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ISSUE 34

'Learning how to learn together'

WELCOME

Founded in 2010 by Dr Dan Rononiakewen (He Clears the Sky) Longboat and Dr Chris Furgal, TRACKS (TRent Aboriginal Cultural Knowledge and Science) Youth Program (p 04) in Canada teaches Indigenous and non-Indigenous young people the benefits of combining Indigenous Knowledge and Western science. We learn how the TRACKS ethos of 'learning how to learn together' provides young people with a fuller picture of the environment and a deeper understanding of our place in it.

And it's not only students who are learning to learn together.

Science on Stage Europe (p 36) is a vibrant network, supporting educators in their professional development and spreading inspiring teaching concepts across Europe. Chair Stefanie Schlunk tells us about the organisation's unique 'from teachers for teachers' approach and how investing in teachers is investing in the future.

Dr Alexandra Babino, Dr Mary Amanda Stewart and Dr Rocío Almanza agree it's important we all keep learning with and from each other. The team's article (p 68) highlights how approaching multilingualism in the classroom with openness and curiosity supports students in their learning and provides learning opportunities for teachers.

For adults and youngsters alike, some of the most powerful learning we experience is shared with others. Let's keep learning and growing together...

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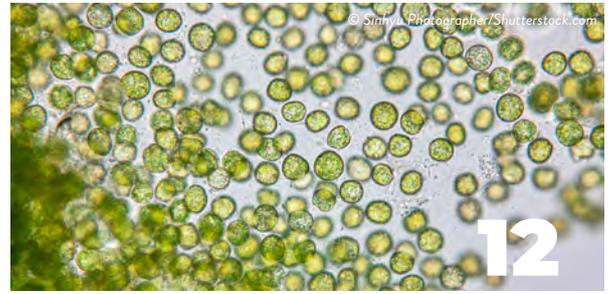
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**COVER
STORY**
TRACKS

04



Learning how to learn together

Looking at the world through a combined lens of Indigenous Knowledge and Western science provides a fuller picture of our environment and a deeper understanding of our place in it. **TRACKS (TRent Aboriginal Cultural Knowledge and Science) Youth Program**, Canada, leads land-based youth programmes that provide this invaluable Two-Eyed perspective.

TRACKS

Why was TRACKS formed?

TRACKS Youth Program was founded in 2010 by Dr Dan Roronhiakewen (He Clears the Sky) Longboat and Dr Chris Furgal.

Professors in the Indigenous Environmental Studies and Sciences (IESS) programme at Trent University, Dan and Chris recognised that many undergraduate students arrived with a perception of barriers between Indigenous and Western science knowledge systems. Many of their Indigenous students did not see mathematics and science as a way of knowing that was accessible to them or as a way to create credible and valuable knowledge of the natural world. Equally,

many of their non-Indigenous students did not see Indigenous Knowledge as a valid and credible way of understanding the environment around them. Dan and Chris realised that these beliefs, which limited their students' learning, were formed long before students arrived at university. To show young people how knowledges can work together and how much more we can know if we 'learn how to learn together', Dan and Chris knew they needed to reach out to both Indigenous and non-Indigenous youth at an earlier age. And so, TRACKS was formed.

TRACKS promotes a deeper understanding of and appreciation for Indigenous environmental knowledges and Western

science, and how they can work together to enrich environmental education. TRACKS was created to take the 'learning how to learn together' approach, which is at the core of the IESS programme at Trent, to both Indigenous and non-Indigenous youth in elementary, middle and high schools. The aim is to introduce more Indigenous youth to STEM fields and skills, while introducing more non-Indigenous youth to Indigenous ways of knowing and showing them the value and credibility of these knowledges.

How does TRACKS enable young people to engage with multiple worldviews?

One way is by including vocabulary from local Indigenous languages (mainly Anishinaabemowin/Ojibwe) in workshop activities. By teaching young participants a word, what it means and how it translates to English, they are exposed to the Indigenous perspective embedded in that language.

Depending on the young person, it might be the first time they hear an Indigenous language, and they can be overwhelmed or think that it sounds funny. The TRACKS team lead programmes with an emphasis on the importance of young people respecting themselves and others, introducing language through games and activities to ease them into it.



© TRACKS

How does TRACKS demonstrate the interweaving of Indigenous Knowledge and Western science?

At the beginning of every programme, the team explains Elder Marshall's concept of Two-Eyed Seeing. Participants are asked to cover one of their eyes and take a look around; then they are asked to switch eyes and notice what they see this time; finally, they are asked to open both eyes and notice their surroundings. The programme leader explains how one eye could be used to see through Indigenous Knowledge and the other through Western science. Using both eyes at the same time provides a broader picture of what surrounds us; if there is a problem to be solved, it is always better to have more tools in the toolbox to tackle the problem.

The team then provides tangible examples of Indigenous Knowledge and Western science working together. From the engineering and thermodynamics behind a tipi, to how snowshoes work, their origin and the materials used.

What do TRACKS school programmes involve?

TRACKS school programmes are for kindergarten to high school students, with activities designed specifically for certain grades. The workshops provide fun, experiential learning experiences that take students beyond the curriculum. From coding robots to solving a maze, to building a

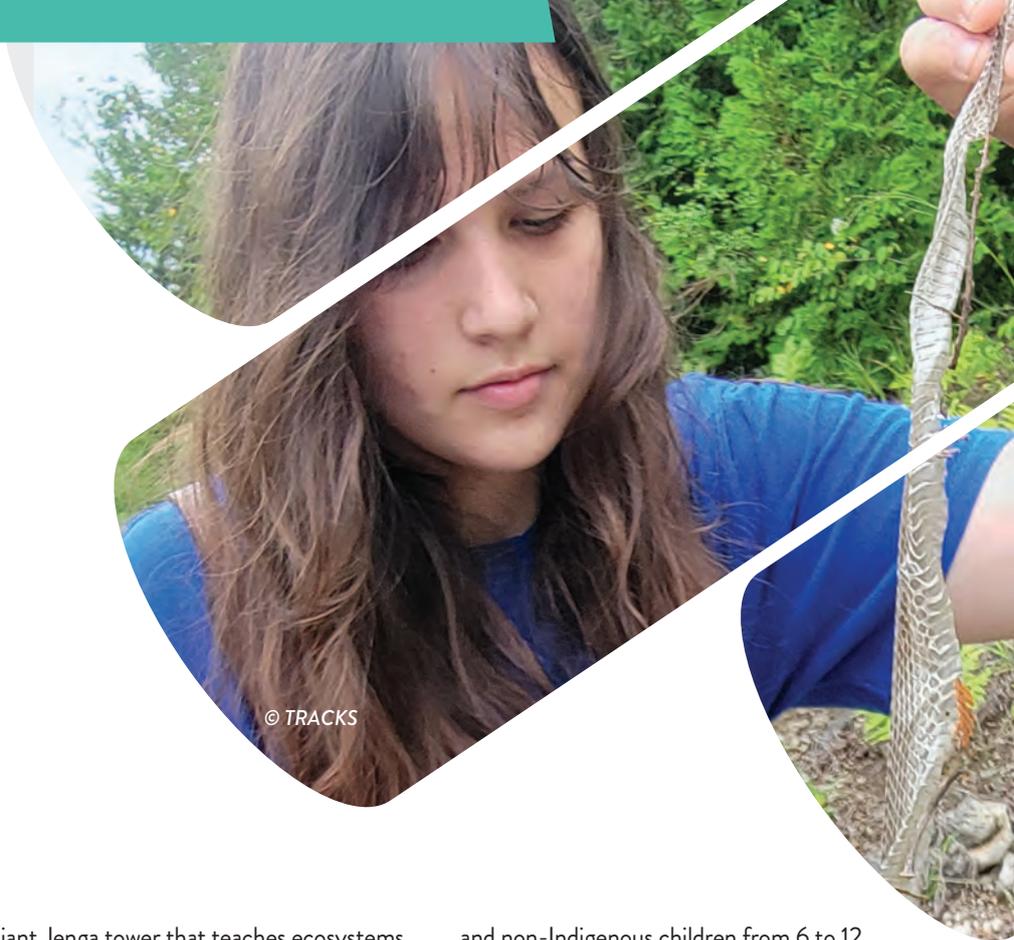
giant Jenga tower that teaches ecosystems, there is a workshop to suit any age group.

Indigenous Knowledge and perspectives belong in all areas of the classroom, not just in traditional social studies lessons. TRACKS offers a unique opportunity to incorporate Indigenous Knowledge into the STEM curriculum, enriching students' learning experiences.

Who are the camp programmes aimed at?

TRACKS offers professional activity days and one-week camps for Indigenous

and non-Indigenous children from 6 to 12 years old in Nogojiwanong (Peterborough, Ontario). Each summer, TRACKS partners with local First Nations – Curve Lake, Hiawatha, Alderville and Mississauga's of Scugog Island – to offer one-week, no-charge summer camps for Indigenous youth from those communities. The topics are driven by the distinct traditional and scientific knowledges of TRACKS staff and guest Elders and Knowledge Holders, but may touch on themes like ecosystems, DNA, animals and coding, as well as traditional teachings of Shkode (Fire), Nibi (Water) and Mashkikiwan (Medicines). →



“

TRACKS promotes a deeper understanding of and appreciation for Indigenous environmental knowledges and Western science, and how they can work together to enrich environmental education.

”



“

... TRACKS provides engagement, learning, growth, training and environmental reconciliation opportunities for both Indigenous and non-Indigenous youth ...

”



© TRACKS

What do young people gain from their TRACKS camp experience?

The camps provide fun and engaging opportunities to explore science in a different way to how it is typically experienced in the classroom. For non-Indigenous youth, this is important as it encourages relationship-building across cultures, recognises the traditional knowledges mainstream education is based on and promotes community reconciliation. TRACKS helps Indigenous youth see their own cultures and knowledge systems represented in STEM fields. The programming also encourages Indigenous youth to see that Indigenous cultural land-based knowledge is science.

What is the Trailblazer Summer Employment programme?

The team engages with Indigenous youth in Nogojiwanong (Peterborough) and local First Nations through workshops and community events. During the summer, TRACKS offers part-time employment for Indigenous youth, between the ages of 14 and 18, known as Trailblazers.

In July, Trailblazers receive training and comprehensive teachings and mentorship from TRACKS staff and local Indigenous Elders and Knowledge Holders in themes such as the Seven Grandfather Teachings (a set of guiding principles for leading a good life). Then, in August, the Trailblazers coordinate and lead a series of on-the-land learning days, known as Land Camps, for up to 20 Indigenous youth in the community.

Land Camps represent an opportunity for the Trailblazers to put their leadership, cultural knowledge and traditional skills into practice by leading a group of their peers through land-based learning activities and

facilitating teachings with a Knowledge Holder. Another great aspect of this opportunity is that Trailblazers are eligible for a high school course credit in leadership and peer support through the Ontario Ministry of Education, via TRACKS' network membership with Actua. This allows Trailblazers to further their traditional knowledge and take steps towards being leaders in their communities.

Why is it important for TRACKS to offer programmes related to employment?

TRACKS is centred on Indigenous ways of knowing and being, which involves giving young people a community of support to help them discover and share their unique identity and gifts as they transition to adulthood. Connecting Indigenous youth with Elders, Knowledge Holders and Indigenous staff creates a welcoming space, where youth can be themselves, while learning employability skills. This is especially important as many other employment spaces are not curated to their knowledges and experiences, and youth may not always feel safe or accepted there.

How do Indigenous Elders and Knowledge Holders support young people through TRACKS?

They support youth directly through invitations to share knowledge and teachings during training for young staff and workshops with summer camps and school groups. The support is also provided indirectly through Elder and Knowledge Holder participation in the TRACKS Advisory Circle, which provides strategic direction and guidance to the organisation.

What impact is TRACKS having?

TRACKS provides an outlet for Indigenous youth to be immersed in other ways of

knowing and thinking, where the authority of Indigenous Knowledge is valued and coupled with science and technology, leading to innovative problem solving for environmental issues facing our world.

In 2024 alone, TRACKS engaged with over 3,500 youth through its workshops, camps and community events, showing how Indigenous Knowledge and Western science can work together. It also trained over 400 teachers on the importance of bringing Indigenous Knowledge into the classroom.

A key success of the TRACKS programme has been its development, maintenance and continuity of strong relationships with local First Nations, Trent University and key community partners. Its success in adapting to the challenges faced during the COVID-19 pandemic and the programme's pivot to providing innovative and unique online learning opportunities for youth is something the TRACKS team is very proud of.

Now, in its 15th year of operation, TRACKS provides engagement, learning, growth, training and environmental reconciliation opportunities for both Indigenous and non-Indigenous youth throughout the region. While TRACKS has received national and international awards, the longevity of the organisation and its ability to continue to add value to the community environmental education landscape in Ontario is its greatest success.

TRACKS is most proud of the number of new youth, educators and other learners who have been introduced to the value of respecting and learning from other ways of knowing and who have embraced 'learning how to learn together'.

Meet the TRACKS team

Field of research

InSTEAM (Indigenous Science, Technology, Engineering, Art and Math)



Dan Roronhiakewen
(He Clears the Sky)
Longboat

Steering Team Member,
TRACKS co-founder



Chris Furgal

Steering Team Member,
TRACKS co-founder



Rachel Gilham

TRACKS Co-Manager,
School Programs



Mon Escobedo

TRACKS Co-Manager,
Development &
Evaluation

What does the future hold for TRACKS Youth Program?

TRACKS is looking to the future with aims of growth and expansion. It will be developing its relationships with schools, expanding its camps and on-the-land learning opportunities it offers and filling in the 'gaps' in the age groups it reaches. It will expand the physical space for housing programmes and focus on staff pathways, enabling campers to become instructors. Ambitious and always forward-thinking, TRACKS will also be spreading its unique educational model beyond Ontario!

Collaborators

Boodweh Centre for Indigenous Knowledges & Languages (Trent University); Kawartha World Issues Centre; Trent School of Education; Camp Kawartha and the Kawartha Outdoor Education Centre; First People's House of Learning (Trent University); GreenUp; New Canadian Centre

Funders

Actua; National Sciences and Engineering Research Council of Canada (NSERC); United Way Peterborough; TELUS & TELUS Friendly Future Foundation, The Community Foundation of Greater Peterborough; The Peterborough K. M. Hunter Charitable Foundation; TD Friends of the Environment Foundation; Kagita Mikam Aboriginal Employment and Training

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A network member of **actua**



How can conservation agriculture improve the climate resilience of women farmers?



Women who farm on small plots of land to produce food and income for their families are particularly vulnerable to the impacts of climate change. An interdisciplinary team of researchers from Brazil, Canada, Nigeria and the UK is working with smallholder women farmers in Brazil and Nigeria to promote sustainable agricultural practices that will improve their climate resilience.

Institutions

Federal University of Paraná, Federal University of Sao Carlos (Brazil); MacEwan University, Toronto Metropolitan University, York University (Canada); Babcock University, National Root Crops Research Institute, Pan-Atlantic University, University of Abuja (Nigeria); King's College London, University of Kent, University of Surrey (UK)

Fields of research

Agriculture, agroecology, business administration, human resource management, psychology, social sciences

Research project

Promoting conservation agriculture to help smallholder women farmers adapt to climate change

Funders

New Frontiers in Research Fund (NFRF, Canada); UK Research and Innovation (UKRI); Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, Brazil)

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Extrême weather events caused by climate change, such as droughts and floods, are having devastating consequences for agriculture. Smallholder farmers are particularly vulnerable to the impacts of climate change, as they typically have limited access to funds, technology, tools and weather-related information. Women farmers are disproportionately affected as cultural norms are likely to restrict their access to land, tools and training.

Talk like an ...

agricultural researcher

Climate resilience — the ability to respond and adapt to the impacts of climate change

Conservation agriculture — a sustainable approach to farming based on the principles of keeping soil covered, minimal soil disturbance and crop rotation

Food security — the continuous state of having reliable access to enough affordable, healthy food

No-till farming — a method of growing crops that minimises soil disturbance

Participatory approach — a research method in which the subjects of the research participate in the research process

Smallholder farmer — a farmer who grows food and/or raises livestock on a small piece of land for their own subsistence and to generate income

Topsoil — the uppermost layer of soil which contains organic matter and nutrients essential for plant growth

In low- and middle-income countries (LMICs), smallholder women farmers play a vital role in providing food security and an income for their families. However, in these countries, women often have lower socioeconomic status and face sexism and other barriers that may limit their opportunities to reach their potential as farmers. “Smallholder women farmers are also often excluded from policy decisions, making it harder for them to adapt to and recover from climate impacts,” says Dr Kelly McShane from Toronto Metropolitan University.

Kelly is leading an interdisciplinary team of researchers from Brazil, Canada, Nigeria and the UK, along with smallholder women farmers and other stakeholders in Brazil and Nigeria, to promote conservation agriculture practices as a method to improve smallholder women farmers’ climate resilience in LMICs.

Conservation agriculture is a sustainable way of farming that boosts productivity and reduces environmental damage by protecting soil and conserving water. “It is based on three key principles: minimising soil disturbance (for example,

Download the team's resources from futurumcareers.com/how-can-conservation-agriculture-improve-the-climate-resilience-of-women-farmers



A smallholder woman farmer grows vegetables on a small plot of land in Barra do Turvo, Brazil. © Laura Martins Carvalho

by using no-till farming), keeping the soil covered (with crops or mulch), and rotating different crops to keep the soil healthy,” explains Dr Gustavo Fonseca de Almeida from the Federal University of Sao Carlos. “These practices are critical for preventing soil erosion, the loss of valuable topsoil, and the release of stored carbon into the atmosphere.”

An equal approach

The team is taking a participatory approach to this project, which means that smallholder women farmers are equal partners in the research process, helping to shape the research questions, collect and interpret the data, and design practical solutions. “This approach empowers smallholder women farmers to voice their needs, promotes knowledge co-production, and ensures that policy recommendations are grounded in real-world experience and lead to practical, long-lasting change,” says Ayesha Tabassum from York University.

So far, the team has been interviewing smallholder women farmers, policymakers and business leaders in Brazil and Nigeria to learn about the farmers’ lived experiences and understand what socioeconomic and climate-related challenges they face. “In our meetings, we discuss what conservation agriculture practices the farmers use,” says Dr Valerie Babatope from Toronto Metropolitan University. “We also ask what training they would find useful to learn new farming methods that could improve soil health, water efficiency and energy conservation.”

The team is investigating what barriers prevent women smallholder farmers from implementing conservation agriculture practices and, in partnership with the farmers themselves, developing training programmes

to teach farmers environmentally friendly techniques to improve their land and yields.

An interdisciplinary project

Part of what makes this work so unique is that the members of the research team all come from different disciplinary backgrounds, meaning they bring a variety of skills and expertise to the project.

As a clinical psychologist, Kelly understands the interpersonal and systemic issues affecting women farmers, and uses her data analysis skills to refine the team’s results. “My background has trained me to ask questions about norms and structures within families, communities and organisations that might facilitate change and increase the rate of adoption of conservation agriculture,” she says.

Gustavo is an agroecologist who evaluates conservation agriculture practices. “Agroecology provides the scientific base for the ecological principles applied to farming and food systems,” he says. His background allows him to collaborate with social scientists to design surveys to understand farmers’ lived experiences, with economists to assess the cost-benefit trade-offs of different agricultural practices, with engineers to develop low-cost tools for conservation agriculture, and with policymakers to discuss how conservation agriculture aligns with national goals.

“My background in human resource management enables me to bring an equity-focused approach to this project,” says Ayesha, who focuses on the people at the heart of the project and understands the structural inequalities limiting smallholder women farmers. She is developing training activities and resources that prioritise inclusion, such as visual aids so that women with low literacy

can participate. She is also helping to develop a peer-learning network where experienced farmers mentor newer farmers and keep field diaries to pass on their knowledge.

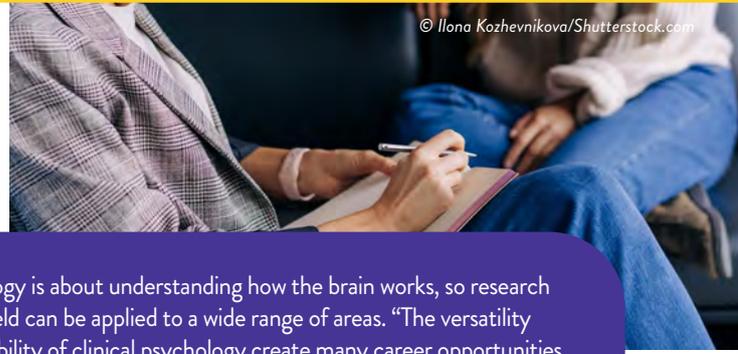
“My expertise in business administration informs our strategies to enhance smallholder women farmers’ adaptive capacities,” says Valerie. “My research on mentorship and empowerment helps us to build sustainable peer-support networks.” Her knowledge helps the team consider a business angle so that projects to train women farmers in conservation agriculture techniques are economically viable as well as environmentally sustainable.

A hopeful future

“We know that conservation agriculture increases climate resilience, as it improves soil health and reduces water consumption,” says Kelly. “So, our goal is to educate smallholder women farmers about conservation agriculture and provide funding for them to adopt sustainable practices.” The team aims to empower smallholder women farmers in Brazil and Nigeria by developing their skills, followed by a pilot funding initiative giving them financial resources to invest in the technologies they learn about during their training.

Not only will this project improve the lives of the Brazilian and Nigerian farmers involved in the project, but the team will also ensure that smallholder women farmers’ voices are heard during policy discussions on proposals to support vulnerable farmers in other regions. In this way, the team hopes to influence policy changes so that smallholder women farmers in LMICs around the world will be better able to adapt to the challenges of climate change.

