the synaptic proteins within them, and measure the synaptic protein signal with a method called flow cytometry," explains Matthew. "This allows us to quantify the engulfment of synapses of thousands of microglia from many mice in one experiment."

But there are challenges with using mice to study human diseases. "Mouse brains are much simpler than human brains, and they develop in different ways," says Beth. "Importantly, it's unclear which stage of mouse development corresponds to human adolescence." While mice are typically considered 'adult' once they reach sexual maturity at two months old, the team found that mouse behaviours and neural pathways continue to change dramatically between two and six months of age, suggesting that they are still developing in this time. "This led us to conclude that this age range may serve as approximately analogous to human adolescence," says Matthew.

Delving deeper

The team is also measuring C4A and other proteins in samples from human volunteers with and without schizophrenia to identify which patients are affected by specific mechanisms, such as excess synaptic pruning. By studying both mice in the lab and human patients, the team endeavours to improve understanding of how effective the mouse model system is for studying human adolescent brain development. The aim is to increase the chances of basic research results being translated to human drug development efforts.

Matthew, Beth and their colleagues are exploring other molecular goings-on, too. "We've found that another schizophrenia risk gene, CSMD1, also affects C4A activity and synaptic pruning," says Beth. "This is important because it shows how two different genetic risk factors converge on a single molecular pathway." The team's work on CSMD1 is in its early stages, but is already proving rewarding, as the CSMD1 gene may be a better target for treatments than C4A. "C4A is a critical part of the immune system throughout the body, so it might be risky to target C4A with a drug," explains Matthew. "CSMD1, on the other hand, is mostly expressed in the brain, so may be a better therapeutic target."

This leads to the overall aim of the team's research – to provide scientific evidence of the neurobiology underlying schizophrenia, which can be used to develop new drugs to treat the disease. "We hope that some of what we learn will uncover new therapeutic targets, such as proteins that could be targeted by new drugs," says Beth. With this evidence in hand, Beth and Matthew hope that schizophrenia will become a better-understood, and therefore more treatable, disease.

About *neurobiology*

Neurobiology is the study of the nervous system, which consists of the brain, spinal cord and nerves. Matthew and Beth specialise in neuroimmunology – the study of the interactions between the nervous system and the immune system. "We collaborate with immunologists, physiologists, molecular and cellular biologists, geneticists, and behavioural and computational neuroscientists," says Beth. "This level of collaboration is critical, allowing us to leverage everyone's expertise to make progress against the significant challenges presented by psychiatric disorders such as schizophrenia."

Despite decades of research, the overwhelming complexity of the human brain means that scientists have barely scratched the surface of neurobiological understanding. "Unlike treatments for diseases in other parts of the body, we tend not to take tissue samples from the brain," says Matthew. "So, we rely on indirect study using methods like neuroimaging or taking samples of blood or spinal fluid that contain proteins that correlate to brain activity." Neurobiologists also rely on mouse models to understand human brains, but this comes with challenges due to the differences between mice and humans.

New technologies are creating opportunities to address the challenges of studying living human brains. "Non-invasive techniques to image live brains (like positron emission tomography or 'PET scans') continue to advance, as do proteomics techniques that can measure thousands of proteins in tiny samples," says Beth. "Geneticists are also making a lot of progress in uncovering the genes behind diseases, including schizophrenia and other psychiatric disorders, creating genetic 'roadmaps' that can help find new drug targets." These advances set the stage for a new chapter in neurobiology – one that will uncover surprising secrets about the incredible organ that is the brain.

Pathway from school to *neurobiology*

At high school, useful subjects to study include biology, chemistry, mathematics, physics and computer science. These can be complemented by arts and humanities subjects for a more well-rounded understanding of human society and challenges that need addressing.

At university, study a degree in neuroscience, cell biology or molecular biology.

Look for opportunities to work in a neurobiology (or general biology) lab to gain practical research experience. "As a young scientist, this hands-on experience is vital for you to apply the concepts you have learnt in the classroom," says Matthew. "It will also allow you to learn about research as a potential career."

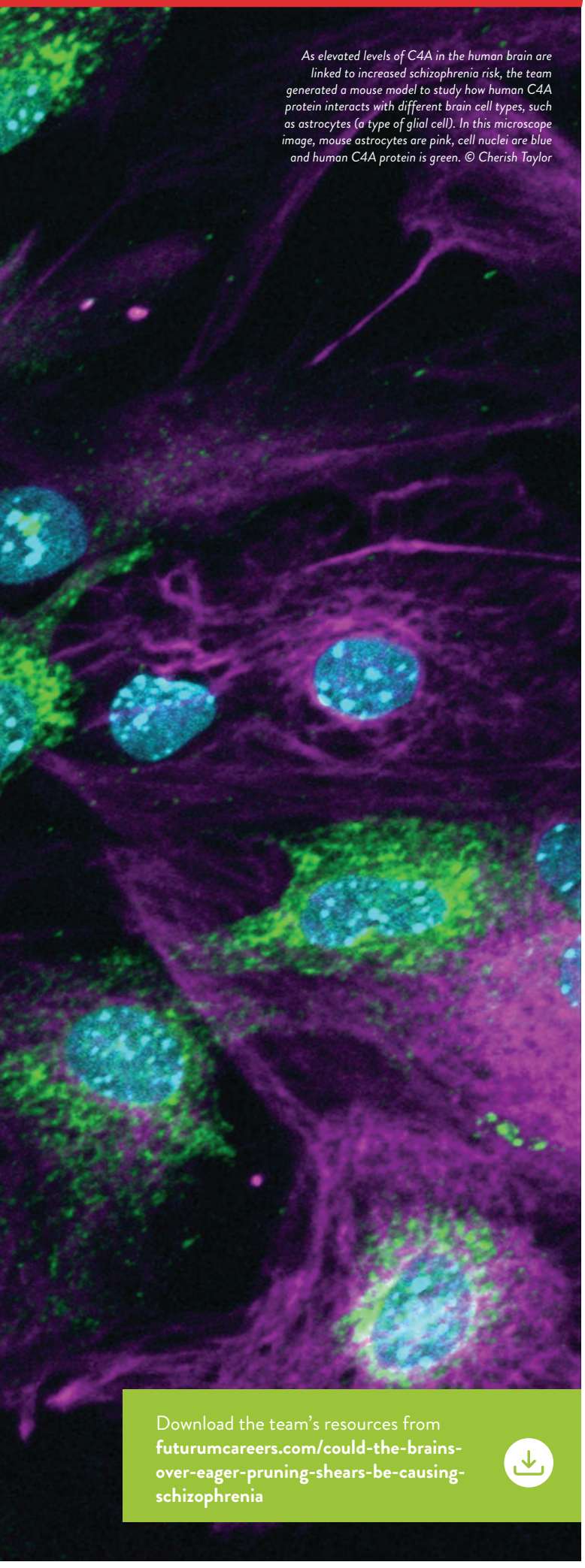
"Attend public talks and events at universities," advises Beth. "These offer another way to be immersed in science." For example, if you are based in Boston, the Harvard Brain Science Initiative (**brain.harvard.edu**) hosts exciting events and provides excellent resources. Dr Cherish Taylor, a member of Beth's team, recommends attending the Black in Neuro (**blackinneuro.com**) seminars to hear from Black researchers working in all aspects of the field.