About *clinical psychology*



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While clinical psychology is often associated with treating patients with mental health conditions, it can also involve working with communities and businesses. “The past 20 years have seen a growth in ‘positive psychology’, which offers guidance for everyone as they pursue growth, change and personal development,” says Kelly. “For example, I often work with employees and leaders to examine the processes and procedures that are impacting individuals’ abilities to thrive and flourish in the workplace.”

Psychology is about understanding how the brain works, so research in this field can be applied to a wide range of areas. “The versatility and flexibility of clinical psychology create many career opportunities for anyone with an entrepreneurial mindset,” adds Kelly.



Meet *Kelly*

As a teenager, I was in the Girl Guides of Canada, a community organisation for girls to focus on empowerment, community and the outdoors. I lived for summer camp – to be outdoors in nature with friends! My time with the Girl Guides inspired my focus on supporting communities and services.

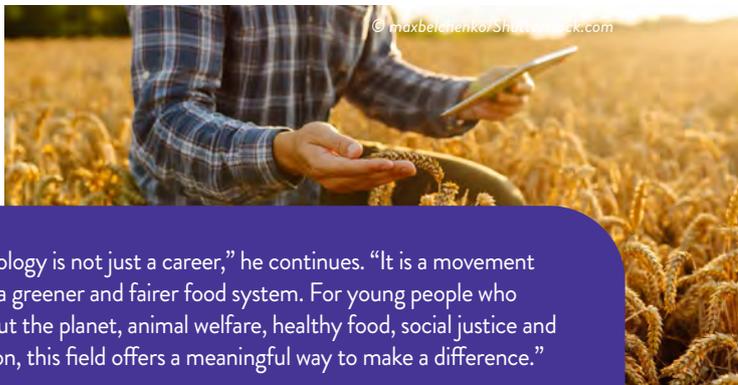
I went to university believing I would become a teacher, having been inspired by many of my schoolteachers. However, when I took a psychology course, I was fortunate to be selected for a research position which really shaped my interest in psychology.

My interest in psychology and passion for service led me to community-based research. For my PhD, I conducted a participatory research project about health promotion with an Inuit community in

Ottawa, Canada. This involved developing a collaborative partnership based on mutual respect in order to support the community to achieve its goals – which remains a core approach in my work today.

As a social scientist in our conservation agriculture project, I can identify the factors that need to be measured and find the right tools for the job. This often requires a balance between what is scientifically rigorous and what is practically feasible for the community context.

About *agroecology*



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Agroecology is an interdisciplinary science that applies ecological principles to farming. It involves sustainable agriculture, environmental conservation and social justice, and often combines Indigenous knowledge with scientific research to design and manage sustainable farming systems. “Agroecology aims to reduce reliance on chemical fertilisers and pesticides, while promoting soil health, biodiversity and carbon sequestration,” says Gustavo.

“Agroecology is not just a career,” he continues. “It is a movement towards a greener and fairer food system. For young people who care about the planet, animal welfare, healthy food, social justice and innovation, this field offers a meaningful way to make a difference.”

To get started, gain hands-on experience working with plants and animals by volunteering at a farm, community garden or conservation project.



Meet *Gustavo*

When I was a teenager, I was passionate about playing sports and being around farm animals. When I realised that a career in soccer or basketball was unrealistic, I looked for options to work with animals.

I studied animal science at university, then moved to Australia for a training

programme and to learn English. I studied the Australian breeding programmes for livestock production, with the aim of applying that knowledge when I returned to Brazil. When I returned, I worked as a marketer for a genetic improvement software company to develop the pork industry in Brazil. However, when I visited industrial pig farms, I was shocked by what I saw and how the animals were treated in cages. As someone with a passion for animals, I decided I could not support the industrial way of farming that I had seen.

I went back to university to study a master’s in agroecology, then completed a PhD in Denmark investigating organic animal production systems. I found that it is possible to farm animals with high welfare standards and while respecting their natural behaviour. So, I returned to Brazil to advise farmers on alternative systems that produce food while respecting animals and nature.

About *business administration*



Business administration is the study of how businesses can best manage tasks, procedures and resources. It is a diverse field that covers everything about running a business, such as handling finances, recruiting the right candidates, implementing good leadership and peer-support, and setting company goals. Working in business administration can directly impact organisational and societal well-being, as it helps address real-world challenges and improves the working conditions of many people's lives.

"Young people should pursue business administration because it offers unparalleled versatility," says Valerie. "You will gain skills in analytics, strategy and human capital management, which are vital to every industry. From launching start-ups to driving sustainability in global corporations, business administration empowers you to innovate and solve pressing challenges."



Meet *Valerie*

I have always had a passion for supporting social impact and systemic change for women's voices to be heard. This has inspired my focus on social entrepreneurship and organisational mentorship. Witnessing Nigerian entrepreneurship influenced me to study business administration in Nigeria and the UK, as I had a desire to understand

organisational dynamics that drive economic and social progress.

In 2019, I founded my own start-up – a gourmet shawarma business in Lagos, Nigeria. More recently, I have served as a human resources consultant for the Canadian start-up, Fairly AI. These experiences have cemented my belief in business as a tool for empowerment, and I now integrate these principles into our project investigating climate resilience for women farmers.

With this project, I most enjoy the opportunity to directly empower marginalised women through actionable research, aligning with my lifelong commitment to gender equity and community development. Collaborating with experts across environmental science, policy and grassroots agriculture to co-create solutions that merge business acumen with ecological stewardship has been deeply rewarding.

About *human resource management*



Human resource management (HRM) combines ideas from psychology, business and economics to manage employees and run businesses in positive and sustainable ways. "HRM is a field where you can directly influence the quality of people's work lives, from hiring and development to well-being and growth," says Ayesha. "I find it extremely rewarding to design systems that help people reach their potential, create fair and inclusive workplaces,

and build cultures where people feel valued and supported."

HRM is shaped by changes in technology, social movements and economic trends. For example, recent developments in artificial intelligence and shifts towards remote and hybrid working are creating opportunities for future HRM specialists to champion employee wellness and sustainable business development.



Meet *Ayesha*

As a teenager, I loved reading, drawing and crafting, which shaped the way I approach my work today. Reading gave me the critical thinking skills required for investigating human-centred problems, while art and crafting taught me creativity and mindfulness.

My inspiration to study HRM came from a deep interest in understanding how people function within organisations. I realised that organisations fail to attract top talents as they lack insights on complex human behaviour. This sparked my interest in HRM as a function that acts at the intersection of human behaviour, business strategy and economic sustainability.

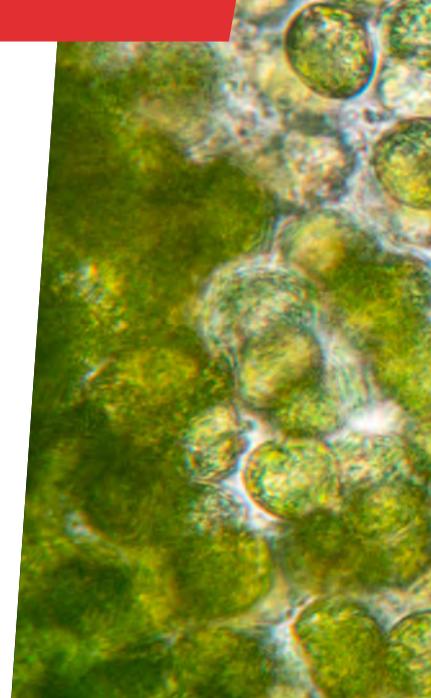
I studied HRM at university in Bangladesh, before pursuing postgraduate studies in Canada. My academic and cultural journey

from Bangladesh to Canada has enriched me with the global insight and local sensitivity that are needed for our project on enhancing climate resilience.

I enjoy the fact that this project allows me to apply HRM beyond organisational settings to directly empower women and transform their lives. I take pride in implementing people-centred strategies for women who are often underrepresented in agricultural decision-making.

Tackling climate change with gas-guzzling microbes

Climate change, and its catastrophic effects on the world, are gathering pace. Even if we completely stopped emitting greenhouse gases tomorrow, the world would continue warming. As such, there is a critical need to remove carbon dioxide and other greenhouse gases from the atmosphere – and some very special microbes might hold the key. **Professor Esteban Marcellin** from the **University of Queensland** and **Professor Chris Greening** and **Dr Leonie van 't Hag** from **Monash University** in Australia work together at the **RECARB Hub**, where they are using microbes to convert gases into protein through the process of bioconversion.



Professor Esteban Marcellin

Fields of research: Bioconversion, synthetic biology

The University of Queensland, Australia



Professor Chris Greening

Fields of research: Bioconversion, microbiology, biochemistry



Dr Leonie van 't Hag

Fields of research: Bioconversion, sustainable processing, biomaterials

Monash University, Australia

Research project

Using specialised microbes to transform gases into useful proteins via bioconversion

Funders

Australian Research Council (ARC); industry partners

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Talk like a ...

bioconversion researcher

Bioconversion — using biological processes or agents to convert materials into useful products or energy sources

Biotechnology — the application of science and technology to living organisms

Gas fermentation — the conversion of gases into valuable products by microbes

Greenhouse gas — a gas that contributes to global warming and therefore climate change

Microbe — a microorganism such as a bacterium

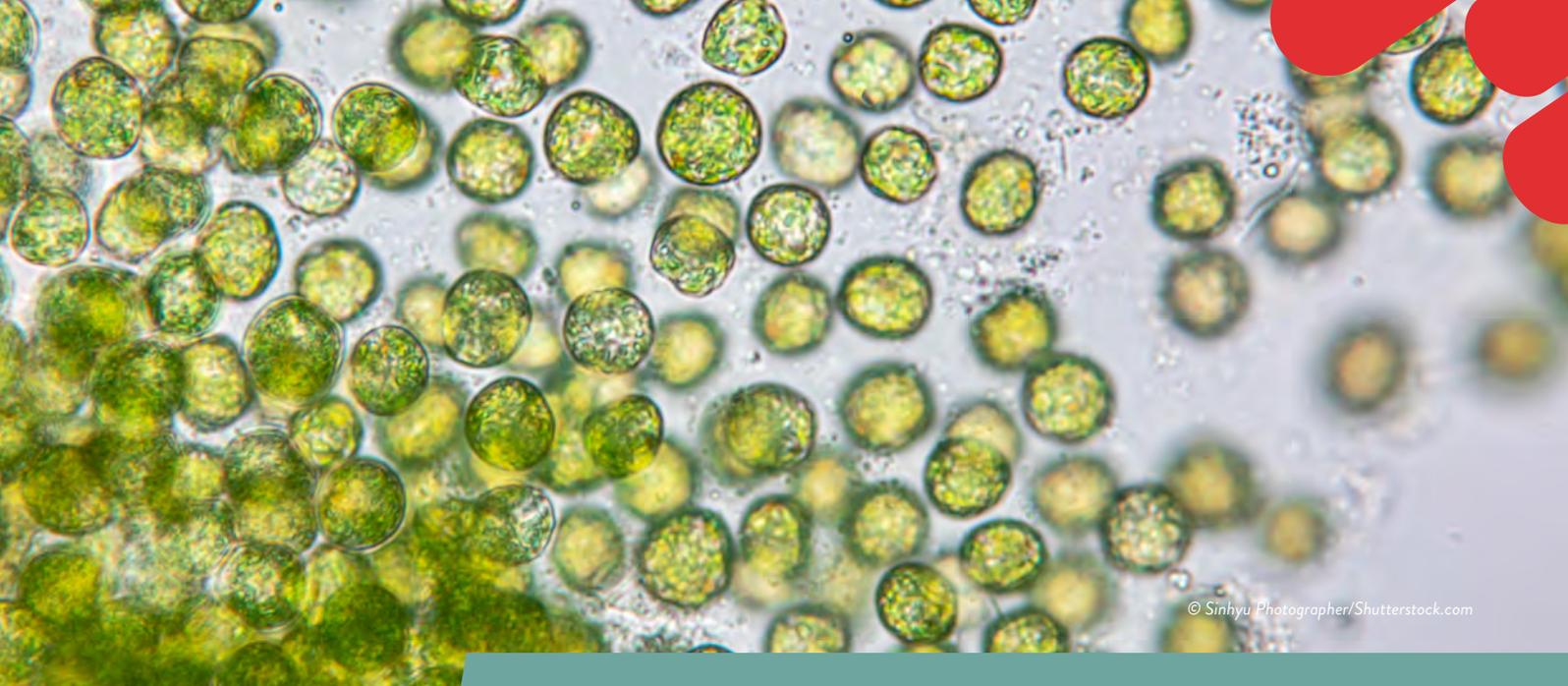
Synthetic biology — using bioengineering techniques to redesign organisms for useful purposes

The release of greenhouse gases from human activities, such as fossil fuel combustion and agriculture, is rapidly warming the planet and contributing to catastrophic and accelerating climate change. Around the world, many research projects are attempting to prevent the emission of further greenhouse gases. However, this will not be sufficient to stop climate change. Even if we could stop all greenhouse gas emissions tomorrow, our planet would continue to warm due to the gases already in the atmosphere.

In light of this, many climate change mitigation projects now focus on removing greenhouse gases from the atmosphere. There are lots of ways to do this: from natural methods, such as

planting trees and mangrove forests, to industrial methods, such as direct air capture which aims to extract carbon dioxide from the air and utilise or store it out of harm's way. While many of these methods have potential, none are universally applicable, and there is a lot more work needed to find viable, scalable solutions.

The ARC Research Hub for Carbon Utilisation and Recycling (RECARB Hub) at Monash University is a collaborative research group that aims to develop technologies that transform carbon dioxide emissions into useful products. For example, Professor Esteban Marcellin from the University of Queensland and Professor Chris Greening and Dr Leonie van 't Hag from Monash University are using



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bioengineered microbes to convert carbon dioxide emissions into products such as animal feed and plastic replacements through a process known as bioconversion.

Introducing the air eaters

“My group’s biggest discovery is that microbes can literally live on air,” says Chris. “When starved for their preferred organic foods, microbes can take up tiny amounts of gaseous energy sources from the atmosphere.” The team is investigating this phenomenon at every scale: from the enzymes that power the process, to the significance of these microbes within ecosystems. “Some ecosystems, like those on the Antarctic continent, are primarily powered by these microbes that use gas as an energy source,” explains Chris. “On top of this, these microbes remove around 350 million tonnes of greenhouse gas from the atmosphere every year, mitigating climate change and air pollution.”

The team wants to harness this natural process at scale by cultivating gas-eating microbes in bioreactors. “Through the process of gas fermentation, these microbes convert gases such as carbon dioxide, carbon monoxide, methane and hydrogen into useful products such as fuels, chemicals or proteins,” explains Esteban. “This approach reduces greenhouse gas emissions by capturing climate-active gases before they enter the atmosphere, removing emissions that have already been released and replacing fossil fuel-based production methods.”

Producing proteins

Using gas fermentation, it could be possible to reduce the negative impacts of agriculture on our climate. “For example,

“

By harnessing natural and engineered microbes, we can recycle waste gases into nutritious food, degradable bioplastics and future fuels.

”

as our microbes grow, they accumulate protein-rich biomass, which is known as ‘single-cell protein’,” says Esteban. “After harvesting and drying, this biomass can be used as a sustainable protein source for animal feed or even human food.” Unlike traditional food production methods, this technique does not require large amounts of land, soil or water.

Single-cell protein products are nothing new. Various meat substitute products are made from mycoprotein, a fungus grown in bioreactors. And, love them or loathe them, some breakfast spreads, such as Marmite and Vegemite, are made from recycled brewing yeast, while the bacterium *Spirulina* has become a staple of health food stores and smoothies. “Our method differs from others in that it uses waste gases as its primary input, rather than other nutrient sources,” explains Leonie. “This makes it an integrated approach. Not only does it reduce greenhouse gases in the atmosphere, but it also produces useful proteins with minimal energy and material inputs.” Other waste products, such as food

waste, also provide excellent feedstock for these bacteria. “Bacteria can convert the starch in food waste into proteins, plastics or biofuels,” says Leonie. “This diverts food waste from landfill, where it would degrade and act as a source of greenhouse gas.”

Synthetic biology and global challenges

Producing single-cell protein is not the team’s only aim. Esteban, Chris and Leonie are also using synthetic biology to create microbes that can convert greenhouse gases into products that would not be produced naturally. “By introducing new metabolic pathways, optimising gene expression and rewiring gene regulation, we can redirect microbes away from cell growth and towards the production of fuels or chemicals,” says Esteban. “This allows us to transform microbes into efficient cell factories that convert greenhouse gases into valuable commodities.” By providing fuels and chemicals that would normally be produced through the extraction or combustion of fossil fuels, the team is helping support both climate goals and industrial needs.

The work of the RECARB Hub addresses multiple societal challenges at once: climate change, food security and industrial demands. “Natural microbes are already removing millions of tonnes of greenhouse gases from the atmosphere every year, supporting ecosystem productivity and resilience,” says Chris. “By learning from and harnessing both natural and engineered microbes, we can create a circular system that recycles waste gases into nutritious food, degradable bioplastics and future fuels.”

About *bioconversion*

Bioconversion involves using biological processes to transform matter into useful products or energy sources. “Bioconversion is exciting because it offers real solutions to climate change and resource scarcity,” says Esteban. “We can transform waste streams and greenhouse gases into food, fuels and materials, creating sustainable alternatives to fossil fuels and agriculture.”

The science of bioconversion brings together expertise from many different disciplines. “Our

work is highly collaborative, with people from different scientific and cultural backgrounds working closely together,” says Leonie. “At the RECARB Hub, our team includes microbiologists like Chris, biotechnologists like Esteban, chemical engineers like myself, materials scientists and chemists.” The team has found that a multidisciplinary approach provides a diversity of thought and solutions, which is essential for dealing with the large-scale challenges faced by society.

Bioconversion is likely to play an increasingly significant role in our future. The RECARB Hub and other research collaborations around the world are opening pathways for new bioconversion applications, including cleaning our atmosphere, putting food on our tables, powering our cities – the list goes on. This means there are likely to be more and more opportunities for exciting careers in the sector.

Pathway from school to *bioconversion*

Leonie recommends building a strong foundation in biology, physics, mathematics and chemistry at school.

At university, degrees in biomedicine, bioengineering, biology, chemistry, biochemistry and microbiology can all lead to a career in the field.

Reach out to researchers at a university near you to see if there are any internships or work experience opportunities in their departments. This is a great way to gain hands-on experience and practical skills.

Explore careers in *bioconversion*

Beyond academia, Leonie notes that there are many bioconversion careers in the food industry, the pharmaceutical industry and renewable energy production.

To learn more about microbes and their applications, Chris recommends exploring the growing selection of learning resources of the International Microbiology Literacy Initiative: imili.org

Download the team’s resources from futurumcareers.com/tackling-climate-change-with-gas-guzzling-microbes





Meet Esteban

I grew up in Mexico, a place full of colour, culture and biodiversity. As a child, I was fascinated by the natural world and the resourcefulness of people with limited means. This environment nurtured my curiosity for science and showed me the value of innovation.

My work is driven by my curiosity and a genuine love for discovery. I enjoy

collaborating with people from different backgrounds and have learnt to be resilient; science doesn't often work the first time! I also care deeply about sustainability, which guides my motivation.

The RECARB Hub brings together world-class expertise to tackle some of society's greatest challenges. Climate change is an urgent problem, so having the chance to combine fundamental science with industry is amazing.

Synthetic biology is endlessly creative. It allows us to redesign microbes and imagine new ways to solve big problems. I love how it blends science and engineering with imagination.

Outside of work, spending time with my family helps me disconnect and recharge.

I enjoy playing soccer with my son, being outdoors and cooking at home. These simple activities keep me grounded and give me balance.

Esteban's top tip

Collaboration is critical; working with others opens opportunities and makes the journey more rewarding.



Meet Chris

As a teenager, I never imagined becoming a scientist. I came from a difficult home and had zero self-esteem. I was more interested in the arts than science, but I took a science degree because I thought the job prospects were better. It wasn't until my PhD that I realised how creative science really is.

Meeting my mentor was a big turning point. Professor Greg Cook believed in me before I believed in myself; he helped me see my

strengths and showed me that science is about discovery and using knowledge to make a difference. I still remember the thrill of my first discoveries.

I thrive on variety. With the support of an amazing team, I'm constantly working across different research areas. I love connecting with people and fields in unexpected ways, and I try to pass on what my mentor did for me: finding talented people from less privileged backgrounds and helping them grow into future leaders.

The RECARB Hub is a partnership between academia and industry. This enables us to use these gas-munching microbes for practical solutions – a direct path for turning scientific innovations into real-world impact.

I don't work long hours, but when I'm on, I'm on. Outside of work, I'm normally found outdoors, hiking, cycling, travelling or being walked by my dogs. Indoors, I love watching films and escaping to fantasy worlds through Japanese video games. A mix of hobbies and an effective work-life balance helps me cope, and often thrive, with ADHD.

Chris's top tip

Focus on honing your strengths and don't compare yourself to others. Try to believe in yourself, and if that feels hard, seek mentors who can help you get there.



Meet Leonie

In high school, I was mostly interested in chemistry and physics. Outside of the classroom, I was engaged in music and dancing. I think the combination of scientific and creative interests helps make innovative links in my work.

I studied molecular life sciences in the Netherlands. Since then, I've had the opportunity to work in Switzerland and Australia. These decisions felt like big leaps at

the time, but I'm grateful I took them – they made me who I am today!

I am highly determined and passionate about nurturing a positive team environment. I aim to empower my team members to be the best versions of themselves and to help each other out. The RECARB Hub enables a collaborative and interdisciplinary team environment, reaching far beyond what we can do in our individual labs.

All of my work focuses on contributing to the United Nations Sustainable Development Goals. By aiming for goals, such as zero hunger and responsible consumption, through working with communities and industry stakeholders, we

can create a positive impact. I try to bridge the gap between new developments in the sector and educating new talent.

To reset, I love rowing, yoga, hiking and biking – anything out in nature! My passion for the natural world is my driving force for working in the area of sustainable processing.

Leonie's top tip

Be curious about the world around you and how you can use curiosity to create new solutions that contribute to mitigating climate change and protecting nature for current and future generations.

What can biostatistics teach us about dolphin culture and communication?



Dolphins are known for their intelligence, but do they also have their own culture? **Dr Ann Weaver**, an ethologist and biostatistician at **Good-Natured Statistics Consulting** and a **National Oceanic and Atmospheric Administration (NOAA)** consultant in the US, has spent over 20 years studying wild bottlenose dolphins. By combining animal behaviour science with statistical tools, Ann has gained cultural insights into dolphin communication and self-expression, along with first-time details of dolphin healing without medical intervention.



Dr Ann Weaver

Good-Natured Statistics Consulting, Florida, USA

Fields of research

Biostatistics, bottlenose dolphin behaviour

Research project

Using biostatistics to study bottlenose dolphin behaviour, communication and conservation. Ann seeks remote and in-person opportunities to teach animal and dolphin behaviour

Websites

dolphinsdigital.org
goodnaturedstatistics.com

doi: 10.33424/FUTURUM626

Talk like a ... **biostatistician**

Anthropological methods — research techniques used to study human and animal behaviour, involving long-term, immersive observation to understand a culture or social group

Biostatistics — applying mathematical computation in biological research to distinguish reality from chance, helping scientists interpret complex data and draw reliable conclusions

Dorsal fin — the fin located on the back of a dolphin (and many other aquatic animals), often used by researchers to

identify individuals based on its unique shape and markings

Ethologist — a scientist who studies animal behaviour, particularly in the species' natural environments

Fieldwork — research conducted in an animal's natural environment, outside of a lab setting or captivity

Grass-wearing — a behaviour observed in dolphins where they place pieces of seagrass on their dorsal fins, possibly as a form of social signalling or communication

Dolphins are among the most intelligent animals on Earth. Known for their playful behaviour and complex communication, they have long fascinated scientists and the public alike. But how much do we really understand about their social lives and emotional worlds? In recent years, researchers have begun to explore the idea that dolphins may possess aspects of culture – behaviours passed between individuals and across generations, much like in human societies.

Dr Ann Weaver, an ethologist and biostatistician at Good-Natured Statistics Consulting and

the Maples Center for Forensic Medicine, College of Medicine, University of Florida, is investigating how bottlenose dolphins express themselves, form social bonds and respond to their environment. Through consistent observation and the use of statistical tools, Ann is helping us to understand not just how dolphins behave, but also why.

What does it take to study dolphins in the wild?

Ann has spent over 20 years observing wild bottlenose dolphins

along the western coast of Florida in the southeast of the US. Her research involves conducting regular boat surveys, often several times a week, to observe dolphin behaviour in a consistent and non-intrusive way. “My job is to get to know some of the smartest animals on Earth on their own terms, in their own habitat,” says Ann. “You could call me a dolphin photojournalist using anthropological and statistical methods to understand a different culture without spoken language.”



© Ann Weaver

Studying wild dolphins typically involves long hours on the water, tracking animals by sight and recording their behaviours and interactions. Because bottlenose dolphins live in warm, shallow waters, they are relatively accessible for fieldwork, but this requires a high level of consistency and patience. Over time, researchers can identify subtle patterns that only become visible through observation over many years. “My fieldwork has only changed over time because of my increasing familiarity with the dolphins and their ways,” explains Ann. “The more the dolphins trust me, the more they show me, the more I learn and the more I see. Happily, my methods for collecting data have been consistent and stood the test of time.”

Can dolphins recognise individual people?

Long-term field studies rely on respectful observation. Ethnologists maintain a strict hands-off approach – no touching, feeding or swimming with dolphins – to avoid influencing their natural behaviour. At the same time, they learn to tell individual animals apart. Dolphin researchers identify individual dolphins by the unique notch patterns on their dorsal fins, a method that allows scientists to recognise hundreds of animals by sight.

Familiarity develops on both sides, and there is evidence that dolphins notice who is watching them. “The dolphins recognise me too,” says Ann. “Among countless examples, one summer I started wearing a full-face mask for sun protection. Every time we approached the dolphins while I was wearing it, they refused to let us near

and often fled at speed. But after seven weeks, I stopped wearing the mask and the dolphins allowed us to approach as closely as before. The mask scared them.”

Why do dolphins wear grass?

In recent years, researchers have begun to understand how dolphins use objects in their environment in more complex ways than previously thought. One such behaviour is ‘grass-wearing’, where dolphins drape blades of seagrass over their dorsal fins. “I knew that dolphins pay attention to how other dolphins look but initially assumed grass-wearing was accidental,” says Ann. “I realised it was intentional the day I witnessed a dramatic sighting: a mother dolphin, frantic over the death of her calf, donning grass to attract other dolphins’ attention, possibly to soothe her grief.”

To test her hypothesis, Ann examined her long-term dataset closely and applied statistical tools to look for patterns. She asked questions such as: Do all dolphins wear grass? Does it happen more often in certain conditions? Is grass-wearing linked to specific behaviours such as feeding or socialising? “My statistical analysis revealed that dolphins do indeed wear grass intentionally,” explains Ann. “This is what statistics do: reveal patterns that help us separate random events from wishful thinking about reality.”

What do the data reveal?

“Every time I saw a dolphin wearing grass, I recorded its identity, the identity of the dolphins it was with, what they were doing at the time, what happened next, how

much and what kind of grass they wore, and the date, time and location,” explains Ann.

Using biostatistics, Ann analysed these records to find meaningful patterns. The results showed that grass-wearing is not accidental or limited to a few individuals – males, females, young and old all wear grass. The main context for grass-wearing is social. Dolphins seem to use it when new individuals arrive, as part of a friendly competition for attention. Interestingly, adult females wear grass regardless of whether they are fertile, pregnant or nursing, which suggests that grass-wearing is more than just ‘flirting’ or attracting a mate.

What does the future hold?

“Dolphin behaviour is a never-ending story,” says Ann. “I look forward to completing several future studies.” Ann has recently described how dolphins heal from injuries and is currently focusing on shark-dolphin interactions, two topics that are closely connected. Dolphins surface regularly, making them easier to observe, while sharks rarely come to the water’s surface, so direct observation of shark-dolphin interactions is difficult. Instead, researchers like Ann can study the evidence left behind, such as shark bite wounds and scars on dolphins.

Using patterns in dolphin behaviour to infer how dolphins and sharks interact, Ann aims to better understand how sharks and dolphins share their coastal environment. By identifying dolphin behaviours that would not occur if sharks were mindless predators, Ann hopes to challenge the negative stereotype of sharks.

About *biostatistics*

Biostatistics is the application of statistical tools to biological questions. It allows researchers to test hypotheses, detect patterns and make informed conclusions about complex natural systems – from genes to ecosystems. While it is a core discipline in medical research, it is equally important in ecology, animal behaviour, epidemiology, environmental science and more.

“Statistics lead to understanding, which leads to caring, which leads to conservation,” says Ann. “Statistics are little islands of conviction in seas of uncertainty.” In the broader scientific landscape, the field of biostatistics plays a crucial role by turning raw data into meaningful insights. It supports

clear, evidence-based reasoning in areas where variability is the norm, helping researchers separate real patterns from coincidence.

“Future opportunities for biostatisticians are countless, and they are likely to pay well,” says Ann. “Computers let us collect mountains of data yet only a fraction of people knows how to analyse them.” While advances in artificial intelligence (AI) are creating new tools for data analysis, the human perspective will remain invaluable. A skilled biostatistician can ask contextually relevant questions, identify limitations and interpret patterns in ways that AI cannot.

A guide to *dolphin fieldwork*

“Dolphin fieldwork requires a manageable study area, a reliable boat and captain, a dolphin dictionary, a camera and commitment,” says Ann. “Establish a study area, survey it regularly, ask questions that interest you, and collect dolphin data to answer them.” This might include: Where are dolphins most often found? Do they follow daily routines? How do they resolve conflict? Why do they babysit? Why do males form long-term bonds? Do males and females form long-term bonds too?

A reliable, small and sturdy boat is essential. Smaller vessels offer better

visibility and access to shallow waters (e.g., 60 cm deep) – places where dolphins often show their most interesting social behaviours. Equally important is a skilled captain who handles the boat predictably and can read dolphin body language. Smooth, respectful manoeuvring helps build trust, which is crucial for close-range observation.

Identifying individual dolphins is done through photo-identification, using a high-speed digital camera to capture images of dorsal fins. Each fin has a unique pattern of notches and scars, like a fingerprint. Current smartphone cameras are not fast

or sharp enough for the required level of detail.

Researchers also rely on a behavioural reference guide called an ethogram or dolphin dictionary. “It is the ‘codebook’ that breaks the endless stream of behaviour into quantifiable data points for statistical analysis,” explains Ann. “Just as games are bound by rules, each statistical test is bound by rules called ‘assumptions’. These assumptions dictate the type of question you investigate and the data you need to answer it.”

Download Ann’s resources from futurumcareers.com/what-can-biostatistics-teach-us-about-dolphin-culture-and-communication



Explore careers in *biostatistics*

To learn more about careers in biostatistics, useful websites to explore include The Analysis Factor (theanalysisfactor.com), which offers practical advice and training resources for biostatisticians; Dolphins Digital (dolphinsdigital.org), Ann's website where you can learn more about dolphin behaviour research and statistical applications in marine science; and The Society for Marine Mammalogy (marinemammalscience.org/professional-development/how-to-become-a-marine-mammal-scientist), which offers guidance on becoming a marine mammal scientist — someone who studies cetaceans (whales, dolphins and porpoises), pinnipeds (sea lions, seals and walrus), manatees, polar bears and sea otters.

Pathway from school to *biostatistics*

Ann advises you build a broad knowledge base by studying botany, biology, animal sciences such as ornithology (birds) and ichthyology (fish), along with chemistry, argumentation, mathematics, logic, writing and illustration.

“Take many different classes to find out what you love, like, tolerate, don't like, etc., then head in the indicated direction,” says Ann. “Career planning can be as much about elimination (“No way does that interest me!”) as finding your bliss.”

“Develop the skills you love – they will come in handy at some point,” says Ann. “For example, after college, I started drawing silhouettes from photos of animals with a black magic marker but did not understand what drew me to do so. Later, I got good enough to illustrate my statistics books with pen-and-ink illustrations.”



Q&A

Meet Ann

You earned bachelor's degrees in biology and English literature. How do these subjects complement each other?

I pursued both for balance. Biology is comforting as the *real* world, an indescribably complex mesh of interlocking parts of which each of us is a part. Literature, poetry and writing are the world of human creativity, soothing because we communicate with words. The combination lets me do dolphin science and write both technical and popular science articles (460 articles to date).

What inspired you to become an animal behaviourist and biostatistician?

What attracted me is that animals treat each other far better than people treat each other. I love the natural world. To me, other animals are role models on how to live honestly and gracefully. But you need statistics and constant observation to convince other people of this!

What experiences have shaped your career?

My passion was shaped by a major ‘Eureka!’ moment when I was 18 years old and clueless about my future. I found a book by Nobel Prize winner Konrad Lorenz, *On Aggression*, in a humble bookstore. I opened it idly. The phrase, “ethology, the science of animal behaviour,” leapt off the page. I was struck as if by lightning. Instantaneously and irreversibly, it set my life's course in search of this mysterious, glowing possibility that I too might someday be an animal behaviorist, whatever that was. This was before animal behavior was a popular career choice or easy to see online. Lacking other guideposts, my search was simple: I took every job with animals that came my way, kept records, and periodically went back to university until I had a post-doc level education.

Unlike many dolphin biologists, I did not pursue dolphins as a career goal. Dolphins came to me in various invitations to study them in different seas. My fifth invitation was to study the dolphins in west central Florida. I ran with it.

What are your proudest career achievements so far?

I'm proud of everything I've been able to do so far. Each is a privilege beyond description. In particular, I wrote and illustrated a 1000-page Natural History Guide of the animals at the San Diego Zoo. I interconnected three major theoretical frameworks for my PhD on the development of peacemaking (attachment, reconciliation and psychobiological attunement theories). I am very proud of earning enough trust from wild dolphins at sea to write and illustrate the 2500-page Faithful Canvas collection.

Ann's top tip

You were put on this Earth to follow your bliss. It is up to you to find your passion and a way to live it. Find what you love and hold it close despite the sacrifices and costs. If you do, you will leap out of bed every morning, ready for the day's new adventures!

How did a Renaissance printer shape the books we read today?

More than five centuries ago, the printer Aldus Manutius permanently changed how people read and shared knowledge with the publication of his 'portable books'. Now, thanks to the work of **Dr John Maxwell** and **Alessandra Bordini** at **Simon Fraser University** in Canada, his legacy is being preserved and reimagined for the digital age.



Dr John Maxwell

Associate Professor

Fields of research

Publishing technology, history of publishing



Alessandra Bordini

Researcher and interdisciplinary PhD student

Fields of research

History of publishing, Renaissance studies

Publishing Program, Simon Fraser University, Canada

Research project

Aldus@SFU: Turning the works of Renaissance printer Aldus Manutius into a rich, public digital resource

Funder

Social Sciences and Humanities Research Council of Canada (SSHRC)

Website

alduslibsfu.ca

doi: 10.33424/FUTURUM633

Talk like a ...

publishing researcher

Classics — the study of Ancient Greek and Roman/Latin literature and language

Digital collection — a curated selection of digital resources accessible via an online interface

Font — the design of a specific set of letters so they go well together. Originally cut in metal, these are now digital files, e.g., Times New Roman, **Comic Sans**

Publishing — the artistic and commercial enterprise of

producing and promoting written work (in printed or digital form), and making it available to the public

Renaissance — a period of cultural change that began in Italy around 1350 and spread across Europe until the late 1500s, marked by a renewed interest in classical antiquity and advances in the arts and sciences

Typography — the art of arranging characters to create legible and appealing writing, including use of font, letter size and spacing, and line spacing

Books are a familiar part of everyday life. Whether printed or digital, their shape and structure – the use of page numbers, punctuation, chapters and tables of contents – feels natural and universal. Yet the design of the modern book has a history, and many of the features we take for granted were introduced by a pioneering individual – Aldus Manutius, a Renaissance scholar and printer who revolutionised book design and publishing. At Simon Fraser University (SFU), Dr John Maxwell and Alessandra Bordini are making

Aldus's books available online through the Aldus@SFU project, to explore how his innovations influence the way we read today.

Who was Aldus Manutius?

"Aldus Manutius lived from around 1450 to 1515 and is celebrated as Renaissance Italy's finest publisher," says Alessandra. Beginning as a classics teacher, Aldus gained international renown as a publisher, helping revive classical learning by printing the major works of the Ancient Greek and Roman worlds. Many of Aldus's books were the first ever printed editions



A beautiful selection of Aldine editions from the SFU Library's Wosk–McDonald Aldine Collection.
© Melissa Salrin, Head of SFU Library Special Collections and Rare Books

of these texts, most of which existed in his day only as rare handwritten manuscripts. “Over time, Aldus’s printing company, the Aldine Press, published all sorts of books,” says John. “In addition to classical texts in Greek and Latin, he also published new Italian literature – all the things that a hip, educated person should read!”

“But the Aldine Press was more than a profit-driven publishing business,” continues Alessandra. “Aldus’s workshop was a centre of learning and cultural exchange, and he used the new technology of the printing press to make education and knowledge more widely accessible.” In this way, Aldus continued his role as a teacher while shaping the future of books.

How did Aldus shape the way we read today?

“Only a few decades before Aldus began publishing, there were no printed books at all,” explains John. “Instead, manuscripts were painstakingly copied by hand, so they were rare and extremely expensive.” Even after Johannes Gutenberg invented the printing press in the 1440s, the first printed books closely resembled handwritten manuscripts because that was what people were used to. “They were typically big, impressive and intimidating!” says John. This meant they were heavy and often difficult to handle. “Aldus created books that, for the first time, had a design of their own.”

“Aldus’s successful ‘portable books’ were small-format volumes that could be conveniently held and carried,” explains Alessandra. “While he didn’t invent the concept of pocket-sized books, by combining

visual appeal with functionality, he made them more widely accessible.” In this way, Aldus and his portable books popularised the idea of reading not just for study, but for pleasure.

Before Aldus, nothing in book design was standardised. There was no consistency in how books were arranged and navigated, or in the use of punctuation and font. Aldus introduced standardised page numbers and, based on that, contents pages and indexes. Modern punctuation, including commas and semicolons, was developed in the Aldine Press. Aldus also established modern typography, as his books had clear and open text which contrasted with the dense, formal style of medieval manuscripts. His books were printed in *italic* type, which he modelled on the handwriting of the time, making his books more legible. And many fonts that we still use today (such as Times New Roman and EB Garamond) are inspired by fonts designed at the Aldine Press.

“All these innovations had a lasting impact not only on the design, structure and format of the book, but also on how readers interact with it,” says Alessandra. “Today, it’s easy to take books and punctuation for granted, but every time you write a comma or carry a book with you to read, you are benefitting from Aldus’s contributions.”

How did Aldus@SFU begin?

The SFU Library is home to the Wosk–McDonald Aldine Collection, which contains over 120 books published by the Aldine Press between 1495 and 1580. These volumes offer a tangible record of the evolution of modern book design, and in addition to being rare items of historical and cultural importance,

they are also admired as beautifully crafted objects.

To digitise the collection, each book was scanned by library staff and student research assistants. “The book sits in a cradle with lights and two cameras suspended over it, pointing at the left and right page,” explains John. Page by page, each volume was photographed – a process that took several months to complete. The photos were uploaded to a digital collection, along with metadata for each book, such as the catalogue number, author’s name, publication date, dimension of the pages and notes on typography.

John and Alessandra wanted to make Aldus’s books accessible online so that everyone can appreciate them. “You don’t need to be a book scholar or fluent in Greek and Latin to enjoy Aldus’s works and learn from the stories they embody,” says Alessandra. “We believe – and I have no doubt Aldus would agree – that just because a book is valuable, it doesn’t mean it should be locked away. On the contrary, its value increases when it is shared with others.”

The Aldus@SFU project is more than just the texts themselves; it tells the stories behind the evolution of the book we know today. These volumes show how typography developed, how punctuation and page layouts were standardised, and which works were considered important enough to print 500 years ago. “We take books for granted,” says John. “They’re just there, and nobody thinks about why they are the way they are.” By showcasing Aldus’s books from the early days of publishing, John and Alessandra are opening our eyes to the extraordinary history of this everyday object.

About *publishing*

“Publishing is the business of finding an audience for written works of all kinds,” says John. But it is also an artistic enterprise as much as a commercial one. “Publishing is the art of listening to and aligning with the needs of different individual and collective actors – the author, their intellectual work, the public, the market,” says Alessandra. “In book publishing, the creative vision of the publisher is the glue that keeps everything together.” Far beyond merely making money, publishing is about building new communities around books, and ensuring books are meaningful, accessible and culturally impactful.

What is the future of the book?

While digital media has dramatically changed how we access and share information, it has not replaced the traditional book. “The book market has proved to be surprisingly durable in the face of digital innovation and disruption,” comments John. “In the early 2000s, many people believed that eBooks would make print books obsolete, but that hasn’t happened.”

While eBooks have their uses and supporters, many people prefer the feel of a ‘proper’ book. “When I read for pleasure, nothing gives me more joy than a printed book,” says Alessandra. “However, for research purposes, digital forms have the advantage of being

searchable.” On the much-debated question about the future of the book, Alessandra agrees with Italian scholar and novelist Umberto Eco: “The book is like the spoon, scissors, hammer and wheel. Once invented, it cannot be improved.”

Just as Aldus Manutius changed the way books were read in the 15th century, technology is changing our reading habits today. Aldus’s portable books encouraged readers to carry books with them – just as smartphones now let us carry the internet in our pockets. Then and now, the shift was not only about technology, but about how people interact with technology in everyday life.

Pathway from school to *publishing*

“The most essential thing is a love of books and reading,” says John. The more you read, the better you connect to the culture and world around you – the key sensibility for making good publishing decisions.

In high school, it would be useful to study literature, languages, media studies, art and design.

At college or university, consider an undergraduate degree in literature, journalism, communications, media, business or the arts. However, you can enter the publishing industry with any academic background: “Students with a science background bring valuable perspectives on the world that translate well into thinking about books and publishing,” says John.

Simon Fraser University offers undergraduate and master’s programmes in publishing: sfu.ca/publishing

Explore careers in *publishing*

Whether you are passionate about literature, design, business or technology, publishing offers the chance to shape public conversation and bring meaningful work into the world.

“Publishers are culture-creators and tastemakers, just like musicians, filmmakers and artists,” says John. “That’s the appeal of working in this industry.”

Publishing offers a wide range of career paths, from editing and design to marketing and sales. Junior roles tend to be in the marketing side of the industry, while those with more experience take on roles such as acquiring and editing new books.

You could also choose an academic career to research different aspects of the publishing industry, like John and Alessandra.

Explore websites of publishing companies and organisations such as the International Publishers Association (internationalpublishers.org), BookNet Canada (booknetcanada.ca), the Association of American Publishers (publishers.org) and the Publishers Association (publishers.org.uk/about-publishing/careers).