Explore careers in *neurobiology*

The Broad Institute, where Matthew and Beth work, offers summer programmes for high school and undergraduate students to participate in cutting-edge research projects: **broadinstitute.org/students/summer-research-programs**

The Society for Neuroscience provides information about career paths in the field: **neuronline.sfn.org/career-paths**

"I would encourage all early career scientists to attend conferences run by neuroscience organisations," says Matthew. "These are great ways to get more involved in neurobiology, and to network with scientists at all career stages and learn about different career opportunities and trajectories."



As elevated levels of C4A in the human brain are linked to increased schizophrenia risk, the team generated a mouse model to study how human C4A protein interacts with different brain cell types, such as astrocytes (a type of glial cell). In this microscope image, mouse astrocytes are pink, cell nuclei are blue and human C4A protein is green. © Cherish Taylor

Download the team's resources from **futurumcareers.com/could-the-brains-over-eager-pruning-shears-be-causing-schizophrenia**

Meet *Cherish*

Dr Cherish Taylor is a researcher in Beth's lab.

As a teenager, I wanted to become a forensic scientist. I was fascinated by how detectives in TV shows like *CSI* and *Law and Order* used science to solve cases. I also loved music – my brother is a musician, and I grew up going to his gigs. At one point, I also thought I would become a singer.

At college, I wanted to gain experience in genetic research to help my dream of becoming a forensic scientist. I joined a lab where we used optogenetics (a genetic tool that uses light to activate genes in genetically modified mice) to study how the brain influences behaviour. I was amazed by how the activity of tiny cells in the brain had such an impact on the mice's behaviour. So, I changed my career goals and decided to study psychology and neurobiology.

Community in science is so important. I was the only Black woman on my PhD programme, and I felt isolated. When I met another Black woman on a different programme, we realised we were navigating the same challenges, so we started meeting for lunch once a week. Soon, other Black women joined us. We built the community we needed, which helped us persevere.

A day in the lab can vary a lot. I might be at the bench doing an experiment, in the animal facility working with mice, or on my computer processing results or reading about new science.

Science is hard. Often, experiments don't go as planned, results are difficult to understand, or we lack the technology we need to test something. These moments can be frustrating and discouraging, so a critical characteristic for any scientist is the ability to persevere. We keep learning, repeating experiments, trying new techniques and reaching out to others. It's important to surround yourself with good mentors and peers who can encourage you when things are challenging and help you see things from a different perspective. I'm proud to act as a mentor for my students, and to see their growth and development.

The brain is an amazing organ, but we still know so little about it. This means that neurobiology is really exciting because our discoveries make new knowledge – we are rewriting the textbooks!

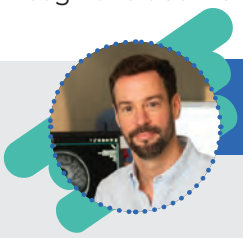
Cherish's *top tips*

1. Stay curious. If you're interested in something, learn about it. And reach out to scientists doing work you find cool! Most would be happy to talk to you about their work.

2. Seek research experience. Hands-on experience is key to becoming a scientist, so actively participate in class labs, shadow a researcher or find a summer research placement.

Healthy hearts = healthy brains? How protecting your blood vessels could prevent dementia

Your heart and your brain are organs with very different functions, but they are deeply connected. **Dr Timothy Hughes**, Associate Professor at **Wake Forest University School of Medicine** in the US, is a neurovascular epidemiologist investigating how diseases that affect our blood vessels, like high blood pressure and diabetes, may also contribute to Alzheimer's disease and related dementias. Through the MESA-MIND study, Tim and his team are investigating how keeping our blood vessels healthy could help prevent cognitive decline and dementia as we age.



Dr Timothy Hughes

Associate Professor, Department of Internal Medicine, Section of Gerontology and Geriatric Medicine and the Department of Epidemiology and Prevention, Wake Forest University School of Medicine, USA

PROFILE

Fields of research

Neurovascular epidemiology; Alzheimer's disease and related dementias; geroscience

Research project

MESA-MIND: Understanding how subclinical vascular disease may increase the risk for Alzheimer's disease and related dementias

Funder

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doi: 10.33424/FUTURUM658

Talk like a ... neurovascular epidemiologist

Atheroma — a fatty deposit that builds up inside arteries, restricting blood flow and increasing the risk of cardiovascular disease

Alzheimer's disease — a progressive age-related brain disorder that causes cognitive decline

Amyloid deposits — clumps of protein that accumulate in the brain

Arterial stiffness — the loss of flexibility in arteries that occurs with ageing or disease, making it harder for blood to flow smoothly

Cardiovascular disease — a group of conditions affecting the heart and blood vessels, reducing or blocking blood flow to the heart, brain, or other organs, causing heart attacks and strokes

Cognition — the mental processes involved in thinking, learning, remembering, and decision-making

Dementia — a general term for conditions that affect memory, thinking, and social abilities severely enough to interfere with daily life

Neurovascular epidemiology — the study of how chronic diseases of the heart and blood vessels spread to the brain in populations, and how they can be controlled

Plasma proteomics — the large-scale study of proteins in blood plasma to understand biological processes and disease mechanisms

Around 57 million people worldwide live with dementia, and almost 10 million new cases are diagnosed each year – a number that continues to rise as populations age. Most people who get dementia have a combination of Alzheimer's disease (with abnormal protein deposits in the brain) and vascular disease in the brain. Scientists have long known that what is good for the heart is also good for the brain but exactly how the health of these two vital organs is linked has not been well-understood.

One step towards understanding this connection was the Multi-Ethnic Study of Atherosclerosis (MESA), launched in 2000. This large-scale study followed thousands of participants from six US cities, examining how early, often invisible, changes in the heart and blood vessels (such as plaque build-up, arterial stiffening and high blood pressure) develop over time and lead to cardiovascular diseases.

"MESA has taught us what risk factors contribute to cardiovascular disease," says Dr Timothy Hughes at Wake Forest University School of Medicine. "These include our genetics, the environment and neighbourhoods we live in, our diets, and the changes in our bodies as we age." Over the past 25 years, MESA has published nearly 3,000 scientific papers and developed risk calculators now used by doctors around the world. And now,

Tim preparing a study participant for a brain MRI study.
© Wake Forest University School of Medicine

MESA's findings are paving the way for new research into how heart health is linked to brain health.

MESA-MIND: studying the link between heart and brain health

Building on MESA's success, Tim now leads the MESA-MIND project, which explores how diseases that affect the blood vessels – such as high blood pressure and diabetes – contribute to Alzheimer's disease and related dementias. These conditions are the two most important modifiable risk factors for dementia later in life, meaning that if we can control them in mid-life, we may be able to reduce the chances of developing memory loss as we age. However, scientists still know surprisingly little about which problems in the heart and blood vessels can damage the brain.

MESA-MIND connects detailed cardiovascular data with information about brain structure, function, and cognition. "The brain imaging and blood tests used in this work are critically important to achieving our goals and require teams of epidemiologists, radiologists, neuroscientists, and data specialists working together," explains Tim. The study combines magnetic resonance imaging (MRI) scans, which show vascular and tissue changes and shrinkage in the brain, with positron emission tomography (PET) scans, which highlight amyloid deposits – the protein clumps that lead to Alzheimer's disease. Analysed with AI, these images have already helped scientists develop new blood tests that can track how dementia-related changes begin and progress long before symptoms appear.

MESA-MIND participants

The study includes older adults who identify as Hispanic, White, Black, or Chinese Americans living in six cities in the US. To ensure that groups often excluded from dementia research are represented, the study conducts cognitive testing in English, Spanish, Mandarin, and Cantonese. "The diversity of the MESA-MIND cohort is central to our mission," says Tim. Researchers once thought that Black and Hispanic people might be at higher risk of Alzheimer's due to genetics or more disease-related brain changes. However, MESA-MIND has helped to show that these groups in the US do not have a greater risk for Alzheimer's disease. Instead, people who develop dementia in these populations often have more vascular disease in the brain, which interacts with Alzheimer's-related changes to accelerate cognitive decline. "We need new strategies to stop vascular disease before it impacts brain health in diverse groups of people," says Tim. "Strategies include: treating vascular diseases before they damage the brain, reducing economic and health disparities, and helping people adopt healthy lifestyles choices."

Early changes in blood vessels

A key focus of Tim's research is subclinical vascular disease – early changes in the walls and function of blood vessels that happen long before a person notices any symptoms. Subclinical means these changes can be detected and measured with advanced imaging or tests, even though the person feels healthy.

"Focusing on subclinical vascular disease means we can intervene early to treat and prevent the underlying causes of future disease before it hurts someone," says Tim. "We hope to detect and treat subclinical vascular disease to prevent the development of problems like stroke and other vascular diseases in the brain long before they cause dementia."

The team's discoveries

This work has revealed important links between subclinical vascular disease and dementia. "We are seeing that the development of atheromas – fatty plaques deposited in the arteries of the heart, neck, and brain – don't appear to contribute directly to Alzheimer's disease," explains Tim. "Instead, they increase the risk for cardiovascular diseases, stroke events, and loss of brain volume in the areas damaged by stroke."

In contrast, controlling blood pressure is one of the most powerful ways to protect the brain. Blood pressure depends on many factors, including how quickly arteries stiffen with age. "My lab focuses much of our research on how arterial stiffness relates to changes in blood flow in the brain, the development of vascular disease in the brain, and even the pathology of Alzheimer's disease," says Tim. "We have learned that the faster your arteries stiffen with age, the more likely you are to have dementia-related pathologies building up in the brain, impacting its function and increasing your risk of dementia." Preventing and treating subclinical vascular diseases before they reach the brain will keep brains healthier as they age.

Next steps in this research

Building on the findings from MESA-MIND, Tim and his team have begun clinical trials to see whether treating early vascular disease can help prevent Alzheimer's and related dementias. They are testing drugs already known to protect the heart, exploring whether these medications can also protect the brain.

Tim's lab is also using plasma proteomics – a method that measures hundreds or even thousands of proteins in the blood at once – to discover new molecules that may link vascular disease to dementia. By repeating these measurements over time, the team can track how changes in proteins relate to the development of subclinical vascular disease, brain changes, and Alzheimer's pathology.

About *neurovascular epidemiology*

Neurovascular epidemiology combines neuro- and cardiovascular branches of epidemiologic research that explore how chronic diseases of the heart, blood vessels, and brain develop across populations. Neuroepidemiologists investigate conditions like Alzheimer's disease and dementia, while cardiovascular epidemiologists study risk factors such as high blood pressure, diabetes, and atherosclerosis (the build-up of fatty deposits in arteries). By combining these two areas, scientists like Tim can better understand how "upstream" heart and blood vessel health influence "downstream" brain structure and function.

Research like Tim's is very rewarding because it links medicine, data science, and public health to make a real-world impact. "Being an epidemiologist allows me to feed my curiosity and sense of wonder, while enabling us to ask very big questions that may one day soon improve people's health," says Tim. "I get to lead teams that find the right questions, design the best studies, and analyse and interpret novel and unique data that no one has ever seen before." Studying large groups of people as they age provides the chance to better understand the causes of disease and identify interventions that can benefit whole communities – just as past epidemiological research helped establish the health risks of smoking and the importance of vaccines.

Looking ahead, the next generation of neurovascular epidemiologists will enter an era of rapid technological change. "We are now in the era of big data; for each study participant, we can generate terabytes of data at each visit," explains Tim. "Data science and AI have already begun to transform how we collect, process, and analyse data, but we will always need epidemiologists to guide the design and interpretation of the data."

Pathway from school to *neurovascular epidemiology*

In high school, subjects like mathematics, biology, and physics build the foundation for understanding how the body works and how to analyse data – essential skills for studying disease patterns. "Our bodies are wonderous, complex, walking, talking miracles," says Tim. "We can use the intersection of math, science, and biology (through epidemiology) to study how and why we get almost any disease."

At college, a degree in biology, public health, biomedical sciences, statistics, or data science offers a route into epidemiological research.

Tim highlights that it is important to remember that your pathway from school to your chosen career may not be obvious to you straightaway, but it is a challenge you should embrace. "You may be surprised to learn that I struggled a bit late in high school and early in college and didn't always see the direct relevance of some of the subjects I took," he explains. "This turned around when I began to see these topics as challenges to learning-how-to-learn and to master. I still use that skill every day of my professional career."

Download Tim's resources from **futurumcareers.com/neurovascular-epidemiology-with-dr-timothy-hughes**

Let us know what you think of this educational and career resource. To provide input, simply scan the QR code or use this link: **redcap.link/dh5j1nes**

Tim and his colleague preparing blood samples for processing.
© Wake Forest University School of Medicine

Explore careers in *neurovascular epidemiology*

"Epidemiologists are involved in every aspect of human health research," says Tim. "For cardiovascular epidemiology, the best resources are the American Heart Association (**heart.org**), the Lancet Commissions (**thelancet.com/commissions-do**), and the World Health Organization (**who.int**)."

"For Alzheimer's disease, the Alzheimer's Association (**alz.org**) leads international effort to prevent, treat, and support the disease," says Tim.

Meet *Tim*

I have always been curious about the world. I've always wanted to know more about our bodies and our place in this world. As a youngster, I loved to draw and thought that I would be an artist or a doctor. Science and meditation had a huge impact on my sense of how the mind works, causality, and wonder of this world. Sports taught me about how to work in teams and the amazing potential of the body. Sickness and death taught me about the impermanence of our bodies and life. Topics like Geroscience help us find ways to stay healthier longer and prevent age-related diseases.

I initially thought epidemiologists only tracked down and stopped infectious diseases. My first courses in epidemiology showed me that we can also track down the causes of chronic diseases and learn how to prevent them. My first job after my master's degree was with the US National Institutes of Health. This work inspired me to find out why high blood pressure increases the risk for brain ageing and dementia. During this time, I fell in love with the brain. Its beauty, its mystery, and its resilience. This experience continues to inspire my work today.

I am lucky to say I have many career achievements I am proud of, but I will give you my top three right now! The first would be the pleasure of building new teams and research studies and watching them succeed. Second, it is hard to put into words the joy and excitement I get from turning a simple observation into a new project, and seeing this progress all the way to a clinical trial aimed at preventing disease. This is where science can become medicine for tomorrow. Third, but not least, is my opportunity to encourage scientific exploration in my children, trainees, and mentees. Watching them develop gives me hope for the future.