Download John and Alessandra's resources from futurumcareers.com/how-did-a-renaissance-printer-shape-the-books-we-read-today



Meet John

As a teenager, I wasn't all that bookish, though I did devour magazines (this was in the 1980s – the golden age for magazines). I was more interested in music and cycling. When I finished high school, I had very little sense of what I wanted to do. I went to university because it was expected, not because I had a goal. I chose to study anthropology, simply because it looked interesting enough to encourage me to go to class each day!

I fell into work as a freelance web designer in the 1990s. Lots of people were getting into web design at that time (it was the early days of the World Wide Web), and in trying to improve my skills I became interested in traditional publishing, specifically design and typography.

One thing led to another, and I returned to university to do a master's degree in publishing. I then worked in distance education, creating online resources for high school kids in remote locations who couldn't access a school, which taught me a lot about digital production. I went back to university again for a doctorate in education, then ended up teaching digital media production in the Publishing Program at SFU.

To mark the 500th anniversary of Aldus Manutius's death in 2015, a colleague suggested we should do something with the Wosk–McDonald Aldine Collection. Alessandra was a master's student at the time, and we have been immersed in understanding Aldus and his 15th century world ever since.

I'm always surprised by the similarities between the cultural contexts of Aldus Manutius and today. Not only is the book industry strikingly similar (though, of course, we now have online retailers like Amazon), but the tumultuous political landscape of the Renaissance provides food for thought today. Like today, the Renaissance was a time of culture wars, Islamophobia and struggles between tyranny and democracy.

In my free time, I am a devoted amateur musician – I play a few different instruments, sing and tinker with music technology. And I ride my bike. So, the same things I did when I was a teenager!



Meet Alessandra

I was a studious and curious teenager – easy-going on the outside, restless on the inside. Reading and writing gave me an outlet for my maverick nature. I was an avid reader of fiction and, as an Italian native speaker, I bought British and American magazines to improve my English language skills. And my desk drawer was populated with extemporaneous poems, unfinished short stories and letters conveying heartfelt appeals to politicians.

My mother, Paola Pinna, was a talented painter and sculptor. When I was a child, she introduced me to the masterpieces of Renaissance art, and I was absolutely flabbergasted. I developed an interest in the visual arts at an early age which later gave me an appreciation of books as aesthetic objects in their own right.

My career journey has been shaped by my love of language and words – both their musical quality and visual expression on the page. Before coming to SFU, I worked as a literary translator and editor in the Italian book publishing industry. My interest in publishing is grounded in the practical consideration that, as a publisher, you are contributing to bringing a vision to life. I see myself as both a thinker and a maker, and publishing is that rare space where the exploration of ideas and the refinement of craft blend harmoniously.

I enjoy studying the works of Aldus Manutius because I get to engage with incredible, finely printed books that carry 500 years of history. These aren't just magnificent objects to look at, but also invaluable records of our vibrant intellectual and cultural tradition. These books, and the cultural richness they represent, are a constant source of wonder and inspiration for me.

Meaningful and long-lasting friendships are formed around books. One rewarding aspect of the Aldine digital initiative is connecting with colleagues, students and librarians who share my interests and values.

Other than reading, I enjoy urban photography, long walks in nature with my partner Jeff, and doing Pilates. I love hanging out with my cat Lila, who also loves to devour paper books – only in a literal way!

Road traffic safety for dummies: the world's first average female crash test dummy

Crash test dummies are used extensively in the development of safety features for cars and other vehicles. However, global regulations only require these features to be tested with average male dummies. **Professor Astrid Linder**, from the **Swedish National Road and Transport Research Institute, Chalmers University of Technology** in Sweden and **Monash University** in Australia, has worked with a team of researchers to develop the world's first average female crash test dummy to ensure that new vehicles are designed to protect both male and female users alike.



Professor Astrid Linder

Professor of Road Traffic Safety, Swedish National Road and Transport Research Institute

Adjunct Professor, Chalmers University of Technology, Sweden

Adjunct Professor (Research), Monash University, Australia

Fields of research

Road traffic safety, injury prevention, physics, engineering

Research project

Developing the world's first average female crash test dummy

Funder

The average female crash test dummy was developed as part of the Open Access Virtual Testing Protocols for Enhanced Road User Safety (VIRTUAL) project that received funding from the European Union Horizon 2020 Research and Innovation Programme under Grant Agreement No. 768960.

doi: 10.33424/FUTURUM630

Talk like a ...

road traffic safety expert

Component test — in vehicle development and evaluation, the assessment of individual components and systems found within vehicles

Crash test dummy — a life-sized model of a person used to assess how the body is affected by vehicle collisions

Open-source — in software, when the original code

is freely available to be used and modified

Road traffic safety — the methods and measures used to minimise the loss of life and health in road systems

Whiplash injury — a soft-tissue neck injury caused by the sudden movement of the head relative to the torso, seen most often in car accidents

test dummies to assess safety,” says Professor Astrid Linder from the Swedish National Road and Transport Research Institute, Chalmers University of Technology and Monash University. “The aim is to create vehicles that protect their occupants and other road users from being injured or killed in the event of a crash.” Such tests are required by international law as part of a bare minimum safety requirement that vehicles have to pass. “Vehicles may also undergo additional consumer tests that go beyond these minimum requirements,” says Astrid. “Organisations use these further tests to provide ‘star’ ratings that indicate the level of safety the vehicle provides.”

However, crash test dummies are modelled on the average male body, and although many aspects of male and female bodies are similar, there are some fundamental differences. For example, males and females have different muscle strengths and body shapes, particularly around the torso and hips. This means that safety tests may overlook some of the ways in which females are affected during a crash. “Injury statistics show us that females are not as well protected as males in certain types of crashes and for certain injuries,” says Astrid. “To establish how and why females are impacted in these ways, we needed to create models that we could use in testing.”

Crash test dummies simulate the human body and how it is affected in vehicle crashes. They are a critical part of the development process for new vehicles, and help to ensure the safety of a vehicle's occupants. “Car manufacturers use crash



Astrid's female crash test dummy, SET 50F, on a crash test sled. © VTI/Philip Sorri

The origins of the first average female crash test dummy

Average male crash test dummies have been around for many decades, so the process for their development is well-established. However, one dummy cannot be used in all scenarios. "The human body is highly complex, and dummies are only made of metal, rubber and plastic!" explains Astrid. "This means we need to make models for different impact directions – if the crash comes from the front, rear or side – as well as for different severity levels and different types of injuries."

Astrid began working with crash test dummies back in the 1990s as a PhD student for a project that made the world's first dummy for low-severity rear impacts. "Our model was based on the average male because that was what we had access to," says Astrid. "For me, the logical next step was to do the same for the average female, since injury statistics from the late 1960s and onwards showed that females were less well protected from whiplash injuries than males." This began Astrid's work into average female dummies, using data on body shape, proportions and muscle strength to build prototypes. "Of course, we didn't get there straight away," she says. "It was an iterative process that required a lot of learning and research over many years."

Investigating whiplash injuries

Astrid is studying how the risk of whiplash injuries can be reduced in the event of a crash. Whiplash injuries are injuries to the soft tissues of the neck and can cause long term consequences. "These injuries occur at lower velocities in all impact directions, but

“

Injury statistics show us that females are not as well protected as males in certain types of crashes and for certain injuries.

”

are most commonly a result of rear impacts, where the seat has the biggest potential to offer protection," explains Astrid. "For the evaluation of the seat, we can conduct component tests." This means the team only uses the relevant parts of the car in their test: in this instance, the car seat. "We put the seat and the crash test dummy on a sled, and then subject the sled to impacts at different severities to test how well the seat protects the occupant from injuries," she says.

Astrid's team uses both average male and average female dummies, the recently developed Seat Evaluation Tool (SET) 50F and SET 50M, in these tests. "Our results, which we are in the process of publishing, indicate that the average male and the average female respond differently," she says. "This has important implications for how to assess seat design to provide maximum safety for everyone." Average female models are not used in any standardised testing, but this could change in the near future, providing important information for consumers about seat safety in different vehicles.

Overcoming regulatory road blocks

Research like Astrid's, coupled with good common sense, makes it clear that average female crash test dummies should be used as a matter of course – so why aren't they? "It's a very common question that people ask," says Astrid. "The answer is that no-one has done the work and put in the effort at the regulatory level." Global safety rules dictate that a model of an average male should be used, so doing something different is not an option. "Until society demands that this changes, things will stay the same," says Astrid.

Astrid is helping lead the charge to make these demands. "My current focus is publishing our research and being present in the groups where possible regulatory changes are discussed," she says. "The models now exist – it is just a matter of using them." Alongside physical tests, Astrid also believes that computer simulations should begin to play a bigger role. "We are about to finalise a virtual model of the SET dummies," she says. "Our data is all open-source: we want to share this knowledge and foster its future development."

Astrid's pioneering work has not gone unnoticed: she was named on the BBC's '100 most inspiring women' list in 2023, and the Forbes Global 50 Over 50 list in 2025. While female crash test dummies are yet to become the norm, she is hopeful that this may soon change. "I think it's reasonable that by 2030 the safety of new cars should be assessed for both females and males equally," she says. "I hope that our average female model will provide the foundation for this."

About *road traffic safety research*

Road traffic safety research involves studying how to keep people safe on the roads. Globally, around 1.2 million people die each year as a result of road traffic crashes, and the United Nations General Assembly has a target of halving this figure by 2030. In addition, 20-50 million people are severely injured on roads every year. Research avenues in this field are varied: they may involve testing the safety of new and current vehicles in different scenarios, designing and improving road systems to prioritise safety, or investigating social factors related to traffic safety, such as alcohol use or road rage.

For Astrid, the numbers give her motivation. “Injury data and statistics

are my ‘fixed point in the universe’,” she says. “They show me that what I am doing is important. This gives me a goal to strive for.” Persistence is key: the rate of progress in this area has been slow, despite extensive data showing the need for average female crash test dummies. “It has taken a long time to get the funding,” says Astrid. “This surprises me because, from an engineering perspective, it couldn’t be more obvious that female crash test dummies are needed.” Engineers design products with a specific target audience in mind, and given that around half of vehicle users are female, it makes little sense that half of the population are excluded from the safety tests!

Astrid is passionate about getting more people involved in road traffic safety research. “This is how we make our world and our society better,” she says. “Students bring new perspectives and new innovations – sometimes the solutions are right in front of us.” Naturally, the field involves a high degree of collaboration. “It’s like building a rocket: it’s hard to do it by yourself in your backyard,” she says. “Learning how to work together is essential: every brain is different, and having different perspectives is always positive.” She recommends beginning to develop teamwork skills as soon as possible, including through projects in the classroom.

Pathway from school to road traffic safety research

Research like Astrid’s involves both knowledge-based and technical skills, meaning that both academic and vocational training can provide pathways into a road traffic safety research career. At school, useful subjects may include physics, mathematics and product design.

At university, courses in engineering, physics and design may all provide routes to a career in the field. Vocational pathways include college courses and apprenticeships that build skills in mechanics, technical work, and manufacturing processes and testing. “Do whatever best stimulates your curiosity – that is what will prepare you best,” says Astrid.

Chalmers University of Technology in Sweden, where Astrid is an Adjunct Professor, has a number of STEM outreach programmes for school students, including study visits, talks, festivals, open lectures and a Girls Code Club summer bootcamp: [chalmers.se/en/collaborate-with-us/activities-for-schools/](https://www.chalmers.se/en/collaborate-with-us/activities-for-schools/)

Download Astrid’s resources from [futurumcareers.com/road-traffic-safety-for-dummies-the-worlds-first-average-female-crash-test-dummy](https://www.futurumcareers.com/road-traffic-safety-for-dummies-the-worlds-first-average-female-crash-test-dummy)





Explore careers in road traffic safety research

Astrid notes that many researchers are happy to hear from students at any stage of their education, including high school. “Find people that work in the topic you are interested in and reach out,” she says. “Make sure it’s a two-way process: have specific questions in mind, based around your interests.” This can help build your understanding of what it is like to work in the area, as well as beginning to build your network.

Read some of the articles in *Traffic Safety Research*, a journal dedicated to the field, to learn more about research in this area: tsr.international

The International Research Council on the Biomechanics of Injury hosts an international conference every year. You can explore the research that is discussed here: ircobi.org/wordpress/proceedings

Internships can be a great way to get hands-on experience in the field. For example, the Institute for Road Safety in the Netherlands offers up to 15 internships each year: swov.nl/en/working-swov-1

Explore the OpenVT website where you can access Astrid’s data on the SET 50F and SET 50M along with other data on different models and tests: openvt.eu/platform_manual_and_guidelines/overview_public_contents



Meet Astrid

As a teenager, I was really into practical skills, so I qualified as a technician. It was only after working for some years that I discovered my passion for mathematics and physics. I started university when I was 29, and really enjoyed it, especially mathematics. I didn’t have my path figured out, so I followed my passion.

Working at a research institute means I can study whatever I am interested in, as long as I can secure funding for the research. This involves identifying what is needed in society, and then finding collaborators to help me study it. Often, if I really want to do something, it involves taking on the tasks that no-one else wants to do – which in my case involves being project manager and coordinator. I am always happy to let someone else take the reins, but I am equally happy to do it myself to make the project a success.

People designed the road transport system. This means that people can redesign it to make it safer. When the day comes that crashes no longer result in injury or death, I’ll be happy to move on to something else. But until then, there is work to do – by me and by future generations.

Having a passion for what I do definitely helps the quality of my work. I am committed and sometimes stubborn – but I try not to be stupidly stubborn! When things get hard, I’m happy to ask for help or support. I never have all the answers – nobody does.

I’m fortunate to also have a rich life outside of work. I have a son and grandchildren who I love spending time with. I’m an outdoor person, spending time trekking or building sea kayaks to take out on the ocean. Earlier this year I made it to Everest Base Camp, which was a demanding, fantastic experience!

Astrid’s top tip

Keep your curiosity alive. There are endless things to be curious about in the world: our ability to be fascinated by the world is humanity’s superpower. My four-year-old grandchild is fascinated by everything, and rightly so! It’s built in, but you have to make sure to foster that curiosity throughout your whole life.

Challenging the legacy of colonialism: advocating for the rights of Indigenous women and girls in Canada

In Canada, Indigenous women face disproportionately high levels of violence and are greatly overrepresented in long-term and unresolved missing person cases. At **Lakehead University**, **Tamara Bernard** is researching the systemic discrimination that takes place against Indigenous women and girls, with the goal of creating a safer and securer world for them in the future.



Tamara Bernard

PhD Candidate and Instructor, Indigenous Learning Faculty, Lakehead University; Advisor for Indigenous Research and Knowledge Systems, Creative Fire, Canada

Fields of research

Indigenous learning, trauma and gender-based violence, education

Research project

Advocating for Indigenous women and girls

Funders

Social Science and Humanities Research Council of Canada (SSHRC); Seven Generations Education Institute

doi: 10.33424/FUTURUM642

“For centuries, the legacy of colonialism has dehumanised and perpetuated harmful stereotypes of Indigenous women and girls,” says Tamara Bernard (Shining Eagle Woman), an Anishinaabekwe and PhD candidate in education at Lakehead University. “As a result, and as highlighted in a 2019 national inquiry, Indigenous women and girls in Canada are 12 times more likely to experience violence compared to non-Indigenous women.”

Tamara’s connection to the issue of violence against Indigenous women and girls goes beyond the academic

Talk like an ...

Indigenous advocacy researcher

Advocacy — the act of supporting something publicly

Anishinaabekwe — a woman from the Anishinaabe, a group of Indigenous Peoples in the Great Lakes region of Canada

First contact — when colonists first made contact with Indigenous People in Canada (from Greenland and Iceland in the 11th century and from Europe in the 15th century)

First Nation — a term for the Indigenous People of Canada

Genocide — the intentional killing of a people or ethnic group

Indigenous — the original people who lived in a land before the arrival of colonists

Systemic discrimination — ongoing biases that are embedded within a society and cause the unfair treatment of certain individuals

or her career. In 1966, her great-grandmother, Jane Bernard, and cousin, Doreen Hardy, were murdered. Both cases are still unsolved today. Tamara’s commitment to Indigenous advocacy is motivated by the need for both social and personal justice – for her family and community members. Realising that all she ever learnt about her great-grandmother was that she was murdered, Tamara believes deeply that Indigenous women and girls need to be recognised beyond the labels of ‘missing’ or ‘murdered’.

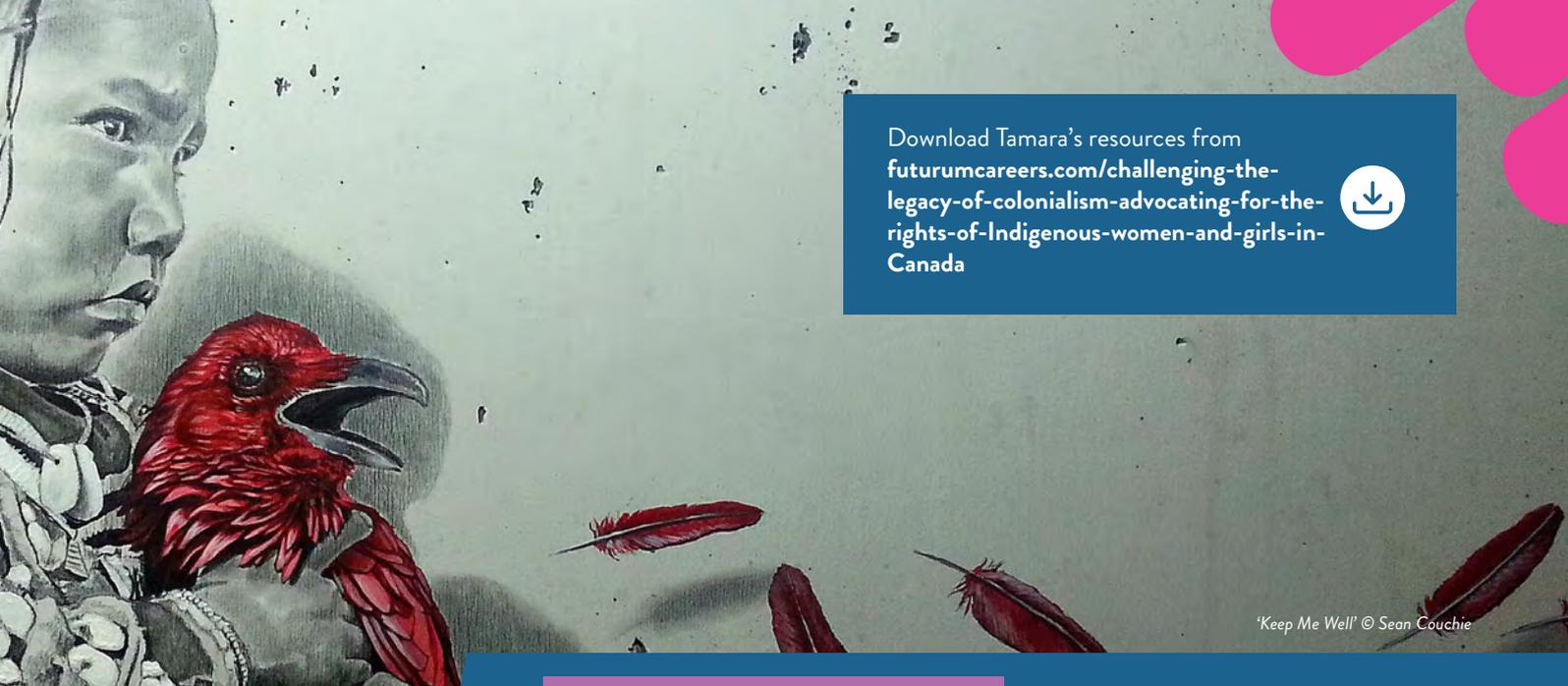
Gaps in the data

Before the national inquiry took place, government data from 1980 to 2012 highlighted that 1,181 Indigenous

women and girls were killed or had disappeared within the 32-year timespan covered.

Tamara challenged the span of these government data: what about the women and girls who were killed or disappeared before 1980, like Jane and Doreen, or since 2012? Their stories need to be heard, and Tamara was determined to ensure they were. She wanted stories, not just statistics. She wanted to breathe life into the numbers.

The National Inquiry into Missing and Murdered Indigenous Women and Girls (MMIWG) took place from 2016 to 2019. “Even after this long



Download Tamara's resources from futurumcareers.com/challenging-the-legacy-of-colonialism-advocating-for-the-rights-of-Indigenous-women-and-girls-in-Canada



'Keep Me Well' © Sean Couchie

overdue inquiry, there continues to be gaps in the data," explains Tamara. "Due to a lack of systemic national data collection, underreporting of cases, and challenges in identifying Indigenous victims due to insufficient racial data collection by police, these gaps mean that the crisis of violence against Indigenous women and girls in Canada is still not fully understood."

The colonial legacy

"The violence targeting Indigenous women is deeply rooted within colonialism, racism, sexism, systemic discrimination and genocide," says Tamara. In fact, the MMIWG report recognises that since first contact, the colonial legacy in Canada is one of genocide against Indigenous peoples.

An important aspect of Tamara's work is highlighting how Indigenous women and girls are forced into vulnerable spaces by discriminatory mechanisms and policies. "Canada is the only country that has a piece of paper that polices and controls a certain demographic based on race," says Tamara. That paper is the Indian Act – a legislation first passed in 1876, aspects of which are still enforced in Canada today.