Right now, my greatest aim for the future is to help support researchers dedicated to developing new treatments and prevention strategies for the vascular contributions to Alzheimer's disease and related dementias. MESA-MIND is just one of the studies where I accomplish these goals. The joy of my work is the range of projects I get to work on; there is so much we can do in this space to help older adults prevent dementia.

Tim's *top tips*

1. Follow your curiosity wherever it leads.
2. Don't be afraid to try and fail. You will often learn more from failing than from success.
3. As American physicist Richard Feynman said, "Fall in love with some activity and do it!" Forging ahead with it will deepen your life and make it more beautiful.
4. Teachers and mentors are critical to your growth, no matter what you choose to do. I have always tried to create a large group of mentors around me. Don't be afraid to ask someone you admire for advice. They may become one of your greatest mentors.
5. Above all, find your own way to help people. Don't lose that purpose.

How does the gut microbiome influence the outcomes of breast cancer treatment?

There are trillions of microorganisms living in your gut. In addition to helping you digest food, your gut microbiome can impact how well you respond to medical treatments. At **Wake Forest University School of Medicine** in the US, **Dr Katherine Cook** is analysing faecal samples from breast cancer patients. She is exploring how the gut microbiome interacts with breast cancer therapies and whether simple dietary changes could improve treatment outcomes.

Dr Katherine Cook

Associate Professor, Department of Cancer Biology, Wake Forest University School of Medicine, USA

Field of research
Translational breast cancer research

Research project
Analysing faecal samples to investigate how the gut microbiome interacts with breast cancer therapies

Funders
US National Cancer Institute (NCI); Department of Defense (DOD) Congressionally Directed Medical Research Program (CDMRP); metaVIVOR; The V Foundation

doi: 10.33424/FUTURUM665

PROFILE

Talk like a ... translational cancer researcher

Gut microbiome — the combination of microorganisms (e.g., bacteria, viruses, fungi) that live in the gut and support digestion, immunity and overall health

Mediterranean diet — a diet high in healthy fats, such as olive oil and fish oil

Probiotic — a supplement (commonly found in yoghurt) containing live, beneficial microorganisms that support a healthy gut microbiome

Receptor — a structure on or inside a cell that attaches to specific molecules, such as hormones, and triggers a response in the cell

Translational research — a combination of lab-based and clinical research, with results from each informing the other

Western diet — a diet high in unhealthy saturated fats, sugar and salt

When Dr Katherine Cook was eight, her grandmother passed away from breast cancer. A few months later, Katherine's aunt was also diagnosed with the disease. And since then, both Katherine and her mother have had surgery after discovering lumps in their breasts.

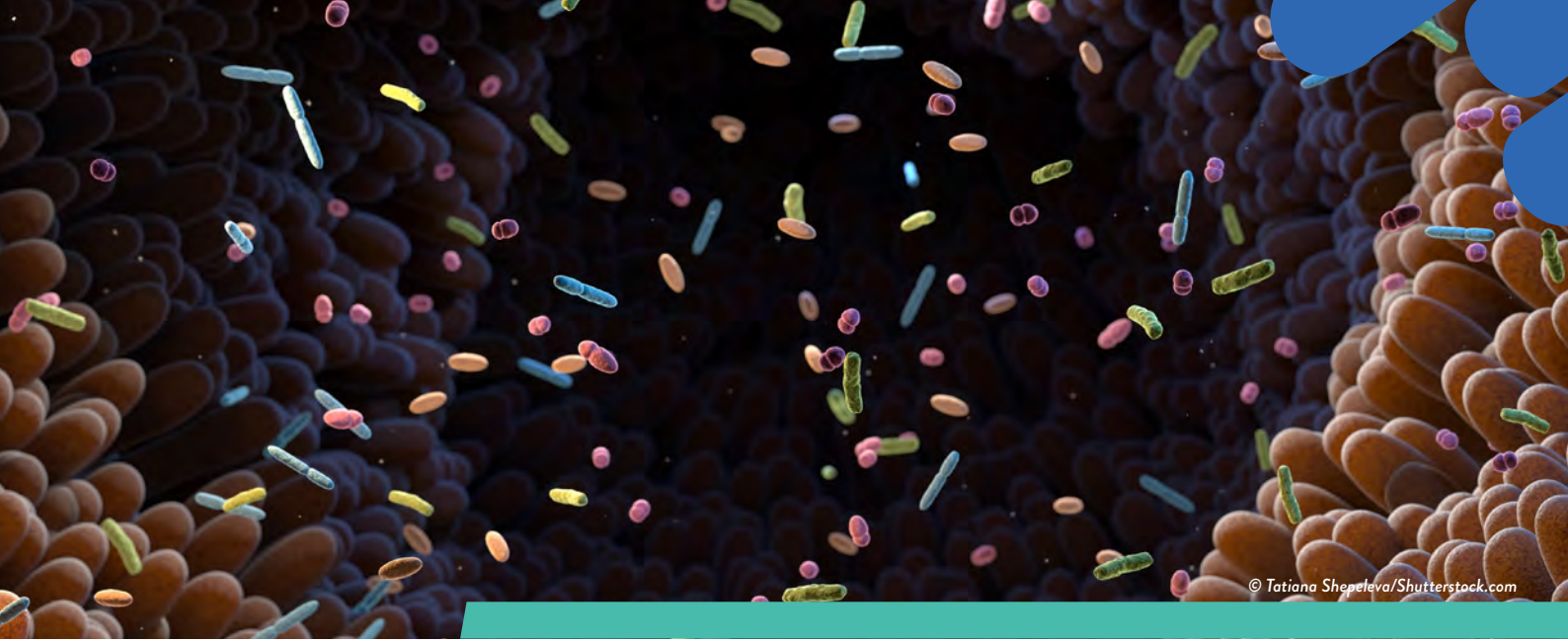
Katherine and her family are not alone. In most countries, breast cancer is the most common form of cancer in women. And in the US, 1 in 8 women will be diagnosed with breast cancer during their lifetime. "My own experience, coupled with my family history, has served as motivation for my career as a breast cancer researcher," says Katherine. She conducts translational research at Wake Forest University School of Medicine to study how the gut microbiome interacts with breast cancer therapies.

What is the gut microbiome?

Your gut contains trillions of microscopic organisms, including bacteria, viruses and fungi. Together, they are known as the gut microbiome and play a vital role in keeping you healthy. "In a healthy person, these microorganisms live within us in a balanced state," explains Katherine. "Your gut microbiome helps you digest the food you eat, generates vitamins to support your health, helps your immune system function and protects you from infections." Lifestyle factors, such as diet and medications, affect the health of your gut microbiome which, if it becomes unbalanced, can affect the health of the whole body.

How is the gut microbiome relevant to cancer research?

Some breast cancer patients are given oral medication that is absorbed into the body from the gut. This means the drugs will interact



with the microorganisms in their gut, and Katherine wants to understand how this impacts the outcome of cancer treatment. Other patients are given immunotherapy – drugs that stimulate the immune system to kill cancer cells. "As the gut microbiome influences immune cell activity, it impacts immunotherapy efficacy," explains Katherine. To explore these issues, Katherine is analysing faecal samples from breast cancer patients.

Why are faecal samples useful?

"Everybody poops!" says Katherine. "Faecal samples are non-invasive biospecimens that could help us determine whether a patient will respond to their therapies." Patients in Katherine's clinical trials collect faecal samples and send them to Katherine's lab, where she analyses the DNA they contain. This allows her to determine what bacteria are present in the faeces and, therefore, in the gut microbiome. "We can then use this information to understand how the bacteria may be influencing the patient," she explains.

How is Katherine conducting clinical trials?

In one trial, Katherine is researching hormone receptor-positive (HR+) breast cancer. This is the most common type of breast cancer, in which cancer cells have receptors that respond to oestrogen and progesterone. These hormones help the cancer to grow, so treatment involves drugs that reduce the hormones' ability to send signals to the receptors.

Katherine is collecting faecal samples from patients before they start treatment and after one and three months of taking the drugs. "We will sequence DNA isolated from the samples and measure how the bacterial species change when HR+ breast cancer patients start therapy," she says. "Some types of bacteria may affect how therapies are excreted from the body, which could change the drug bioavailability (the amount that enters the body)."

> ***"Some types of bacteria may affect how therapies are excreted from the body, which could change the drug bioavailability."***

In another trial, Katherine is researching triple-negative breast cancer (TNBC), a type of breast cancer that is more common in young and minority women. It requires a different type of treatment because the cancer cells lack hormone receptors, so patients are treated with a combination of chemotherapy (drugs that kill cancer cells) and immunotherapy.

Katherine is collecting faecal samples, blood samples and diet information from TNBC patients before and after they complete their treatment. "We aim to investigate if certain diets or gut microbiome species are associated with better health outcomes," she says.

Why is translational research important?

In addition to her clinical trials, Katherine uses mouse models to test her clinical observations in the lab. "For example, if we identify bacteria that are enriched in the gut microbiome of breast cancer patients, we can feed these bacteria to mice with tumours," she says. "This allows us to determine whether these bacteria may promote tumour growth or increase anti-cancer outcomes."

Each discovery informs the next stage of Katherine's work. By understanding how diet, the gut microbiome and cancer therapies interact, Katherine can design future clinical trials to test whether key dietary features could improve patients' outcomes. "For example, if our clinical trial identifies that TNBC patients who eat at least 25 grams of fibre a day respond better to chemotherapy and immunotherapy, then we could design a study to determine whether fibre improves anti-cancer efficacy," explains Katherine.

What has Katherine discovered?

Katherine's clinical trials are still ongoing, but she has already made exciting discoveries from her lab-based research. She has shown that, if mice are fed an unhealthy Western diet, a probiotic made from the bacterium *Lactobacillus* improves the effectiveness of drugs to prevent HR+ breast cancer from recurring. "We have also demonstrated that mice with TNBC tumours respond better to immunotherapy if they are fed a Mediterranean diet rather than a Western diet," she says. "In our clinical trial, we are now investigating whether women who eat more healthy fats respond better to immunotherapy."

Katherine hopes her research findings will improve outcomes for future breast cancer patients. "Ultimately, I want our studies to improve clinical care to reduce breast cancer related deaths."

About *translational cancer research*

"Translational research bridges the gap between basic science and clinical practice to develop practical applications that will directly benefit patients," says Katherine. Translational cancer researchers use lab-based methods and clinical trials to explore questions such as how cancer cells grow, how the immune system reacts and, in Katherine's case, how the gut microbiome and diet might affect treatments. Answering these questions will lead to more effective prevention strategies and better therapies.

From bench to bedside and back again

"Translational research is defined as the ability to move scientific discoveries from the lab into the clinic for testing to develop real life applications," says Katherine. This is often known as the 'bench-to-bedside-to-bench approach', where researchers make discoveries in the lab, then see if these apply in human testing, and then take the results of clinical trials back to the lab to build on them further.

For example, having discovered in the lab that mice with triple-negative breast cancer (TNBC) tumours respond better to immunotherapy when fed a Mediterranean diet, Katherine is now using her clinical trial to investigate whether women with TNBC who eat more healthy fats also respond better to immunotherapy. "This represents bench-to-bedside research," she says. "But if we observe something different in the clinical trial, we would then go back to the lab to test that factor in mice, which would represent bedside-to-bench research."

A day in the life of a cancer researcher

"Every day is different from the next!" says Katherine, whose tasks include collecting faecal and blood samples from the clinic then analysing them in the lab, meeting with students and collaborators to discuss research projects, and presenting scientific data at seminars. These different responsibilities enable Katherine to make advances in science, while improving the treatment outcomes for patients with breast cancer.

Download Katherine's resources from **futurumcareers.com/translational-cancer-research-with-dr-katherine-cook**

Pathway from school to *translational cancer research*

"Study anything and everything science!" advises Katherine. "It's amazing how interconnected all the science topics are to each other. Chemistry and physic concepts relate to biological research questions. Studying chemistry could lead to the discovery of new cancer drugs, while studying physics could lead to the development of new diagnostic cancer techniques."

As well as studying biology, chemistry and physics at high school, it would be useful to study mathematics to learn about statistics for analysing data, computing to learn coding for processing data, and psychology to help you relate to patients you work with during your career.

At university, a degree in biomedical science, biology or medicine could lead to a career in translational cancer research.

Look for opportunities to take part in scientific research to gain valuable work experience. "Participate in summer research experiences or volunteer at a science lab to find out what topics you are passionate about," advises Katherine. "The Department of Cancer Biology at Wake Forest University School of Medicine (**school.wakehealth.edu/departments/cancer-biology**) has summer research programmes for high school and college undergraduate students."

Let us know what you think of this educational and career resource. To provide input, simply scan the QR code or use this link: **redcap.link/dh5j1nes**

Katherine discusses ongoing experiments with Zipporah Cornelius (a current PhD graduate student).
© Wake Forest University School of Medicine

Explore careers in *translational cancer research*

"There are a lot of job opportunities for people with a PhD in biomedical sciences," says Katherine. This includes roles in academia (conducting research at universities), industry (working for pharmaceutical companies) and government (working for organisations such as the National Cancer Institute [**cancer.gov**] or Food and Drug Administration [**fda.gov**]). "These paths can leverage your expertise and overall career interests."

Explore organisations such as the American Association for Cancer Research (**aacr.org**), the American Institute for Cancer Research (**aicr.org**), the Cancer Research Institute (**cancerresearch.org**) and the American Cancer Society (**cancer.org**) to learn about recent cancer research and the type of careers available in the field.

Meet *Katherine*

I've always been interested in science, taking advance placement biology and chemistry coursework during high school. I also played soccer throughout high school and for a local team. My first job was a cashier at a grocery store. I hate to admit but to this day, I still remember those produce codes!

Breast cancer has profoundly impacted my family and served as a driver behind my desire to become a breast cancer researcher. My grandmother was diagnosed with the disease when I was young and, unfortunately, passed away. My mother and aunt have each had a double mastectomy (removal of both breasts). Then, when I was in graduate school in the middle of writing my PhD thesis, I found my own breast lump. I underwent surgery to remove the lump which, thankfully, was benign (not cancerous).

One of the most rewarding aspects of my job as a translational breast cancer researcher is seeing our laboratory-based discoveries move into the clinic. Working on clinical trial projects means participating in real-time to fulfil our ultimate goal of improving breast cancer patients' outcomes and quality-of-life.