The Indian Act sets the standard for how the Canadian government interacts with First Nation people. "The Indian Act is an aggressive, colonial piece of legislation that has forced many Indigenous women to lose their rights, identity and connection to their community," says Tamara. Among other things, the act defines which First Nation people are given 'Indian status'. Until it was amended in 1985, the sexist act declared that status women who married non-status men would lose their status, whereas status men

Helpline

The **Talk4Healing Helpline** offers help, support, and resources 24/7 through talk, text and chat. It has provided over 30,000 Indigenous women and their families with real-world solutions, without judgement, in a safe and accepting environment.

Talk: Call 1-855-554-HEAL and live support will be there to listen, any time of day

Text: Send a message to receive support anywhere

Chat: Click on the live chat option and start a session.

marrying non-status women would not. "It is estimated that over 270,000 Indigenous women and their descendants are trying to regain their status rights and community ties," says Tamara.

The missing or murdered Indigenous women who lost their status through the Indian Act are not included in the data highlighting crimes against Indigenous women and girls. "The flawed data downplays the impact that colonialism and its ensuing violence has had – and continues to have – on Indigenous women," explains Tamara. To address ongoing injustices, all crimes against Indigenous women and girls need to be fully acknowledged – even if the women in question do not have official status.

Sharing stories

Part of Tamara's work is focused on finding and sharing stories that challenge narratives of how Indigenous women are viewed and which honour them as individuals. "Personal stories and connections can reveal more than data," explains Tamara. "Stories that challenge colonial ideas can humanise and

bring hope, healing and empowerment. I want to show how Indigenous women continue to take up roles of leadership, like pursuing education, despite facing adversities."

Tamara is using Indigenous research methods to gather these stories. "These methods are a collective experience where the researcher also shares their own stories to build relationships, connections and trust," she explains. "For example, I have sat with Indigenous women and girls in many communities, groups and spaces, sharing parts of my own work and spirit."

The stories Tamara gathers are co-edited with Indigenous Knowledge Sharers and Storytellers before being shared in articles, artwork, exhibitions and textbooks. One collection that Tamara coordinated, in partnership with CTV Bell Media and Atlohsa Native Family Healing Services, is an MMIWG Public Education exhibit called 'See Me'. The first of its kind when it first took place in 2014, the project uses stories to honour Indigenous women and girls among MMIWG, beyond those represented in the data.

There is still lots to be done to create a safer society for Indigenous women and girls, but Tamara is passionate and determined in her work. "My aim is for Indigenous women and girls to feel seen, heard and reflected," she says. "Because far too often, Indigenous women's voices and representation are not at the table. I am pulling up chairs and inviting other Indigenous women to join me."

About Indigenous learning

Part of the Missing and Murdered Indigenous Women and Girls exhibition 'See Me', coordinated by Tamara in partnership with CTV Bell Media and Atlohsa Native Family Healing Service.

Indigenous learning combines ideas from history, sociology, geography and anthropology. It focuses on understanding the societal structures affecting Indigenous groups, the ongoing and complex impacts of colonial practices, and the creation of policies and spaces that might lead to a more equitable world.

An important part of Indigenous learning is championing different perspectives and voices. "The majority of our history books are written from non-Indigenous perspectives," says Tamara. "And while we have some great ally faculty who have dedicated themselves to building trusting and holistic relationships with Indigenous communities, Indigenous faculty members and representation is still needed."

What are the challenges of advocating for Indigenous women and girls?

"Since first contact, Indigenous women have been sexualised, treated as less human and traded like objects," says Tamara. "Canada has a hidden history of slavery, and the majority of those enslaved

were Indigenous women and girls." For advocates like Tamara, the challenge is ensuring that ongoing violence is not minimised or 'brushed under the carpet'. "Often, I witness no amber alerts being administered (to highlight an emergency situation) and a lack of participation when searching for missing individuals," says Tamara. "When sharing risk assessments of concerns of intimate partner violence or human trafficking, I see frontline officials dismissing concerns."

"I was often told that I cared too much, but there is a reason that Indigenous women and girls reach out to me privately to support their navigation of the system. The system is broken," says Tamara. Tamara gives these women a voice, and many voices need to be heard if the system is to be fixed. She explains, "There is an invisible, heavy backpack that many Indigenous women carry, and I see it when I am in the community and when I'm teaching."

What needs to be done?

A large part of working in this field involves engaging with members of the

public, political leaders and community groups to provide education on systemic discrimination.

"We need more investment into Reconciliation Action Plans," says Tamara. Tamara is an advisor for Creative Fire, a national Indigenous communications firm bridging the divide between Indigenous and non-Indigenous groups and facilitating Reconciliation in Action. "Creative Fire is advocating within multiple sectors across Canada to ignite social impact for Indigenous peoples, especially Indigenous women. Our work focuses on economic development, self-determination and Indigenous Peoples rights; it is about healing, empowerment, inspiration and hope."

Long-term sustainable funding is also needed for Indigenous gender-based violence programmes and services. "We need to develop Indigenous informed and culturally grounded services, invest in and support Indigenous approaches, and foster decision making by Indigenous communities," says Tamara.

Injustices

Injustices targeting Indigenous women can be seen in practices such as 'birth alerts'. These alerts, which disproportionately affected Indigenous women, meant that hospitals could flag mothers they considered high-risk, for social services to seize their babies when they were born. Birth alerts were banned due to 'Calls to Justice' from the 2019 national inquiry, grounded from stories by Indigenous women across Canada. However, in the province of Ontario, the ban did not take effect until 2021, and some provinces in Canada still practice alerts.

'Birth alerts' built on historic and ongoing colonial practices of Indigenous parents having their children taken away from them by the state. From the 1830s to 1996, the Canadian government created a Residential School System with the goal of taking Indigenous children from their culture and assimilating them into Western Canadian culture, with less than 50%

chance of survival.

Moreover, instances such as the 'Sixties Scoop', a continuation of the Residential School System, in the 1950s to 1980s saw authorities forcibly removing around 20,000 Indigenous children from their communities, often without telling their families. The 'Millennial Scoop', which started in the 1990s, continued a similar practice and has been indicated in research as a pipeline to incarceration and human trafficking. "There are more Indigenous children in care in the present day than there were in the Residential School era," says Tamara. "Indigenous children continue to not be raised by their families."

Ongoing impacts

The impacts of these injustices and the trauma forced on Indigenous women are complex and far-reaching. Separating mothers from their children can create a cycle of **insecure attachment**, where children grow up seeking love from unhealthy relationships because their needs

have not been met earlier in life. "We need to acknowledge the intergenerational impact that a lack of secure attachment has on feeling safe and confident in the future," says Tamara. "Without this understanding of social psychological development, victims are often blamed, and Indigenous trauma-informed support is still lacking, which leads to a failure to address the root causes of these issues – intergenerational trauma and lack of secure attachment impacting social determinants of health."

Indigenous women are also more likely to have been exposed to family violence, witnessed or been involved in intimate partner violence, or known a family member or friend who became one among missing or murdered. "Indigenous women are often in survival mode at early stages of their life, and are susceptible to being groomed and 'love bombed'," explains Tamara. This creates a dangerous cycle where Indigenous women can be



Pathway from school to Indigenous learning

During high school, study geography, history and communications-based courses such as English, French and other languages. It is also useful to take some maths or statistics classes for understanding data analysis methods.

At university, study for a degree in Indigenous learning or a subject that develops your critical thinking skills and engages with different cultures and perspectives, such as sociology. If you can choose any of your courses, Tamara recommends taking classes in Indigenous history, Indigenous law, Indigenous governance, Indigenous self-determination and advocacy, Indigenous gender-based violence, Indigenous peoples and the land, and Indigenous research.

Visit the Lakehead University admissions page for their Indigenous learning degree, which gives some great information on what the course will involve and potential future careers:

lakeheadu.ca/indigenous/indigenous-programs/indigenous-learning

Have a look at the National Centre for Collaboration in Indigenous Education (nccie.ca/about-us), which has a brilliant resource library with articles about Indigenous learning.



Meet Tamara

The Creator choose this path for me. I was the first generation in my family to not attend residential school. I have the legacy of missing and murdered Indigenous women and girls in my family. It's not easy work being a cycle breaker or the first for many things in my life, but I do it with hope to inspire change. I want our world to be a better place for the future generations. This is about breaking a trail for those coming behind me.

One of my roles also involves conducting death reviews under the Chief Coroner, as part of the Domestic Violence Death Review Committee, and I am leading one of the first Indigenous reports of its kind by integrating Indigenous risk factors to address the gaps and barriers within our existing system. I am doing this important work with two other Indigenous women. We are a small team of three in Ontario, but we are mighty, dedicated survivors, and want justice and healing for our women and girls. The time is now for change. Addressing Indigenous gender-based violence is not only political, it is also personal.

My PhD dissertation focuses on understanding the various forms of violence that target Indigenous women, particularly the experiences of violence that women Indigenous students face while pursuing post-secondary education. Although post-secondary institutions can serve as a means of 'escape', Indigenous women often fall through the cracks due to a lack of intervention training at the institutional level, including among faculty, staff and administration, on issues such as intimate partner violence and human trafficking.

My work is difficult, so it's important I look after my own well-being. To do this, I go to ceremonies held on the land and water. They ground me, clear my head and help me to be a better human being, to not carry the trauma I can witness as a helper for Indigenous women and girls. I surround myself with Elders and healers to help me.

It's difficult to give specific advice about pursuing a career in Indigenous rights-based advocacy, because it's not one role or title. I have multiple, layered and connected roles, from teaching at the University of Lakehead to my advisory role at Creative Fire, from studying for my PhD to serving on committees, because there are not enough of us to hold government accountable. I'm working to represent Indigenous rights in lots of areas and have often been alone in my efforts.

To become a leader and to be heard, I have had to ensure I have the educational criteria

Western society expects. I have been in education for the last 20 years, gaining degrees in sociology, psychology, Indigenous education and research.

To take steps to become more Indigenous trauma informed and to educate yourself on the issues that directly impact Indigenous women, attend Indigenous training that is led by and facilitated by Indigenous Peoples. Go to Indigenous conferences, sit and listen and learn First Nation history. If you're not Indigenous, ask yourself what it means to be an ally. Ask Indigenous individuals that you have relationships with on what being an ally means to them. So much can be learnt by reading and listening to Indigenous people's stories.

My proudest achievement is having my son. Due to colonialism, being a mother is a role that many Anishinaabe women in my life did not get the privilege to enjoy. Being a mother is life changing. My aim is to be the mom my son deserves. My son is everything, and being his mother heals so many generations of trauma.

In the future, I also hope to do work for and with United Nations.

Tamara's top tip

1. Learn as much as you can and have the courage to learn from different perspectives.
2. Remember decolonisation is not an easy journey of learning; it takes great vulnerability. I wish you a wonderful journey of decolonisation. Baamaapii.

Searching for enigmatic biomarkers to address a devastating degenerative disease

Friedreich's ataxia is a genetic disorder that damages the nervous system and dramatically reduces life expectancy. It is caused by low levels of an elusive protein called frataxin. Innovative treatments aim to boost frataxin levels, but measuring the success of these treatments is not easy. Fortunately, **Professor Ian Blair** and his team of pharmacologists at the **University of Pennsylvania** in the US are on the case. They are using powerful mass spectrometry techniques to identify biomarkers – other molecules that correlate with frataxin levels but are easier to measure. Their discoveries could accelerate the development of new treatments for Friedreich's ataxia.



Professor Ian Blair

Department of Systems Pharmacology and Translational Therapeutics, Perelman School of Medicine, University of Pennsylvania, USA

Fields of research

Pharmacology, translational therapeutics

Research project

Using mass spectrometry to analyse frataxin proteins as biomarkers to improve treatments for Friedreich's ataxia

Funders

US National Institutes of Health (NIH); Friedreich's Ataxia Research Alliance (FARA); Lexeo Therapeutics; Mantle Therapeutics; Design Therapeutics; Penn Institute on Aging

Website

med.upenn.edu/blairlab

doi: 10.33424/FUTURUM639

Friedreich's ataxia affects roughly one in 50,000 people in the US. "It is a disorder that progressively damages neurons and other tissues over a period of years," says Professor Ian Blair, a pharmacologist at the University of Pennsylvania. "Most patients

Talk like a ...

pharmacologist

Biomarker — a measurable characteristic that indicates the state of a biological process

Biopsy — an examination of tissue removed from a living body

Frataxin-M — a protein found in mitochondria that is essential for the assembly of other proteins required for mitochondria to function properly

Friedreich's ataxia — a rare neurological disease that causes progressive damage to the nervous and cardiovascular systems

Gene therapy —

a treatment for genetic diseases that involves providing the patient with the correct gene to supplement the malfunctioning gene that is responsible for the disease

Mass spectrometry —

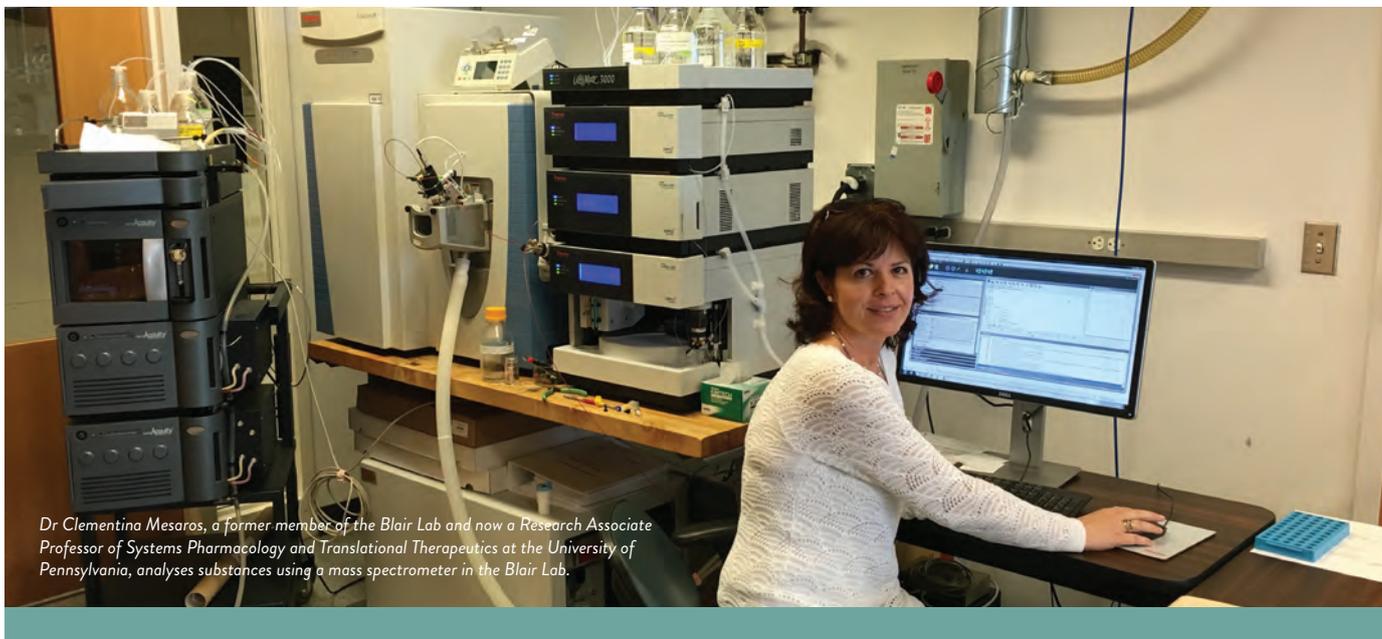
an analytical technique used to identify and quantify the molecules in a sample

Mitochondria —

small structures in all cells (except red blood cells) that provide the cell with energy

progress to wheelchair dependency within twenty years of diagnosis in childhood, and most die in their thirties from heart disease." Ataxia refers to poor muscle control, which leads to difficulties with co-ordination, balance and speech – and in Friedreich's ataxia these symptoms get worse over time. Friedreich's ataxia also causes heart problems and other complications. There is currently no cure for

Friedreich's ataxia. "There is one approved treatment that slows its progression, but it is far from a cure," says Ian. "Alternative therapeutic approaches are in development, but challenges in measuring their effectiveness are slowing progress." To address this, Ian and his team in the Blair Lab are using innovative laboratory techniques to improve methods for determining the success of treatments.



Dr Clementina Mesaros, a former member of the Blair Lab and now a Research Associate Professor of Systems Pharmacology and Translational Therapeutics at the University of Pennsylvania, analyses substances using a mass spectrometer in the Blair Lab.

Frataxin: an elusive protein

Friedreich's ataxia is caused by a genetic mutation that leads to low expression of a protein called frataxin. The mitochondrial form of frataxin (frataxin-M) is essential for mitochondria to function properly and supply cells with the energy they need to stay alive and healthy. Emerging therapies for Friedreich's ataxia aim to boost levels of frataxin via different means. Gene therapy, for example, would modify patients' genes to increase frataxin expression, while pharmacological approaches include developing drugs to modify the activity of transcription factors – proteins designed to boost the transcription, and therefore expression, of genes that produce frataxin.

But measuring whether these therapies are working is difficult because tracking disease progression by observing clinical symptoms can take months or even years. To detect changes over shorter timeframes, thereby enabling faster development of new treatments, it is necessary to look at molecular activity. As therapies for Friedreich's ataxia aim to increase frataxin levels in the body, frataxin would be the most obvious molecule to measure to determine whether the therapy is effective. However, it is not an easy molecule to measure.

“Frataxin is not secreted by cells into the bloodstream or other body fluids,” says Ian. This means it is challenging to collect samples. Instead of a simple blood test, patients require a biopsy (usually from the heart) to remove tissue that can be analysed, a process that is both costly and invasive. “Also, frataxin levels are naturally very low – only a few nanograms per millilitre,”

Ian continues. This means it is challenging to detect and quantify changes in frataxin levels.

Mass spectrometry: ultra-sensitive molecular detection

To overcome these challenges, Ian and his team use a powerful technique called mass spectrometry. “Mass spectrometry is an analytical technique used to identify and quantify molecules,” Ian explains. It can precisely and sensitively detect even very low levels of frataxin protein – something no other technique can do.

“The most powerful mass spectrometers now enable us to quantify frataxin levels from very small samples – as small as only one milligram of heart biopsy tissue,” says Ian. “I anticipate that future advances in mass spectrometry technology will continue to push the limits of sensitivity, which will make it possible to quantify proteins from even smaller samples.”

Using mass spectrometry, Ian has shown that frataxin levels increase after gene therapy, indicating the treatment is effective. The technique has also highlighted a strong correlation between frataxin levels and the severity and progression of Friedreich's ataxia in patients. However, highly sensitive mass spectrometers are expensive, uncommon and require specialised knowledge to use them effectively. This means this method cannot be used to monitor the disease and therapeutic effectiveness for every Friedreich's ataxia patient. So, Ian and his team are using mass spectrometry to pave the way for more accessible techniques – specifically by searching for biomarkers.

Biomarkers: correlating with frataxin

Ian wanted to find other molecules whose concentrations correlated with frataxin concentrations, but which were easier to quantify. “A biomarker is any measurable characteristic that indicates the state of a biological process,” he explains. “In our case, we sought a molecular biomarker – a molecule whose levels correlate with frataxin levels.” Mass spectrometry provided a tool that was sensitive enough to detect such correlations. During their search, Ian and the team made an unexpected discovery. They found a different form of frataxin, which they named ‘isoform E’, that is present in red blood cells, which do not contain mitochondria.

The purpose of isoform E remains mysterious, but it adds a highly useful tool in Friedreich's ataxia diagnosis and monitoring. “The isoform E version of frataxin provides a precise, sensitive and physiologically relevant biomarker for Friedreich's ataxia,” says Ian. Most importantly, isoform E is found in the blood, meaning it can be measured from a blood test rather than an invasive heart biopsy, and it is present in much higher concentrations than frataxin, meaning it can be detected by less sensitive equipment.

“Our mass spectrometry measurements of frataxin and isoform E expand the biomarker landscape, improve clinical trial outcomes and advance research for Friedreich's ataxia treatments,” concludes Ian. “Our comprehensive approach is crucial for supporting ongoing and future research into therapeutic strategies for Friedreich's ataxia.”

About *pharmacology*

Pharmacology is the branch of science and medicine that focuses on how drugs, chemicals and gene products interact with the body. “Pharmacology is a hybrid science encompassing chemistry, biochemistry and molecular biology,” says Ian. “This means that diverse careers are available in academia, the pharmaceutical and biotechnology industries, and instrumentation development.”

Ian is an expert in mass spectrometry and its applications to pharmacology and biochemistry. “I am highly motivated to use my expertise to enable better therapeutic development, faster

evaluation of potential treatments and improved prediction of patient outcomes,” he says. “It’s been highly rewarding to help facilitate the development of new therapies for Friedreich’s ataxia and other diseases.” For example, the Blair Lab is also using mass spectrometry to support the development of new therapies for Alzheimer’s disease, a neurological disease that causes memory loss and impaired cognition. Recently, Ian and his team showed how the secretion of a specific protein leads to the death of neurons and other cells, and that preventing this secretion could disrupt this process. “This protein could be a

viable drug target to help restore neuron function,” says Ian.

Techniques such as gene therapy are radically expanding the breadth of pharmacology. “A pharmacologist’s work can range from the study of how tiny molecules can be used as drugs and how they are transformed in the body, through to the analyses of large proteins and how modifying their regulation can help treat genetic diseases,” says Ian. “This makes pharmacology a very exciting scientific discipline to pursue as a career.”

Pathway from school to *pharmacology*

At high school, it would be useful to study chemistry, biology, mathematics, computer science and physics.

At university, study a degree in pharmacology or a related field such as pharmaceutical science, biochemistry or molecular biology. Ian recommends taking modules in organic chemistry, analytical chemistry, medicinal chemistry and mathematics.

Download the team’s resources from futurumcareers.com/searching-for-enigmatic-biomarkers-to-address-a-devastating-degenerative-disease



Explore careers in *pharmacology*

Ian recommends seeking a research internship in a pharmacology, biochemistry or medicinal chemistry lab at a university or other research institution. Pathways to Science is a useful directory of summer camps, internships and other student opportunities across the US: pathwaystoscience.org/Discipline.aspx?sort=MED-PharmSci_PharmaceuticalSciences

The Perelman School of Medicine at the University of Pennsylvania runs the Teen Research and Education in Environmental Science (TREES) Program, a research and mentorship programme for high school students: ceet.upenn.edu/education-training/high-school

The British Pharmacological Society provides a wealth of educational resources about the range of career opportunities in pharmacology, from academic research and clinical pharmacology to science policy and medicine licensing: bps.ac.uk/careers-in-pharmacology



Meet Jingqi

Dr Jingqi Fan is a research associate in the Blair Lab.

I've loved animals and all kinds of living creatures since my teenage years. I've also always been curious about the origins of life and how life functions. For example, I often wondered things like 'Why doesn't blood flow out of our bodies?' and 'How does our hair regenerate?'

I previously worked as a clinical doctor, and it was my patients who inspired me to pursue pharmacology research. I realised I couldn't clearly answer their questions to explain the specific mechanisms of drug actions, the true causes of diseases, or why drugs work more effectively in some people than others. This sparked my interest in exploring biomarkers, which led me to conduct protein-related research in the Blair Lab.

I had no prior experience with mass spectrometry before joining the Blair Lab. My most memorable day in the lab was when I first used the mass spectrometer to obtain high-quality protein signals. I was thrilled!

Exploring the unknown is the most captivating aspect of pharmacology lab work. When you do research in pharmacology, you will be exposed to many interesting areas of study and technologies. This means you can explore what you are most interested in.

When I'm not working in the lab, I love playing badminton, swimming and travelling.

“

It was my patients who inspired me to pursue pharmacology research. I realised I couldn't clearly answer their questions to explain the specific mechanisms of drug actions.

”



Meet Teerapat

Dr Teerapat Rojsajakul is a research associate in the Blair Lab.

As a teenager, I was interested in science and engineering. I didn't follow a traditional path into pharmacology research. My journey spans multiple institutions and took me from Thailand to Italy to the US. In that time, I have worked as a chemist across multiple disciplines, as a process engineer in the semiconductor industry, and now I use the breadth of my knowledge and experience to contribute to pharmacology research as an analytical and protein chemist.

I enjoy the opportunity to integrate cutting-edge analytical techniques with translational goals. I find it especially rewarding to contribute to projects that have direct therapeutic implications, where our findings can inform drug development and improve patient outcomes.

Pharmacology demands curiosity, precision and creativity – qualities that thrive in young minds. It offers the chance to explore how drugs interact with biological systems, uncover mechanisms of disease and contribute directly to the development of life-changing therapies. For those who want to make a tangible difference in human health while pushing the boundaries of scientific discovery, pharmacology is an incredibly rewarding path.

In my free time, I enjoy activities that help me recharge and stay curious. I love learning about gene therapy as it keeps me inspired and sharp, and I find joy in writing. I also enjoy spending time outdoors, which helps me stay balanced and brings fresh perspective to my work.

Teerapat's top tips

1. Stay curious and never stop learning. Science is constantly evolving, and a commitment to lifelong learning will keep you sharp and relevant.
2. Build strong technical skills. Mastering core techniques, such as mass spectrometry or computational analysis, will open doors for you.
3. Choose work that aligns with your values. When your research contributes to improving lives, it becomes more than a job – it becomes a legacy.



From teachers for teachers

To help young people become scientists and innovative thinkers, we need empowered and passionate STEM teachers. With this goal at its heart, **Science on Stage Europe** is a vibrant network, supporting educators in their professional development and spreading inspiring teaching concepts across Europe. Chair **Stefanie Schlunk** tells us how investing in teachers is investing in the future.

Science on Stage Europe

How did Science on Stage come about, and how has the network grown?

Science on Stage was born from a simple yet powerful idea: that teachers are the key to inspiring the next generation of scientists, engineers and innovators. It began in 2000 as a European initiative launched by the largest European research institutions, because they realised that they were running out of young STEM talent. When the European Commission stopped funding the network, we founded the non-governmental organisation Science on Stage Europe as a grassroots initiative from teachers for teachers.

Since then, it has grown into a vibrant network reaching over 100,000 STEM teachers across more than 30 countries. Our community is constantly expanding, driven by passionate educators who believe in learning through creativity, experimentation and collaboration.

Who makes up the Science on Stage community?

Our community includes primary and secondary school STEM teachers. In our network, we have hundreds, even thousands, of volunteers involved. What makes Science on Stage unique is our 'from teachers for teachers' approach, our international network, and the fact that



we are a long-term initiative rather than a short-term project. Achieving an impact in education takes time.

We cooperate with industry partners, mainly Gesamtmetall (the Federation of German Employers' Associations in the Metal and Electrical Engineering Industries) but also Vernier Science Education and Amazon Future Engineer, to ensure our projects' and the network's funding. We also have strong connections to other STEM initiatives, such as the EU STEM Coalition, and to universities, non-profit foundations and government ministries.

Science on Stage is powered by passionate teachers, but we cannot do everything we want to do on our own. To equip young people with the skills to tackle global challenges, we need strong partnerships. We invite companies, organisations and national stakeholders to invest in education – not just financially, but through collaboration and support for our member countries. We welcome partners who share our mission to inspire, connect and empower educators so they can ignite their students' curiosity. Investing in teachers means investing in our future.

What are the challenges facing science teachers in Europe today?

Science teachers face many challenges: curriculum overload, lack of resources, multiple administrative tasks, and the need to keep up with rapid scientific and technological advances like AI, Education for Sustainable Development, etc. Perhaps most importantly, they often feel isolated. Science on Stage tackles these issues by building a support network where teachers can exchange teaching strategies, find high-quality materials and boost their confidence. We help teachers in their professional development and growth, motivate them, and value their work by offering opportunities to learn from each other – because committed teachers inspire committed students.

What does a Science on Stage Festival involve?

A Science on Stage Festival is like a science fair but for teachers. It's the largest STEM education event in Europe, bringing together 500 teachers who showcase their best teaching ideas, attend workshops and collaborate across borders. The atmosphere is electric!

A Science on Stage Festival includes:

- **A fair:** Hundreds of primary and secondary teachers present their creative projects at stands where they share experiments, classroom activities and interactive tools.
- **Workshops:** Teachers lead practical, hands-on sessions designed for colleagues to explore, adapt and take back to their classrooms.
- **Highlight sessions:** Selected projects and small experiments are highlighted on stage.
- **Partner forum:** Companies and partners showcase their education initiatives and career paths.
- **Networking:** Cultural activities, evening receptions and excursions for networking and informal exchanges of ideas.

The Science on Stage Festival 2026 will take place in Klaipėda, Lithuania, between the 28th and 31st of May.

Seven guiding themes will shape the festival's programme:

1. STEM for the Youngest (under 10s)
2. STEM Education for Sustainable Development

3. AI in STEM Education
4. Career Orientation in STEM Education
5. Equity and Inclusion in STEM Education
6. Self-Directed Learning in STEM Education
7. Low-Cost Experiments in STEM Education

Special-themed tracks:

- Joint Projects – collaborations between teachers from two or more countries
- STEM for Teachers in Training – initiatives led by future educators

The local organisers of Science on Stage Festival 2026 are Science on Stage Lithuania, the Lithuanian Agency for Non-Formal Education, the Klaipėda STEAM Center, and Klaipėda University supported by the Ministry of Education.

The Science on Stage Festival isn't just an event – it's a launchpad. The projects that originate here are implemented in national teacher trainings, classrooms and communities across Europe, amplifying their impact long after the closing ceremony. ➔

“ Investing in teachers means investing in our future. ”



How does Science on Stage facilitate the sharing of good practice?

We believe that great ideas shouldn't stay locked in a single classroom. Through our events, we bring together teachers from all school levels to share what works. Primary and secondary teachers learn from each other, breaking down silos and building a stronger community. Our projects often focus on interdisciplinary learning and topics related to students' daily lives so that ideas can be applied across the full school spectrum. Teachers work together in long-term projects; they share good ideas via our webinars, and we support cross-border teacher exchanges.

What professional development opportunities do you offer?

We offer a wide range of training opportunities, from workshops and webinars to international teacher exchange programmes. In these exchanges, teachers from different countries visit each other's schools to learn and co-develop new teaching materials. These projects are transformative; they not only improve classroom practice but also foster long-lasting professional friendships.

What teaching materials do you provide?

We provide free, high-quality STEM teaching resources developed by teachers for teachers. These include lesson plans, experiment guides, and interdisciplinary projects that bring science to life. All materials are available on our website as Open Educational Resources, in multiple languages and aligned with curriculum goals. Whether you're looking for ideas on climate change, AI, coding or simple experiments related to everyday life, we've got something for you. Our resources are always practical and classroom-tested.

How can scientists get involved with Science on Stage?

Scientists and academics play a vital role in bridging cutting-edge research with everyday classroom teaching, and we welcome their involvement!

In many countries, Science on Stage's national committees are hosted by universities. This opens the door for academic staff to actively support our mission. They can help spread the word about Science on Stage within their networks, connect with teachers, and

offer valuable insights at national festivals, workshops and webinars.

What impact is Science on Stage having across Europe?

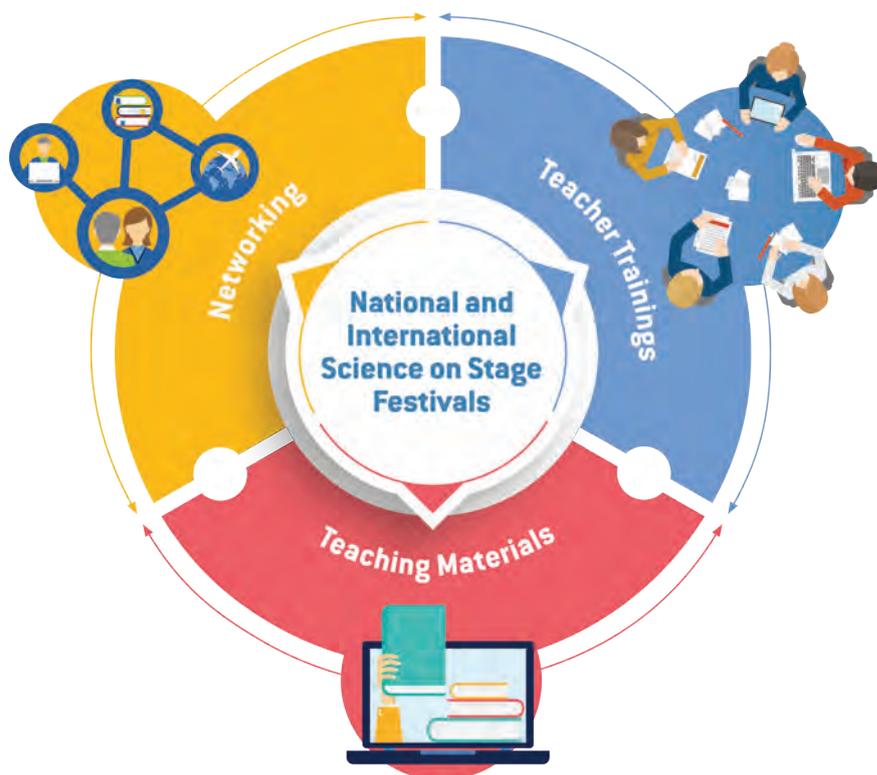
Science on Stage has inspired thousands of teachers to bring innovation into their classrooms. Over the years, Science on Stage has become a powerful catalyst, transforming how STEM is taught across Europe. Here are some numbers from our long-term evaluation:

- 96% of participating teachers have implemented ideas they discovered at Science on Stage events in their lessons.
- 85% have taken those ideas to teacher training events back home, becoming 'multipliers' who spread the innovative ideas shared at our festivals and events.
- The festival ignites international collaboration, with 92% of attendees making new international contacts.
- 89% of festival attendees rate the long-term effects of our festivals as 'high', and 83% plan to participate in the next festival.

“ The Science on Stage Festival isn't just an event – it's a launchpad. ”



“
Science on Stage has inspired thousands of teachers to bring innovation into their classrooms.
 ”



These figures come from our long-term evaluation following the 2022 European Science on Stage Festival in Prague, Czech Republic. The survey covered the period before the event, during the festival and 14 months afterward, showing lasting transformation, not just fleeting inspiration.

As one teacher who has been involved with us over several years expressed: “Science on Stage has changed the way I teach and also my life. I feel motivated and more passionate about my profession.” It’s also very nice to receive positive feedback from the students of these teachers, such as: “I truly hope you continue organising such amazing competitions, with interesting topics that engage students! For me, Science on Stage was a crucial supporter of my journey as a student, and I wish you to continue supporting students the way you always supported me!”

What’s next for Science on Stage?

As ever, we have a lot going on! In preparation for the Science on Stage Festival 2026 in Lithuania, each country is actively hosting national festivals, competitions or selections throughout 2025 to choose teachers to represent it.

Our member countries are running a range of projects. For example, **STEM Jobs for the Future** is in full swing, with two in-person gatherings planned, including a meeting in Berlin in November 2025 and another in June 2026. ‘Quantum Computing in STEM’ and ‘Money and STEM’ projects are also on the horizon.

We will continue upscaling and disseminating good projects. And of course, we want to expand our teacher network. Science on Stage is open to all STEM teachers across Europe, so please join us!

Connect with Science on Stage



THE EUROPEAN NETWORK FOR SCIENCE TEACHERS

-  science-on-stage.eu
-  [scienceonstageeurope](https://www.facebook.com/scienceonstageeurope)
-  [science-on-stage-europe-e.v.](https://www.linkedin.com/company/science-on-stage-europe-e.v.)
-  [scienceonstageeurope](https://www.instagram.com/scienceonstageeurope)
-  [scienceonstageeurope](https://www.youtube.com/scienceonstageeurope)

GESAMTMETALL
 Federation of German Employers' Associations in the Metal and Electrical Engineering Industries

How do immune cells 'evolve' to protect us?

Your immune system is constantly updating to protect you from harmful diseases, but how does it do this? At **Western University** in Canada, **Dr Steven Kerfoot** and his team of immunologists are studying the interactions between B cells and T cells in the immune system and exploring how malfunctions can lead to the development of autoimmune diseases.



Dr Steven Kerfoot

Department of Microbiology and Immunology,
Western University, Canada

Field of research

Immunology

Research project

Investigating interactions between B cells and T cells and how they control B cell immune responses

Funders

Natural Sciences and Engineering Research Council of Canada (NSERC); Canadian Institutes of Health Research (CIHR)

Website

kerfootlab.com

doi: 10.33424/FUTURUM629

Talk like an ...

immunologist

Antibody — a B cell receptor that is no longer attached to a B cell

Antigen — a foreign substance that triggers an immune response, such as a part of a virus or bacterium protein

Autoimmune disease — a disease that occurs when the immune system mistakenly identifies molecules on a healthy cell as antigens and attacks them

B cell — a type of white blood cell that recognises antigens (each B cell recognises a unique antigen)

B cell receptor — the part of a B cell that binds to antigens directly

Multiple sclerosis (MS) — an autoimmune disease caused when myelin is damaged, with symptoms including fatigue, difficulty walking and vision problems

Myelin — the protective substance that surrounds nerve axons

T cell — another type of white blood cell that recognises antigens, but cannot bind to them directly, so other cells have to 'show' the antigen to T cells

can then attack it, or direct other immune cells to attack the invader. Steven and his team are researching how B cells and T cells interact with each other as the immune response to a new antigen develops.

How do B cells and T cells fight infections?

"B cells work by binding directly to an antigen using a feature on their surface called a B cell receptor," explains Steven. "They can also produce

multiple copies of the B cell receptor which, once released to float around the body, are called antibodies." But at first, a B cell does not know if the antigen it recognises is something it should attack or not. To find out, it must bind to the antigen and show it to a T cell that also recognises the same antigen. In this way, T cells and B cells that recognise the same antigen form a partnership to guide the development of the immune response to the new target.

“We all have an immune system to protect us from things that are trying to infect us,” says Dr Steven Kerfoot, an immunologist at Western University. Whenever you develop a cold or pick up a new infection, B cells and T cells in the immune system share the job of identifying the harmful antigen. They



A student checks on the health of a mouse in the lab.
© Steven Kerfoot

“You have millions of B cells, and each recognises its own antigen,” explains Steven. In the same way that each basketball player defends against a specific player on the other team, each B cell is responsible for defending against a specific antigen. For the immune system to work effectively, the B cell receptors and antibodies must stick to the antigen very strongly. The problem is, at the start of the immune response they usually do not stick very well, so to become effective, B cells must ‘evolve’ each time the body encounters a new threat.

How do B cells ‘evolve’?

The first step in B cell ‘evolution’ happens when a B cell meets a new antigen. At first, it will not be good at binding to this unknown antigen, but it immediately begins to replicate itself to create identical clones. “Each of the clones then begins to mutate its gene for producing the B cell receptor,” explains Steven. As with all mutations, some are advantageous and some are disadvantageous. “This means you end up with some B cells that are better at binding to the new antigen and some that are worse.”

Once the B cell clones have mutated, the race is now on, as only the B cells that are most effective at binding to the antigen and carrying it to the T cells will survive. “All the new B cells essentially have a massive fight to the death!” says Steven. “Those that can’t grab the antigen will die.”

The most effective B cells will survive and replicate, producing a new generation of clones, which again mutate themselves. And of these new mutations, some will be even more effective at binding to the antigen and

Over a period of 10 to 14 days after exposure to a new antigen, B cells ‘evolve’ to become ever more effective at binding to it.

will therefore go on to replicate themselves. In this way, over a period of 10 to 14 days after exposure to a new antigen, B cells ‘evolve’ to become ever more effective at binding to it. “Once your immune system has ‘evolved’ B cells that can fight that particular antigen, the next time you get infected (or the first time, if your initial introduction to the antigen was through a vaccine) your B cells will be ready to produce effective antibodies straight away,” says Steven.

What research is the Kerfoot Lab conducting?

“In my lab, we’re interested in the interactions between B cells and T cells,” says Steven. “Once a B cell has captured an antigen, it needs to take it to a T cell and receive a signal to acknowledge it as a ‘successful’ mutation, which can then go on to produce antibodies and replicate itself.” The team is looking at the properties of antigens to understand how changing the quality of the antigen might impact the interaction between B cells and T cells. This involves creating new hybrid antigens and introducing them to genetically modified mice with B cells and T cells that have been programmed to recognise different parts of

antigens. “We can ‘mix and match’ different B cells and T cells by engineering hybrid antigens so that the B cells will recognise one part of the antigen and the T cells will recognise another,” says Steven. “By changing the combinations, we’re trying to understand how that impacts the immune response.”

As a master’s student in the Kerfoot lab, Eden Kemal was involved in designing and making these new hybrid antigens and measuring the outcome of the B cell response. “I discovered that we can improve a bad B cell response by putting a strong T cell in charge of it,” she says.

The team is also studying what happens when the signals between B cells and T cells do not work as they should. Some B cells mistakenly identify molecules on healthy cells in the body as antigens and attack them, leading to autoimmune diseases. For example, if B cells attack myelin in the brain, it causes multiple sclerosis (MS). “In this case, the signals between B cells and T cells aren’t very good, and we’re trying to understand why this is,” says Steven.

PhD student Yi-Han Chen is studying the interactions between these malfunctioning B cells and T cells. “My findings indicate that the immune system might have a previously unrecognised mechanism which limits these harmful B cells,” he says. “This is something we’re excited to explore further.”

These projects give the Kerfoot Lab plenty to study, and the team is looking forward to seeing what they discover next!

About *immunology*

Immunology is the study of the immune system. “The immune system is a finely tuned system,” says Yi-Han. “It protects us from infections but, when it goes out of balance, it can also harm our own bodies. Understanding how it works is not only fascinating but also important for improving human health.”

What does a day in the lab involve?

“A typical day in the lab often starts with data analysis from previous experiments, which helps me plan my next steps,” says Yi-Han. “On days when I conduct experiments, I usually start early since many procedures take several hours to complete.” Yi-Han also spends time ensuring that the mice involved in the

lab’s experiments are healthy and well-cared for. “Working with animals and doing hands-on experiments is a privilege as it gives us a powerful way to understand how the immune system works.” During her master’s project, Eden’s days in the lab involved harvesting cells from mice, staining them so she could observe certain markers, and imaging them to view the cellular architecture.

The joys of being an immunologist

“The most rewarding part of working in the Kerfoot Lab was collaborating and engaging in the scientific process with other lab members,” says Eden. “It’s amazing to see a final product come together that was only possible due to

shared knowledge.” For Yi-Han, studying immunology is rewarding because it provides opportunities to constantly learn and grow as a scientist. “During my PhD, I have developed several new scientific techniques to study B cells,” he says.

The importance of immunologists was globally recognised with the development of the COVID-19 vaccine, which changed the course of the worldwide pandemic and saved over 20 million lives in the first year after its release. Working as an immunologist is an incredibly rewarding career, with the opportunity to contribute towards the development of new vaccines for infectious diseases and new treatments for autoimmune diseases and cancers, improving the lives of countless people.

Explore careers in *immunology*

Some research immunologists, like Steven, conduct scientific experiments in a lab to learn more about the immune system, while others use this knowledge to develop new vaccines against infectious diseases and treatments for problems with the immune system.

Clinical immunologists are medical doctors who diagnose and treat patients who have problems with their immune system, such as autoimmune diseases, allergies or an inability to fight infections.