I started my research lab 10 years ago and in that time, I have experienced several momentous career achievements: my first graduate student obtaining her PhD degree, seminal lab discoveries on how diet influences breast tissue-resident microbiome populations, being awarded my first research grant, starting our first clinical trial at the Wake Forest Comprehensive Cancer Center. I have been proud of each of these moments.

I have the pleasure of working with brilliant students and colleagues who share the goal of reducing breast cancer risk and improving survivorship. My hopes for the future are to continue making meaningful advances in the field and to teach the next generation of cancer researchers.

In my free time, I run, work out and go to yoga class. Staying active helps clear my mind. I also enjoy travelling and experiencing new places.

Katherine's *top tips*

1. Be curious and don't be afraid of asking questions.
2. Don't be discouraged when things don't work out. Keep trying. Sometimes, the experiment that doesn't work will be the most informative and will point you in a new direction.

Targeting senescent cells to promote healthy ageing

As people live longer, many spend their extra years managing chronic illnesses rather than enjoying life. Cellular senescence, the accumulation of damaged cells that refuse to destroy themselves, plays a key role in this age-related decline. At the **Institute for Clinical and Experimental Medicine** in Czechia, a team led by **Professor Martin Haluzík** and **Dr Soňa Štemberková Hubáčková** is developing senolytic compounds, drugs that can selectively remove senescent cells, reduce age-related damage and help people stay healthier for longer.

Dr Soňa Štemberková Hubáčková

Laboratory of Translational and Experimental Diabetology and Obesitology (LTEDO), Centre for Experimental Medicine, Institute for Clinical and Experimental Medicine, Czechia

Fields of research

Molecular biology; cellular senescence; healthy ageing; molecular and translational medicine

Research paper

Targeting Mitochondrial Integrity as a New Senolytic Strategy. Hubáčková S., et al. (2025) doi: 10.14336/AD.2024.1100

Funders

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doi: 10.33424/FUTURUM662

PROFILE

Talk like a ...

molecular biologist

Cellular senescence — a state in which damaged or stressed cells permanently stop dividing but remain metabolically active, often releasing molecules that cause inflammation, fibrosis and tissue dysfunction

Fibrosis — the excessive build-up of structural proteins, leading to tissue stiffening and impaired organ function

Inflammation — the body's response to injury or stress that can cause swelling, redness and tissue damage

Mitochondria — tiny structures inside cells that generate energy, regulate cell death and play a central role in the onset of cellular senescence

Metabolic diseases — disorders that affect how the body processes and uses energy from food, often leading to conditions like obesity and diabetes

Senolytic compounds — drugs designed to selectively remove senescent cells from the body

In 1800, the average person lived for around 40 years; today, that number is closer to 80. However, living longer does not always mean living well. There is a growing gap between lifespan – the total number of years we live – and healthspan – the number of those years spent in good health.

"Around the world, people are living longer but often spend those extra years managing chronic illnesses like diabetes, cardiovascular disease and cancer," says Dr Soňa Štemberková Hubáčková from the Laboratory of Translational and Experimental Diabetology and Obesitology (LTEDO) at the Institute for Clinical and Experimental Medicine. "Most current therapies primarily alleviate symptoms or slow disease progression but do not address the underlying biological mechanisms driving the illness."

What is cellular senescence?

Research at the LTEDO focuses on cellular senescence, a fundamental biological process that links ageing, inflammation and the gradual decline of tissues. Normally, when cells become damaged or stressed, they stop dividing and destroy themselves to prevent further harm. But during senescence, instead of quietly disappearing, some of these cells linger – alive but no longer useful.

"Senescent cells are like 'zombie cells' that have stopped dividing but refuse to die, releasing a wide range of inflammatory and tissue-remodelling molecules," explains Soňa. Over time, these cells build up throughout the body,

Professor Haluzik (left) is the Head of the Diabetes Centre at the Institute for Clinical and Experimental Medicine. Dr Werner (middle) and Dr Štursa (right) are the chemists behind the development of new senolytic compounds.

Download the team's resources from **futurumcareers.com/targeting-senescent-cells-to-promote-healthy-ageing**

creating a constant, low level of inflammation that contributes to age-related decline.

While cellular senescence begins as a protective mechanism, its long-term effects are damaging. The process is linked to many chronic conditions, including obesity, type 2 diabetes, cardiovascular disease, liver and kidney disorders, and neurodegenerative diseases. Senescence can even play a double role in cancer – helping to suppress tumour growth at first, but later encouraging it through inflammation and fibrosis.

How can we destroy senescent cells?

If senescent cells drive ageing and disease, then how can we remove them? The LTEDO team has developed a series of senolytic compounds – drugs designed to seek out and destroy senescent cells while leaving healthy ones intact.

This work began with a compound called MitoTam, originally created as an anti-cancer drug in Professor Jiří Neužil's laboratory at the Institute of Biotechnology of the Czech Academy of Sciences. When Soňa tested MitoTam, she discovered that it also had a strong senolytic effect. "Building on these findings, the team at the LTEDO developed and patented a new generation of mitochondria-targeting senolytic agents that eliminate senescent cells by exploiting their characteristic metabolic and structural vulnerabilities," explains Soňa.

These compounds specifically target mitochondria, the energy centres inside cells that are involved in maintaining senescence. Once inside the mitochondria, these senolytic compounds disrupt their structure and energy supply, triggering the controlled death of senescent cells. Healthy cells, which are more adaptable, remain largely unaffected.

How does the team test the senolytic compounds?

To study their senolytic compounds, the LTEDO team combines in vitro and in vivo experiments – meaning they test them both in the lab and in living organisms. In their in vitro studies, they induce senescence in cultured human and animal cells, allowing them to closely examine how the senolytic compounds affect mitochondrial function, cell survival and the secretion of inflammatory molecules. These experiments reveal the cellular mechanisms behind each compound's action and help optimise their selectivity and dosing.

However, senescence affects many organs and depends on complex interactions between metabolism, the immune system and communication between tissues. "We therefore use several animal models of metabolic diseases and their complications to evaluate physiological and molecular outcomes," says Soňa. "In parallel, collaboration with clinicians allows us to analyse human samples, confirming the translational relevance of our findings."

What comes next?

The next step for the LTEDO team is to move from laboratory and animal studies into early-phase clinical trials. "This process is both exciting and challenging," says Soňa. "It requires extensive testing to confirm long-term safety, define optimal dosing, and ensure selective elimination of senescent cells without harming healthy tissues." Each clinical phase, from initial safety testing to large-scale trials, requires careful validation, regulatory approval, and close collaboration between scientists, clinicians and industry partners.

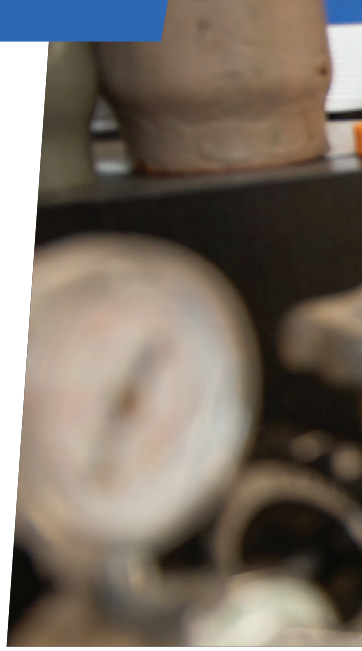
Alongside this work, the team is collaborating with clinicians to explore a novel use of senolytic therapy in organ transplantation. By administering their compounds directly to donor organs outside the body, they hope to rejuvenate these organs, improve their function and make them more suitable for transplant. "This strategy may expand the donor pool, improve transplant outcomes and shorten waiting times for recipients," explains Soňa. "Because this approach reduces senescence in organs outside the donor or recipient's body, it offers a faster and safer path to clinical application, effectively shortening the time required for full clinical testing."