CareerExplorer provides information about the pathways to becoming a research or clinical immunologist and what the different careers could involve: careexplorer.com/careers/immunologist/how-to-become

Pathway from school to *immunology*

During high school, study biology and chemistry. Other science subjects will also be useful, as well as subjects that will develop your communication skills, such as English.

To become a research immunologist, study immunology, microbiology, biochemistry or biology at university. To become a clinical immunologist, you will need to study a medical degree and then specialise in immunology during your practical training.

Look for opportunities to gain hands-on research experience. This could be as a student researcher in a university immunology lab or through summer schools.



Meet Yi-Han

Yi-Han Chen is a PhD student in the Kerfoot Lab.

As a teenager, I was fascinated by the idea of exploring the unknown. I immersed myself in books about history and geography, imagining the places and cultures I hadn't yet visited. Now, I explore the unknown through science!

I was inspired to study immunology by the revolutionary success of cancer immunotherapy. The idea of harnessing the immune system's natural ability to target cancer cells fascinated me. Eager to learn more, I joined an immunology lab during my final year of university in Taiwan. That hands-on experience solidified my interest in the immune system and its potential, leading me to pursue graduate studies in immunology.

During the COVID-19 pandemic, my interest in immunology deepened further. Vaccination is the most effective way to protect against the virus, and I found my interest shifting to how immune protection is built and maintained. I was fortunate to find the Kerfoot Lab in Canada as the lab's focus aligned perfectly with my growing interest, and I believe Dr Kerfoot's mentorship will shape me into a confident and capable researcher.

After completing my PhD, I hope to pursue a postdoctoral fellowship in the fast-moving field of biomedical science. Working in the Kerfoot Lab has prepared me for this path. By designing experiments, developing new techniques and troubleshooting complex problems, I've gained technical experience and scientific confidence. These skills will help me navigate future challenges and grow as a researcher.

In my free time, I enjoy taking pictures. Photography helps me discover stories in everyday life and has greatly improved my storytelling skills. I also enjoy playing tennis. The rhythm of striking the ball back and forth is very satisfying, and it's a great way to clear my mind and stay active.

Yi-Han's top tips

1. Stay curious and passionate about science.
2. Seize every opportunity to explore and learn.
3. Never stop asking questions – each one brings you a step closer to becoming a skilled and competent researcher.



Meet Eden

Eden Kemal is now a medical student, having previously worked in the Kerfoot Lab as an undergraduate and master's student.

At school, biology was always my favourite subject. I loved learning how the human body works. Outside of school, I enjoyed spending time outdoors, especially cycling to nearby parks with my friends. I also enjoyed volunteering in different settings (including at summer festivals, a daycare centre and hospital gift shops), as it gave me the chance to meet new people and hear about their diverse life experiences.

I was first exposed to the world of immunology as a second-year undergraduate student when I joined the Kerfoot Lab as a work-study student. Hands-on experience in an immunology lab allowed me to deepen my interest in the immune system. During my four years in the lab, I was fortunate to learn from senior students, the lab manager, Heather, and Dr Kerfoot.

Working in the Kerfoot Lab helped prepare me for medical studies, and I am now at medical school. I came to understand the value of learning from mistakes, and I learnt how to approach problems with a resilient and growth mindset. I truly learnt that just because something doesn't work the first time, it doesn't mean you have failed. Instead, it presents an opportunity to learn something new. This mindset is critical in medicine, where challenges are always present and resilience is key. Learning how to seek help from others, reflect on mistakes, and adapt to new approaches has helped me grow both as a researcher and future physician.

In my free time, I love gardening with my family and taking care of my indoor plants. I also enjoy crafting clay pottery, exploring new cafés and going thrifting.

Eden's top tips

1. Be curious and open-minded about science.
2. Science is such a broad field, so try different activities, classes and opportunities to find out what really sparks your interest. Once you discover what excites you, learning becomes so much more enjoyable.

Download the team's resources from
futura-careers.com/how-do-immune-cells-evolve-to-protect-us



How is AI improving smart biomedical devices?

Advances in artificial intelligence (AI) are creating new possibilities for biomedical systems – the implantable or wearable devices that support health and well-being – through a wide range of applications. At **Université Laval** in Canada, **Professor Benoit Gosselin** and his PhD students **Félix Chamberland** and **Michelle Janusz** are embracing these possibilities, creating smart prostheses and solutions for chronic pain.



Professor Benoit Gosselin

Director, Smart Biomedical Microsystems Laboratory, Department of Electrical and Computer Engineering, Université Laval, Canada

Fields of research

Electrical engineering, biomedical engineering, bioelectronics



Félix Chamberland

PhD student

Fields of research

Biomedical engineering, electrical engineering

Research project

Developing a smart prosthetic hand



Michelle Janusz

PhD student

Field of research

Electrical engineering

Research project

Developing a smart vertebra implant

Talk like a ...

biomedical engineer

Analogue-to-digital converter — a device that converts an analogue signal (e.g., voltage) into a digital signal (a series of numbers) that can be processed by a microcontroller

Bioelectronics — the interdisciplinary field that combines biology and electronics to develop devices that interface with, monitor or control biological systems

High density electromyography (HD-EMG) — a technique that measures the electrical activity produced by muscles

Fluorescence — a phenomenon where a substance

absorbs light of one colour and then re-emits light of a different colour

Microcontroller — a tiny computer that controls specific tasks within a single integrated circuit

Myoelectric prosthesis — an artificial limb that is controlled by electromyography signals from muscles in the residual limb

Optogenetics — a biological technique that uses light to control the activity of cells by genetically modifying them to express light-sensitive proteins

Partners

CERVO Brain Research Centre; Centre for Interdisciplinary Research in Rehabilitation and Social Integration (Cirris); Centre for Optics, Photonics and Lasers (COPL); Institute of Intelligence and Data (IID); Strategic Microsystems Alliance of Quebec (ReSMiQ); CMC Microsystems

Funders

Natural Sciences and Engineering Research Council of Canada (NSERC); Fonds de Recherche du Québec (FRQ); Canada Research Chair in Smart Biomedical Microsystems

Website

biomicrosystems.ca

doi: 10.33424/FUTURUM622



Members of the Smart Biomedical Microsystems Laboratory at work in the lab.

Biomedical engineering involves using the principles of engineering to improve health and healthcare. As scientists push the boundaries of our technological capabilities and biological knowledge, the possibilities within biomedical engineering become ever greater and more diverse. In particular, the advent of artificial intelligence (AI) and advances in bioelectronics are enabling increasingly complex biomedical devices.

Professor Benoit Gosselin leads the Smart Biomedical Microsystems Laboratory at Université Laval. “Smart biomedical microsystems are tiny devices that monitor, diagnose or even treat medical conditions,” he says. “They are ‘smart’ due to their ability to sense and process physiological signals and respond intelligently, thanks to embedded electronics, sensors and AI.” Benoit and his team are developing these smart components to usher in the next generation of highly personalised biomedical devices.

Developing a smart prosthetic hand

Félix Chamberland, a PhD student in the lab, is leading a project to develop a smart prosthetic hand, focusing on how the prosthesis receives and interprets signals from the body. “A myoelectric prosthesis is an artificial limb that is controlled by the user’s muscle activity,” he explains. “Electrodes are placed on the surface of the residual limb where they detect electrical signals generated by voluntary muscle contractions, which activate the prosthesis’ motors.”

Most current myoelectric prosthetic hands have a limited range of movements

because they are only capable of processing a few signals from the muscles. “In contrast, our prototype uses high-density electromyography (HD-EMG), which involves placing 64 electrodes in a grid-like configuration on the residual arm,” says Félix. “This enables the extraction of richer information from the muscles, allowing for more complex control strategies and more precise hand movements.”

The electrode grid senses muscle activity from the residual arm, and the large electrode count allows for the capture of a wider range of muscle contractions. An analogue-to-digital converter samples the HD-EMG signals and transmits them in digital form to a microcontroller. “The microcontroller is the ‘brain’ of the prosthesis,” explains Félix. “It processes the signals and feeds them to an AI algorithm to predict the user’s intention based on their muscle contractions. The resultant commands are sent to the prosthesis’ motors to make them move in a specific way.”

Like all such AI systems, the algorithm needs training. “Each hand gesture has a unique muscle activation pattern,” says Félix. “By asking participants with a hand to wear the 64 electrodes while performing specific hand movements or various muscle contractions for amputees, we can record the corresponding activation patterns to use as training data for gesture recognition.” By feeding this data into the AI algorithm, it learns to associate muscle activation patterns with the gestures they lead to. “So far, we have successfully developed the HD-EMG recording system and the AI gesture recognition algorithm,” says Félix. “The next step is to integrate them into a fully functional prosthetic hand.”

Designing a smart vertebra implant

Elsewhere in the lab, PhD student Michelle Janusz is designing a new type of spinal implant to help researchers better understand, and potentially treat, chronic pain. “The spinal cord contains neurons that carry pain signals from the body to the brain,” she explains. “In chronic pain conditions, some of these neurons become overactive and keep telling the brain there’s pain, even when there’s no injury.” To stop these false signals, Michelle’s smart vertebra uses light to control which neurons are active. This technique, called optogenetics, involves genetically modifying specific neurons to make them responsive to light. “By using light instead of electricity, we can target only the problem cells and avoid affecting the others,” she says. “This allows for much more precise treatment than current spinal cord stimulators, which rely on broad electrical signals.”

But controlling the neurons is only half the battle. The implant also needs to monitor neuron activity in real time to know when to intervene. To do this, it uses fluorescent light-sensitive proteins that glow when neurons activate. “This ‘glow’ acts like a signal that tells us when the neurons are active, so we can respond at just the right moment to stop the pain signal,” Michelle explains. This helps the smart vertebra intervene only when necessary, reducing side effects like numbness.

The implant will replace one of the spine’s vertebrae and is shaped to fit naturally into the spinal column. “Since visible light doesn’t pass through tissue very well, replacing the bone lets us get close enough to shine light directly onto the neurons without damaging the spinal cord,” says Michelle.

Michelle is currently building a prototype smart vertebra using off-the-shelf components to test the system. The goal is to eventually create a smaller version with custom electronics and optics. “We’re combining microelectronics, AI, light and biology to design a smarter, more precise tool for chronic pain treatment,” she says.

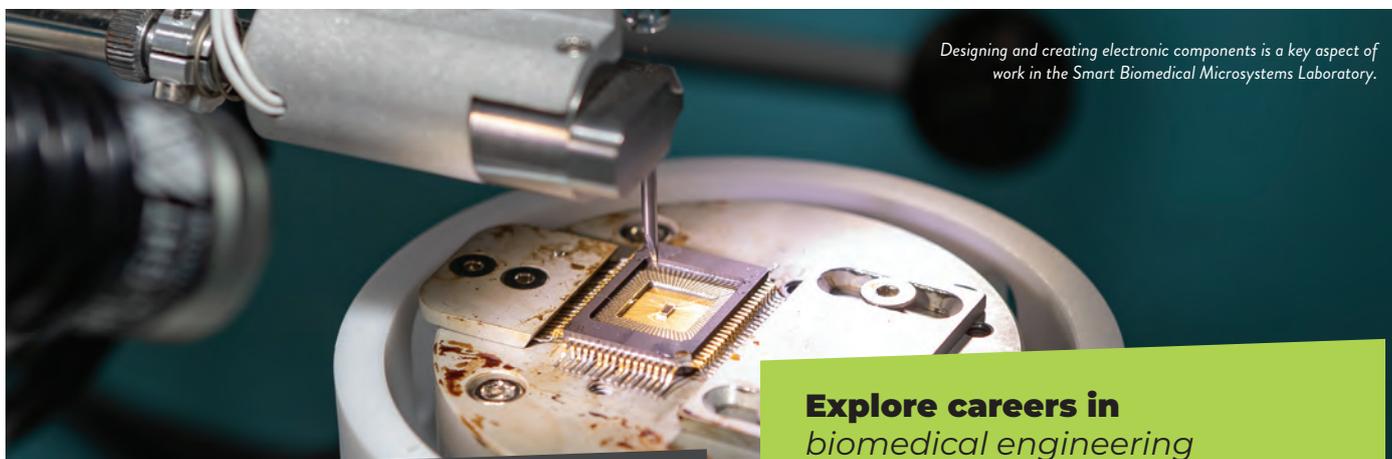
The importance of interdisciplinary collaboration

“Developing smart biomedical devices isn’t just about electronics – it requires a blend of skills,” says Benoit. “Our lab is home to a vibrant, multidisciplinary team of graduate students, postdoctoral fellows and research associates, all working together in a collaborative and supportive environment.”

Electrical and computer engineers design the circuits and sensors needed in the devices, while biomedical and materials scientists ensure the devices are compatible and safe for the body. Neuroscientists and physiologists interpret biological signals recorded by the devices, computer scientists and AI specialists build the underlying code, and clinicians and rehabilitation experts ensure the devices meet real-world medical needs. The lab also collaborates with other research centres to strengthen this interdisciplinary approach. “Together, these partnerships create a rich ecosystem for developing smart biomedical microsystems that are innovative, intelligent and clinically meaningful,” explains Benoit. “It’s at this intersection of disciplines that true innovation happens.”

Lab success

The technology being developed in the Smart Biomedical Microsystems Laboratory will pave the way for exciting advances in biomedical engineering. As well as contributing to high-impact research projects, students in the lab also benefit from personalised mentoring, a culture of excellence and equal opportunities to participate in a respectful, inclusive environment. Many team members have won awards in recognition of their work, such as Michelle’s success at reaching the national level of the ‘3 Minute Thesis’ competition. As Benoit proudly states, “Our lab offers the environment and support for students to thrive and make their mark in the world of biomedical engineering!”



Designing and creating electronic components is a key aspect of work in the Smart Biomedical Microsystems Laboratory.

Pathway from school to biomedical engineering

At high school, focus on studying mathematics, physics, biology, chemistry and computing to build a foundation for engineering and medical science. “Start coding as early as possible,” advises Félix. “Programming is one of the most essential skills in engineering.”

At university, a degree in biomedical engineering, electrical engineering or computer engineering could lead to a career in biomedical engineering. Take courses in biomechanics, medical imaging, bioinstrumentation (the design and application of devices and systems for measuring, monitoring and analysing physiological signals in healthcare and research) and neural engineering, and learn how to apply this knowledge to real-world healthcare problems.

Scientific communication and presentation skills are highly valuable in the interdisciplinary field of biomedical engineering. “I am a strong advocate for being able to communicate the topic to a range of audiences,” says Michelle. “Use any oral presentations as opportunities to improve your communication skills while sharing your interests and passions.”

Explore careers in biomedical engineering

“Biomedical engineering is the application of engineering in the medical domain,” explains Félix. “Whether it is developing a prosthetic hand, a neural implant, a skin graft, a medical imaging instrument or a wheelchair, the range of opportunities in the field is vast.”

Look for internships to gain hands-on experience with biomedical engineering, reach out to professors to ask whether you can visit their lab, attend science camps, volunteer in healthcare settings, and read about recent research and technologies.

“Stay curious,” advises Michelle. “Take an active interest in biomedical engineering to identify which areas of the field most interest you.”

“Remember that real learning often starts outside the classroom,” says Benoit. “Use platforms like OpenBCI (openbci.com) and Hackster (hackster.io) to build your own biomedical engineering projects.”

Organisations such as the Canadian Medical and Biological Engineering Society (cmbes.ca), the IEEE Engineering in Medicine and Biology Society (embs.org), and the Biomedical Engineering Society (bmes.org) provide outreach opportunities and career information.

Meet the team



Meet Benoit

As a teenager, I was drawn to discovering new technology – whether it was opening gadgets to see how they worked or getting excited about the latest innovations. I also loved watching sci-fi movies, which

sparked my imagination and interest in futuristic ideas, and made me dream about building the future.

I was inspired to become an electrical engineer thanks to these sci-fi movies, plus the contagious passion of my college and university professors. From classroom demos to stories about advanced technology and AI, it all made engineering feel like the perfect path to turn imagination into reality.

Developing smart biomedical microsystems starts with creativity

and imagination. My background in electrical engineering gives me the tools and scientific understanding to convert ideas into real working devices. I love solving complex challenges with innovative solutions that can truly make a difference.

In my free time, I still enjoy watching sci-fi movies. I also love hanging out with my family and friends and, whenever possible, travelling to discover new places and experiences.



Meet Félix

I enjoyed hockey, math and science when I was in high school. My dad is an electrical engineer which had a big influence on my decision to pursue a career in engineering, though for many years I was torn between becoming an engineer or a doctor. In the end, I chose to become an engineer who works with doctors to help patients!

I'm a biomedical engineer at heart, which means I have skills to take on a leadership

role in developing our smart prosthetic hand. I've had to learn electrical engineering skills along the way, as most of the work involves developing the AI-embedded system for muscle activity recording, which requires circuit design and programming. I am involved in multiple aspects of the project, bringing together various components to create a complex, functional system.

Outside of the lab, I'm very active. I enjoy running, working out, and playing volleyball, soccer and tennis. I also like spending time with my friends and playing intellectual games like chess and poker.



A representation of Félix's myoelectric prosthetic arm. The custom-made socket integrates an electrode array for HD-EMG sensing, a microcontroller for real-time signal processing, and batteries for power. The system can send commands to finger motors of most commercial prosthetic hands.



Meet Michelle

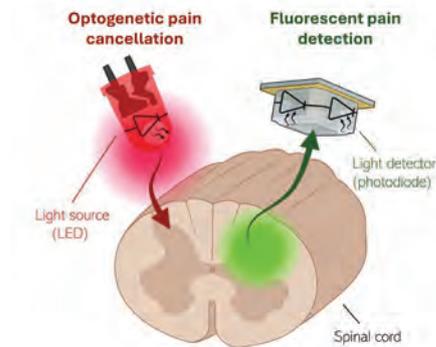
As a teenager, I had creative hobbies such as sewing and painting. I took an advanced math curriculum in high school and participated in a science co-op where I did a research placement at a children's hospital. This showed me that research was definitely a path I wanted to follow.

My father urged me to pursue whatever career I wanted and was very supportive

of my decision to follow in his footsteps as an electrical engineer. During my time at university, I became aware that not everyone is lucky enough to have such a strong support system. This drives my passion to encourage more women to study electrical engineering, where representation remains very low.

I've been working to increase my neuroscience knowledge. This allows me to approach the smart vertebra project with my technical electrical engineering skills and an awareness of the biological challenges and limitations that neuroscientists work with.

In my free time, I enjoy yoga, weightlifting, long-distance running, hiking in nature, sewing and painting.



A representation of Michelle's vertebra implant, which includes a light detector and light source to identify then prevent pain signals being sent by neurons.

Download the team's resources from futurumcareers.com/how-is-ai-improving-smart-biomedical-devices



What can data tell us about the long-term effects of surviving childhood or adolescent cancer?

Our childhood and teenage years are full of milestones and transitions that impact the rest of our lives. For children and adolescents who receive a cancer diagnosis, this important period can be severely disrupted, and the long-term effects of their disease and its treatment can stay with them their whole life. **Dr Paul Nathan** at **The Hospital for Sick Children** and the **University of Toronto** in Canada is using large datasets to gain a better understanding of these long-term effects, with the aim of improving outcomes and support for survivors of childhood and adolescent cancer.



Dr Paul Nathan

Director of the Aftercare Clinic and Head of the Solid Tumour Program, Division of Haematology/Oncology, The Hospital for Sick Children, Canada

Professor, Department of Paediatrics, Department of Health Policy, Management and Evaluation, University of Toronto, Canada

Fields of research

Paediatric and adolescent oncology, cancer survivorship, health services research

Research project

Investigating the late effects of childhood and adolescent cancer through the Real-World Outcomes of Cancer in Children and Adolescents (ROCCA) research programme

Funders

The Canadian Institutes for Health Research (CIHR); The US Department of Defence (DOD); Advancing Childhood Cancer Experience, Science and Survivorship (ACCESS); Canadian Cancer Society

Websites

lab.research.sickkids.ca/rocca

lab.research.sickkids.ca/nathan

doi: 10.33424/FUTURUM627

Talk like a ...

paediatric oncologist

Adolescence — the transitional phase of growth between childhood and adulthood

Chemotherapy — a treatment that uses drugs to kill cancer cells

Late effects — health problems that continue for months or years after cancer treatment has ended

Paediatric oncology

— the study, diagnosis and treatment of childhood and adolescent cancer

Surveillance — the ongoing and repeated monitoring of a patient's health to make sure any issues are spotted as soon as possible

Life as a child or teenager can be like a high-speed rollercoaster, full of changes and new experiences, such as forming friendships, gaining qualifications and travelling to new places. Unfortunately, receiving a cancer diagnosis at this age can make these formative years challenging.

“Getting diagnosed with cancer during adolescence can derail all the important life transitions that are taking place at this time,” says Dr Paul Nathan from The Hospital for Sick Children. “Puberty, dating, going to college or university, getting a job, moving out of the family home, and taking increasing responsibility for one’s life are all important things

that happen during this period.” Over 80% of children and teenagers will survive cancer, but these survivors may face the effects of their cancer and the disruption it caused for the rest of their lives. Paul is working to understand more about these long-term effects, with the aim of improving care and support for survivors.

What are late effects of cancer?

“Late effects of cancer include the long-term side effects that can develop from the cancer itself, such as the destruction of healthy bone due to a bone tumour, or from the treatments such as chemotherapy, radiation, surgery and bone marrow



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transplants,” explains Paul. “Late effects can be physical, psychological or social, and some can be serious or even life-threatening.”