Why does this research matter?

Senolytic therapies could have a transformative impact not just on individual health by improving quality of life, but on society as a whole. As populations age, the rising number of chronic and degenerative diseases places huge pressure on healthcare systems. "By targeting one of the fundamental mechanisms of ageing, senolytic therapy has the potential to delay, prevent or even reverse multiple age-related disorders simultaneously," says Soňa.

Restoring tissue function and reducing inflammation could help people spend more years in good health, rather than simply living longer. Fewer years of disability, lower healthcare costs and healthier, more active lives would contribute to a more productive, vibrant and sustainable society.

Why do our muscles get weaker with age – and can we do something about it?



As we get older, our muscles get weaker – a phenomenon known as sarcopenia. The causes of this muscular degeneration are not well understood, although research suggests that functional decline in our mitochondria may be a key factor. At **Wake Forest University School of Medicine** in the US, **Dr Bumsoo Ahn** is studying exercise training and a hormone that has the potential to counteract sarcopenia by improving mitochondrial function. The goal of his lab is to slow the ageing process, allowing people to stay healthy for longer.

Dr Bumsoo Ahn

Assistant Professor, Department of Internal Medicine, Section of Gerontology and Geriatric Medicine, Wake Forest University School of Medicine, USA

Field of research
Mitochondrial biology

Research project
Investigating the role of mitochondria in age-related muscle degeneration and how the hormone ghrelin may be able to slow this decline

Funders
US National Institute on Aging (grant numbers: R01 AG092766 & R00 AG064743);
American Federation of Aging Research

doi: 10.33424/FUTURUM653

PROFILE

Talk like a ...

mitochondrial biologist

Bioenergetics — the field in biochemistry and cell biology that studies how energy flows through living systems

Genome — the complete set of genes in a cell, organelle or organism

Ghrelin — a hormone produced in the stomach, with a range of functions including appetite stimulation

Homeostasis — the biological processes that maintain a stable and constant internal environment within a cell or organism

Mitochondria — organelles found in most cells, responsible for cellular respiration (among other roles)

Oxidative modification — the chemical alteration of biomolecules like proteins, lipids and nucleic acids by reactive oxygen species

Reactive oxygen species (ROS) — unstable molecules that remove electrons from other molecules, causing damage

Sarcopenia — the loss of muscle tissue as a part of the ageing process

In recent decades, human lifespans in developed countries have improved dramatically. However, 'healthspans' – the time over which we are healthy and active – have not increased in the same way. Many aspects of age-related decline remain unaddressed, including the loss of muscle mass and function known as sarcopenia. "Muscle mass and function are critical for mobility, independence and therefore quality of life in older people," says Dr Bumsoo Ahn from Wake Forest University School of Medicine. "Although several compounds for addressing sarcopenia are being evaluated in clinical trials, none have yet translated into effective, widely-used therapies."

To date, the only effective method for reducing sarcopenia is exercise; however, even the positive effects of exercise decrease as we reach old age. To address this issue, Bumsoo is investigating the biomolecular pathways that lead to sarcopenia – and whether there are opportunities to disrupt them. "The research in my lab aims to find ways to delay sarcopenia so that people can maintain a high-quality lifestyle for longer," he says.

Bumsoo's journey

Bumsoo grew up in South Korea (which has one of the world's highest life expectancies), where he spent much of his time playing sports. "Naturally, this made me curious about the human body, and I wondered why my heart would beat faster during exercise, or how training improved my performance," he says. "That curiosity sparked an early, though vague, dream of studying human physiology."

After graduating from university, Bumsoo spent three years working in industry. "Eventually, I realised how much I missed science and decided to return to academia, which ultimately set me on my current path," he says. "My postdoctoral mentor, Dr Holly Van Remmen, had a profound influence on my career in mitochondrial biology. Working in her lab, I experienced the excitement of scientific discoveries and gained the confidence and curiosity that continue to drive my research today. That curiosity has now turned into a deep desire to uncover how mitochondria support muscle health, and what happens when they fail."

Mitochondria: may cause side effects

Mitochondria provide our cells with energy via the process of respiration – but this activity is just the tip of the iceberg. "Mitochondria also play central roles in bioenergetics, redox regulation and calcium regulation," says Bumsoo. "They may have other roles too – experiments using isolated mitochondria only began in the 1950s, and we have a lot left to learn."

While mitochondria are essential, their hard work does have some unfortunate side effects. "As a by-product of respiration, mitochondria generate reactive oxygen species (ROS) which can cause oxidative modification in proteins, lipids and nucleic acids," says Bumsoo. ROS take electrons from other molecules, changing the structure and function of these molecules in the process. "The modified molecule then becomes an oxidant itself, which means the effect propagates," explains Bumsoo. "One ROS can lead to the disruption of countless other molecules." While ROS are important for cell signalling, these oxidative modifications are generally bad news, as the modified molecules become useless or even harmful. These disruptions can also damage our DNA, accelerating the ageing process.

> **"Our ultimate aim is to enhance the mobility and independence in older adults for as long as possible."**

Muscles are full of mitochondria which allow them to contract, which is an energetically demanding activity. But this high concentration of mitochondria also means a high concentration of ROS and, therefore, oxidative modifications. "The cellular machinery that enables muscles to contract can be inhibited by ROS," explains Bumsoo. "For example, an enzyme called myosin ATPase, which is essential to muscle contraction, becomes less active when modified by ROS." Actin – the protein that makes up muscle filaments – is also damaged and becomes less flexible.

The superhero hormone

However, Bumsoo is studying a molecular miracle-worker that may be able to rein in all this damage. "Ghrelin is a hormone produced in the stomach," says Bumsoo. "It is sometimes called the 'hunger hormone', but its functions go beyond just controlling our appetite." For example, a form of ghrelin called unacylated ghrelin appears to be linked to counteracting the loss of muscle mass and function. Bumsoo conducted experiments showing that unacylated ghrelin counteracted muscle degradation in old mice. It appeared to promote mitochondrial respiration – the process that generates ROS as a by-product – but also mitigated the production of ROS at the same time, leading to an overall positive effect. Ghrelin also appeared to have a protective effect in mice with cancer, slowing the rate of rapid muscle wasting.

From mice to humans

Ghrelin has been used in clinical trials, but so far only for its role in hunger control. "Prader-Willi Syndrome is a genetic disease that causes constant hunger, as well as other effects including weak muscles," says Bumsoo. "Patients with the disease who received daily injections of an unacylated ghrelin analogue had positive food-related behaviours without side effects." Though Prader-Willi Syndrome is very different from sarcopenia, the trial demonstrated that administering the hormone can produce positive results – so perhaps the same could be true for slowing age-related decline. "Our group is keenly interested in developing an unacylated ghrelin analogue that can be swallowed (rather than injected) for a longer-term study with a bigger sample size in the near future," says Bumsoo.

While ghrelin may prove to be an excellent tool for slowing the ageing process, it will need to work in tandem with other therapies. "My lab is investigating combining pharmacological strategies with exercise regimes to discover the most effective interventions," says Bumsoo. "Our ultimate aim is to enhance the mobility and independence in older adults for as long as possible."

About *mitochondrial biology*

Mitochondria are fascinating organelles: they have a huge range of functions, host complex molecular interactions and continue to present new questions. "Because mitochondria are central to nearly every aspect of human physiology, the field offers opportunities to make meaningful advances in medicine, ageing research and personalised health," says Bumsoo. "For young scientists, mitochondrial biology provides a vibrant and interdisciplinary career path that connects molecular mechanisms to real-world impact."

"Mitochondria have multiple roles that are all important for normal functioning and homeostasis," continues Bumsoo. "They are found in almost all of our cells, with the exception of red blood cells." Because mitochondria have many and varied roles, many researchers around the world are studying them, each with a unique research angle. "This leads to numerous collaborations, which I find rewarding," says Bumsoo. "My team and I get to learn about mitochondria in other organs and organisms – it could be in brain slices, blood cells or fruit flies."

These research efforts continue to yield new and surprising results, indicating a long and fruitful era of discovery ahead. Bumsoo also predicts that technological advancements will affect the future of the field. "Artificial intelligence, for instance, can accelerate the discovery of mitochondria-targeting drugs, as well as the analysis of imaging to assess incidences of disease," he says. "A new chapter for mitochondrial biology is just around the corner – it's a very exciting time."

Pathway from school to *mitochondrial biology*

Bumsoo recommends getting a strong foundation in biology, chemistry and physics during school. "These subjects provide the basic principles of energy, molecules and life processes," he says.

At college and university, Bumsoo suggests seeking courses or modules in biochemistry, cell biology, physiology and genetics. "Beyond undergraduate studies, further training in molecular biology, bioinformatics and data analysis is becoming increasingly important," he says. "Modern mitochondrial research relies heavily on genomic and proteomic tools."

If a more applied route appeals to you, biomedical engineering, pharmacology and exercise physiology provide opportunities to develop interventions to improve mitochondrial health.

"You can learn a great deal from hands-on experience, so I would highly recommend seeking opportunities for laboratory experience," says Bumsoo.

Download Bumsoo's resources from **futurumcareers.com/mitochondrial-biology-with-dr-bumsoo-ahn**

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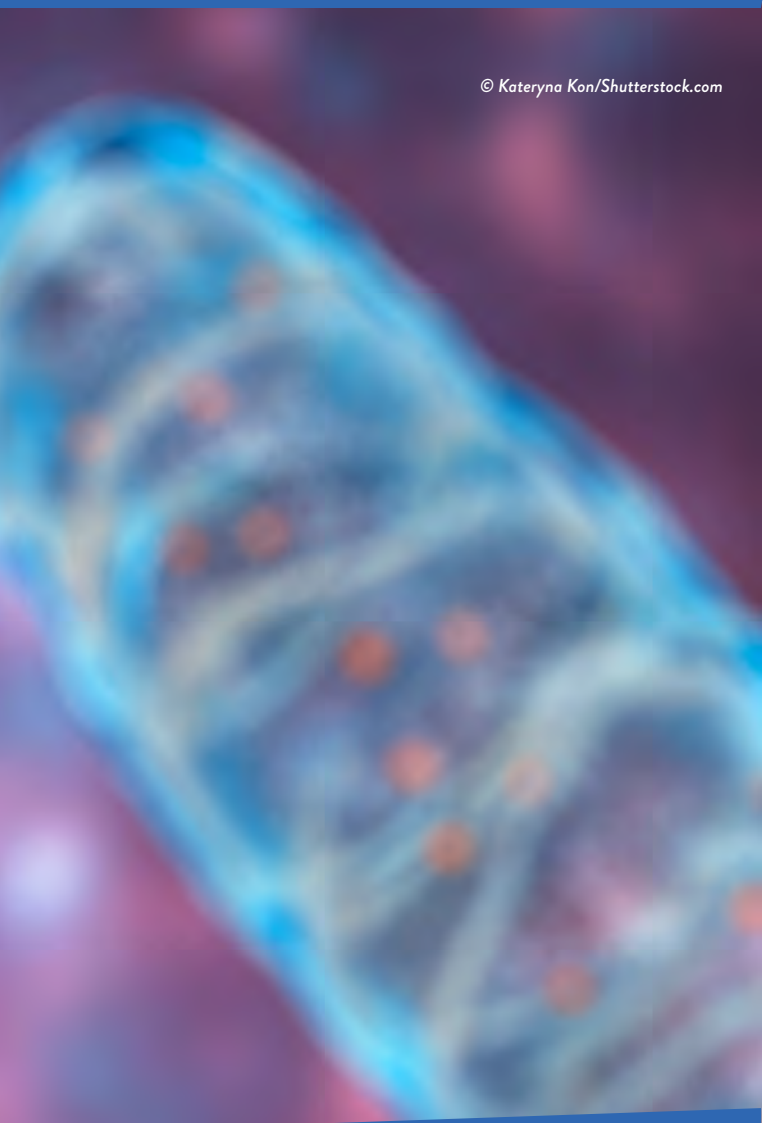

Explore careers in *mitochondrial biology*

Careers in mitochondrial biology fall into two broad camps: academia, which involves primary research, and biotechnology and pharmaceuticals, which involve translating academic discoveries into ways to improve mitochondrial function.

Bumsoo recommends keeping up to date with the latest research. "There is an excellent website that I often use to search for publications related to mitochondrial biology: **wiki.oroboros.at/index.php/O2k-Publications:_Topics**," he says.

Wake Forest University School of Medicine offers several summer programmes for high school students, including their LEAP Internship Program (**wakedowntown.wfu.edu/community/the-wake-forest-leap-program**), which provides STEM lab experience and mentorship, and the Summer Immersion Program (**immersion.summer.wfu.edu**), which provides a diverse range of experiences to help students discover their passions and goals.

Meet *Bumsoo*

During my mandatory army service in South Korea, I had to do parachute jumping as part of a Special Force team training. It was an involuntary and extremely scary experience at the time, but it has now become an interesting memory. Sometimes we don't see the benefits of our actions until later on.

My career is a bit different than most researchers' – I worked in the private sector prior to my academic career, and those three years were crucial for convincing me to pursue academia. You don't need to have your whole career planned out; sometimes, the only way to really know what you enjoy is through experience.

I like that science, at its best, is transparent and based on merit. In research, the data you generate becomes your own scientific credit, regardless of position or seniority. Graduate students and postdoctoral fellows are recognised as first authors for their research contributions. This system of open recognition creates a sense of fairness and accountability that I deeply appreciate.

I also enjoy the collaborative and global nature of science – travelling to conferences, sharing findings and learning from others around the world are privileges that make this career especially fulfilling.

I still exercise a lot, especially running, which helps clear my mind and makes me feel accomplished. I also like to play tennis with my son and chess with my daughter. And when we can, we all go to the mountains to hike as a family.

Bumsoo's *top tip*

Dive into whatever excites you right now. The experiences you gain by doing so will help you find the next step of your career.

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