A cancer diagnosis and the following treatment can also result in financial difficulties for patients and their families. In countries such as Canada and the UK, public health care systems help to cover some treatment costs; however, hidden costs can still create financial difficulties. In countries with weaker public health systems, the financial challenges inflicted by a cancer diagnosis can skyrocket. “In the US, survivors of childhood cancer are at elevated risk of debt and occasionally need to declare bankruptcy,” says Paul. There are often hidden costs, such as travel to and from appointments, and parents may have to reduce their working hours or even leave their jobs so they have time to care for their child or teen with cancer. “Interruptions to schooling or work (and the transition from one to the other) can have long-term financial impacts,” says Paul. “Because of their cancer or its late effects, adolescents may pursue a different education or employment path than they had hoped for.”

Why is continued surveillance important?

Once someone has survived cancer, it is important that they attend regular appointments to undergo surveillance in case further health problems arise. Although the risk of the cancer returning begins to decrease after the first 5 years, the risk of late effects increases as survivors get older. For example, some cancer therapies put survivors at risk of developing new cancers, heart disease and even post-traumatic stress disorder, so continued surveillance is vital. However,

“

Because of their cancer or its late effects, adolescents may pursue a different education or employment path than they had hoped for.

”

many survivors fail to regularly attend their appointments. “Many survivors do not know what specific treatments they received, or the late effects that may result from these,” says Paul. “This makes it harder for them to share this information with doctors, and harder for the doctors to provide appropriate care.”

What is the ROCCA programme?

Working with his colleagues, Dr Sumit Gupta, a paediatric oncologist, and Dr Petros Pechlivanoglou, a health economist, Paul has founded the Real-World Outcomes of Cancer in Children and Adolescents (ROCCA) research programme. In Canada, a wealth of data is collected within the public health system, including demographic data, such as sex and area of residence, and data about cancer, recording things like type of cancer, treatments and outcomes. “ROCCA takes advantage of these data to study a whole range of outcomes in children and adolescents who have had cancer,” says Paul. “Because we capture the whole population, this gives us a unique perspective that we can’t get just by looking at patients who participated in clinical trials.”

Paul must ensure that patient anonymity is preserved throughout the research, so precautions are taken. “For all of this research, all personal identifiers such as name and date of birth are removed from the data so we are not able to identify individuals, but we can still study outcomes across the whole population.”

What has Paul learnt?

Paul has been using the ROCCA data to answer a number of questions. “We have used these data to study different late effects, to explore the best places for teens with cancer to receive care and to understand which survivors are most at risk of missing their surveillance tests,” says Paul. “This allows us to design interventions to try and improve adherence. For example, a new programme called ONloop is using administrative data to find out which survivors are not up-to-date with their surveillance. This allows us to reach out to them and their family doctors to make them aware of the surveillance they need and then to send them periodic reminders to ensure they stay up-to-date.”

In future research, Paul is keen to learn more about the long-term financial impacts of cancer on patients and their families. “For example, if someone gets cancer aged 15, how does their education and financial situation change over time compared to their classmate who didn’t get cancer?” says Paul. “To study this, we are linking data about patients in our Canadian paediatric cancer registry with their tax return and education data.” As ROCCA uncovers more about the late effects of childhood and adolescent cancer, paediatric oncologists like Paul will be better equipped to support patients and their families.

About *paediatric oncology*

The field of paediatric oncology aims to improve outcomes for children and adolescents who have been diagnosed with all types and stages of cancer. Paediatric oncologists might work directly with patients on the ward or in outpatient clinics, they might conduct clinical trials and analyse data, or they might train and supervise other oncologists and healthcare providers. “The balance between all of these responsibilities varies from one oncologist to the next, but there is always good variety and lots of fascinating challenges,” says Paul. “Many of us also spend time travelling to conferences where we learn about, or teach others about, the latest research.”

Paul finds working in paediatric oncology incredibly rewarding. “The medicine is fascinating and the science is constantly evolving,” he says. “Supporting the patients, their parents and their siblings through the psychosocial challenges of cancer treatment is tremendously rewarding. I really enjoy the blend of clinical care and research, and I am constantly learning from my patients which helps to generate new research ideas.”

Despite the rewards, paediatric oncology can be a challenging field to work in. “Even with the much-improved survival rates, there are still patients who cannot be cured,” says Paul. “The difference I can make is

not always about curing a patient, but often about helping a child or teenager navigate their cancer diagnosis and trying to make their road through it a little easier, even if, ultimately, they do not survive. Having an excellent team that supports each other both professionally and emotionally is incredibly helpful.” Paul splits his time between clinical work and research. This balance allows him to invest all of his emotional energy into helping patients and their families.

Pathway from school to *paediatric oncology*

At school, study biology, chemistry and physics to build a solid foundation for pursuing medicine and specialising in paediatric oncology. Developing skills in data analysis and programming will also be useful for further research in college, university or work as a paediatric oncologist.

“The journey to becoming a paediatric oncologist has many steps,” says Paul. “In Canada and the US, you should start with an undergraduate degree with a science focus. Then, you must complete medical school followed by a paediatric residency and a fellowship in paediatric oncology. This pathway may be different in other countries.”

While at university, get involved in the research projects being conducted in your department to gain direct experience of biomedical research.

“Try to get volunteer experience in a medical or hospital setting to find out if patient care or medicine is really something that you want to do,” says Paul.

Explore careers in *paediatric oncology*

The American Society of Clinical Oncology (asco.org), the British Association for Cancer Research (bacr.org.uk) and the British Oncology Network for Undergraduate Students (bonus-oncology.co.uk) all have useful websites with information, resources and volunteering opportunities. You could even consider becoming a student member.

The University of Toronto runs a Youth Summer Programme where students can get together to learn about life sciences: yssp.utoronto.ca/medysp

The Hospital for Sick Children offers a Summer Research Programme that provides undergraduate students with professional and career development opportunities: sickkids.ca/en/research/research-training-centre/summer-research-program

Download Paul's resources from futurumcareers.com/what-can-data-tell-us-about-the-long-term-effects-of-surviving-childhood-or-adolescent-cancer



Meet Paul

As a teenager, I didn't know that I would be interested in medicine, although it was certainly on my radar. I liked math and science, but I also liked English and social studies. At university, I realised that I wanted to work with and help people, so medicine seemed like an ideal path.

I love the opportunity to work with and help kids, teenagers and their families. I can't imagine anything as challenging as having to face a cancer diagnosis. To be able to care for and support young people and their families through this huge challenge is immensely rewarding. It is a privilege to be part of their lives.

The science I work with is fascinating, constantly evolving, and always opening new opportunities to treat patients or help them deal with the short- and long-term side effects of their therapy. To be working at this cutting edge of knowledge is incredibly stimulating.

I get to work with a team of amazing, smart, compassionate colleagues. Paediatric oncology is hard, but having such an incredible group of colleagues to share this journey with is a real gift.

Being inquisitive and enjoying working with people has enabled me to lead a successful career. I'm also fascinated by science and discovery, and I love being able to make a difference to people's lives.

Oncology is hard — even when you do your best, some patients don't survive. Being able to process and cope with this loss is one of the job's big challenges. Separating your work life from your home, family and relationships is critical. I am blessed to have an amazing family and to really enjoy my life outside of work. This balance is key.

To unwind from work, I enjoy spending time with family and friends. This is simple, but so rewarding and rejuvenating. I also enjoy reading, mindfulness meditation and exercise.

Paul's top tip

Paediatric oncology is an immensely rewarding profession. But there are lots of rewarding professions, so be sure that this is something you are passionate about. It is a long road, so you have to enjoy the process and love learning, and you need to be happy living in the moment – you must enjoy the journey as well as the destination.

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Making nuclear-powered space travel a reality

Nuclear reactions are capable of producing huge amounts of energy, which can be harnessed in nuclear power stations. However, current systems are limited by their size and durability. **Dr Austin Lo**, Chief Research Officer at **GenAlpha Nuclear Technologies** in the US, is developing a groundbreaking new technology to overcome these limitations. His innovation is paving the way for compact and long-lasting nuclear energy systems, which could open new frontiers for many industries, including space exploration.



Dr Austin Lo

Chief Research Officer,
GenAlpha Nuclear Technologies, USA

Fields of research

Nuclear engineering, thermionic energy conversion, low-temperature plasma physics

Research project

SPACE-TEC (Structured Plasma Cell-Thermionic Energy Conversion): developing a groundbreaking nuclear fuel technology that can directly convert nuclear heat into electricity

Funder

US Advanced Research Projects Agency – Energy (ARPA-E)

The contents are solely the responsibility of the authors and do not necessarily represent the official views of ARPA-E.

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In most of our energy generation systems, heat is created and converted into electricity. For example, burning fossil fuels, such as coal and natural gas, generates heat, as do the nuclear reactions that take place in nuclear power plants. After this heat is created, both systems work on the same principles: the heat causes water to evaporate, creating high-pressure steam which spins turbines,

Talk like a ...

nuclear engineer

Clean energy transition

— the global shift away from fossil fuels to clean energy sources

of unstable atoms in the form of particles or electromagnetic waves

Low-temperature plasma

— ionised gas in which the smaller, negatively-charged electrons have higher energy than the larger, positively-charged ions, allowing reactions to occur at lower temperatures

Nuclear reactor — a device used to initiate and control a self-sustaining nuclear reaction

Photon — a particle representing the smallest possible unit of light

Metal foam — a solid metal with many gas-filled pores, like a sponge made of metal

Thermionic energy conversion (TEC) — a method of directly converting heat into electrical energy without intermediate conversions, such as movement

Nuclear radiation — the energy released by the nuclei

creating mechanical energy that is converted to electrical energy by generators. But these intermediate steps – evaporating water and spinning turbines – require a lot of parts, space and ongoing maintenance.

While the fossil fuel industry is expected to wind down over the coming decades (because of its negative impacts on the climate), the nuclear industry could become a

major source of clean energy in the future. Current nuclear power plants are massive and take a long time to plan and build, but Dr Austin Lo, Chief Research Officer at GenAlpha Nuclear Technologies, believes it is possible to harness a different, much more compact system to convert nuclear heat into electricity. Such a system would open up a huge range of new applications for nuclear energy – not least as a power source for the spacecraft of the future.



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Thermionic energy conversion: cutting out the middleman

Thermionic energy conversion (TEC) is a method of converting heat into electricity without any moving parts. “TEC involves heating up a special ‘emitter’ metal to very high temperatures, at which point it begins to lose electrons,” explains Austin. “These electrons travel across a very small gap to a ‘collector’ metal, creating an electrical current.”

In principle, this process works well, but in practice, it has some major efficiency limitations. For example, as electrons are released, they can build up around the surface of the emitter, creating an electric field that blocks any further electrons from being emitted. “This is known as the space-charge effect, and most current thermionic energy converters counteract it using a low-temperature plasma to help conduct the flow of electrons between the emitter and collector,” explains Austin. “Most designs create this plasma using the energy from the emitted electrons, which means there’s much less energy available to be converted to electricity.” Given the extremely high temperatures involved, further energy is lost as heat radiation. Current TEC systems have a typical efficiency of below 7%, and have few applications beyond research laboratories.

SPACE-TEC: uniting nuclear radiation and thermionic energy conversion

Austin’s ground-breaking project, SPACE-TEC, employs innovative solutions to address these inefficiencies. In particular, SPACE-TEC uses nuclear radiation to heat the emitter and create the low-temperature

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Our system could help power future space stations, rovers, or even settlements on the Moon or Mars.

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plasma needed for TEC to operate. While other nuclear-based TEC systems also use nuclear radiation as a heat source, they still rely on energy from emitted electrons to create the plasma.

“In contrast, the highly-pressurised gases used in SPACE-TEC create an environment in which the nuclear radiation naturally knocks electrons off atoms in the emitter, collector and other structural components, creating the low-temperature plasma,” says Austin. “This means that more energy is available to be received by the collector, rather than being used to create the plasma.”

SPACE-TEC also uses specialised metal foams as the emitter and collector. These are essentially highly-porous metal ‘sponges’, full of tiny holes and channels that give them a huge overall surface area. “This means more places for electrons to escape from the emitter, travel through the plasma, and be collected at the collector,” says Austin.

Metal foams also help address the issue of heat loss. In a conventional TEC system,

heat is lost through the emission of photons, which radiate out of the system. However, in SPACE-TEC, photons have a much higher chance of being reabsorbed thanks to the high surface area of the porous metal foam. This means that the system can operate efficiently at lower temperatures.

Nuclear-powered futures: even the sky’s not the limit

The qualities of SPACE-TEC technology give it a range of exciting applications. “SPACE-TEC could make nuclear power plants much smaller, simpler and cheaper,” says Austin. “Since it doesn’t involve big turbines and complicated equipment, we can build power systems that are easier to transport and quicker to set up.” This could make nuclear power a much more practical, efficient and economical option for the clean energy transition – not to mention a viable means of exploring the final frontier. “In space, it’s ideal to have a lightweight, compact power source with no moving parts,” explains Austin. “Our system could help power future space stations, rovers, or even settlements on the Moon or Mars.”

But before these applications can become reality, Austin needs to test and refine the technology. “We’re currently testing the system in a research nuclear reactor,” says Austin. “Our next steps include improving the materials, making the system more efficient, and running longer tests to make sure it’s safe and reliable. After that, we’ll work on scaling it up and designing versions for different uses – both on Earth and in space.”

About *nuclear engineering*

Nuclear engineering involves finding innovative methods of harnessing the energy released by nuclear reactions. Much of this work occurs at the cutting-edge of our knowledge and capabilities. “Nuclear engineering is at the forefront of solving some of the world’s biggest challenges, such as providing clean energy, enabling space exploration and advancing medical technologies,” says Austin. “Whilst conducting the first experiment to test one of these concepts, I thought, ‘I might actually be the first person in the world to do this.’ It is incredibly rewarding to work on brand new ideas that nobody has tried before, but it doesn’t come with an instruction manual – you have to figure it out as you go.”

Making mistakes and learning from them is a necessary and indispensable part of such research. “Trust me, you won’t get it right the first time – nor the second, nor the third,” says Austin. “Be willing to try, fail and try again.” This takes resilience and perseverance, but will ultimately pay off. “Another challenging, but also rewarding, factor is that nobody is going to make you do the work,” says Austin. “You have to be your own biggest motivator.”

The field of nuclear engineering involves a lot of collaboration across disciplines. “My research combines nuclear science, materials engineering, plasma physics and advanced manufacturing,” says Austin. “No one person can master all

these areas, so working with experts from different fields is essential.”

The future of nuclear engineering is very bright, with many sectors just beginning to consider how nuclear energy could bring revolution. “There will soon be exciting opportunities to design advanced reactors, develop new radiation therapies and explore innovative ways to generate energy,” says Austin. “The field is growing quickly, so now is a great time to get involved!”

Pathway from school to *nuclear engineering*

Austin says that studying mathematics and physics in high school is essential. Other complementary subjects include computer science, chemistry and biology, as well as humanities subjects that build world knowledge and communication skills.

At university, Austin recommends looking for courses in nuclear engineering, mechanical engineering or physics.

“Look for opportunities to get involved early,” says Austin. “Try for internships, even if they aren’t directly in nuclear engineering – anything that gives you hands-on experience solving problems will help you build useful skills.”

Explore careers in *nuclear engineering*

As well as academic careers, there are a range of career options in nuclear engineering in sectors such as energy, defence, space and healthcare. This page from RaiseMe gives an idea of roles and responsibilities:

[raise.me/careers/architecture-and-engineering/nuclear-engineers/](https://www.raise.me/careers/architecture-and-engineering/nuclear-engineers/)

The Pathways to Science website provides a great directory of US-based summer camps, internships and activities in the field of chemical and nuclear engineering, including opportunities for high school students: [pathwaystoscience.org/Discipline.aspx?sort=ENG-ChemNuclear_ChemicalNuclearEngineering](https://www.pathwaystoscience.org/Discipline.aspx?sort=ENG-ChemNuclear_ChemicalNuclearEngineering)

DanFusion provides a list of plasma physics summer schools based in Europe: [danfusion.dk/for-members/summer-schools](https://www.danfusion.dk/for-members/summer-schools)

Download Austin's resources from
futurumcareers.com/making-nuclear-powered-space-travel-a-reality



Meet Austin

As a teenager, I was mostly focused on learning classical piano and playing tennis. While I was good at math and science, they weren't really my passions. That changed in my senior year of high school, when a physics class completely shifted my perspective: suddenly, math wasn't just abstract number puzzles, but a way to understand how the world works.

Nuclear energy has incredible power. Every nuclear reaction releases or absorbs about a million times more energy than a typical chemical reaction. The possibilities of what we could do with that energy are limitless. There is still so much we don't know, and so much potential to discover and apply.

Curiosity, creativity and persistence are essential in my field. I've learned to ask tough questions, to stick with ideas that show promise and to walk away from ones that don't. Also, doing what I'm not 'supposed' to do has been the key to my biggest innovations. I love being able to run the show and make my own decisions.

I always try to be honest with myself and with others, even if it's uncomfortable. People can tell when you're being real, and they respect that. And although you might be able to get pretty far on your own, it's your collaborators, mentors and teammates who help you over the finish line every time.

Outside of work, I'm a very active person! I love tennis, pickleball, boating, rock climbing and jetboarding – which is riding on a jet-propelled surfboard!

Austin's top tip

Nuclear engineering has a lot of different career paths. Don't lock yourself into one too early. Explore different areas, try new things and don't stress if it feels like you're jumping around or moving slower than others. The variety will make you more adaptable and well-rounded in the long run.

Bugs and artificial intelligence: what is happening in the field of software engineering?

Software plays a huge role behind the scenes of our lives, but there can be disastrous consequences when it malfunctions. **Dr Masud Rahman**, a software engineering researcher at **Dalhousie University** in Canada, is studying how to fix software bugs, as well as confronting the challenges and opportunities that artificial intelligence (AI) is bringing to this field.



Dr Masud Rahman

RAISE Lab, Faculty of Computer Science,
Dalhousie University, Canada

Field of research

Software engineering

Research project

'Mining, Intelligence and Automation in Tackling Machine-Learning Bugs' – developing new tools and methods for tackling deep learning bugs

Funder

Natural Sciences and Engineering Research Council of Canada (NSERC)

Website

raise.cs.dal.ca

doi: 10.33424/FUTURUM632

Although software bugs are tiny errors in computer code, the impact of the failures they cause can be catastrophic. Software bugs cost the global economy trillions of dollars every year and have been the cause of significant information leaks, air and spacecraft crashes, power outages, company bankruptcies and medical disasters. Being able to find and fix these errors is a massive part of the work of software engineers and is crucial for creating safe and dependable software. But why is it so difficult?

Talk like a ...

software engineering researcher

Artificial intelligence (AI) — the ability of computers to perform tasks previously done by humans, such as translating languages, analysing data and making recommendations

Bugs — a flaw or error in a computer program that causes the machine to behave incorrectly

Debugging — the process of removing errors so that a computer program runs as expected

Deep learning — a method of teaching AI models

to process complex data so that they can mimic the human brain

Large language models (LLMs) — AI models that have been trained on large amounts of text to understand human language

Software developer — a person developing software by writing programming code

Software engineer — a person designing and developing software following the best engineering practices

Maintaining and fixing software

Unlike other consumer products, software is unique in that once it has been produced and is in use by customers, engineers still spend time changing it. Think of an app that you use regularly, and you will probably realise how certain features have been changed or altered. For example, in July 2025 alone, TikTok's updates ranged from launching 'Bulletin Boards' to releasing its own font, TikTok Sans. Such updates are part of

what is called the maintenance phase of software and take up around 50% of software developers' time. "Software might go through changes due to a number of circumstances," explains Dr Masud Rahman of Dalhousie University. "It might encounter a failure that needs to be addressed immediately, it might miss very important features that need to be incorporated, or it might be changed to run on an operating system for which it was not originally designed."



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If a user (often a regular customer) notices a bug in the software – something that does not seem to be working properly – they might submit a complaint explaining it. Developers then try and recreate the bug on their own machine. “Reproduction is useful in two ways,” says Masud. “Firstly, it confirms the presence of the reported bug in the software. Secondly, it provides complementary information about the bug (e.g., symptoms, root causes), which might not be present in the bug report.”

However, recreating a bug is not straightforward. “Software users (a.k.a., bug reporters) often fail to provide the necessary details in their bug reports due to a lack of experience or security/privacy concerns,” explains Masud. “In some cases, recreating the same reported scenario on a developer’s machine is either infeasible or prohibitively costly.”

How is AI changing software engineering?

Up until now, software has always been written by human developers. This has meant that if there was a bug hidden within a piece of code, it was relatively easy for developers to find and fix it, as they were often the ones who wrote the code in the first place! However, in recent years, more companies are beginning to use artificial intelligence (AI) to write their software.

While AI models are bringing huge benefits to the world of software engineering, they come with a new wave of challenges too. “AI (a.k.a., Deep learning)

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Unlike traditional bugs, deep learning bugs are often unpredictable, data-driven, multifaceted and highly complex.
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models learn to mimic human capabilities, such as writing an essay or a computer program, by looking at tons of human-generated artifacts (e.g., code, texts) and can sometimes be unpredictable. Thus, if something goes wrong within the AI model writing software, whose working process is not well known to the developers, it is difficult for them to detect and correct,” says Masud.

As well as being difficult to find, studies have found that only 3% of deep learning bugs are reproducible by developers. “Unlike traditional bugs, deep learning bugs are often unpredictable, data-driven, multifaceted and highly complex,” says Masud.

While many tools have been designed over the last few decades to help find traditional software bugs, these methods are not capable of tackling errors in deep learning systems.

The need for new methods

In his software engineering research lab, Masud and his team are trying to

detect and reproduce more of these deep learning bugs and find new ways of fixing them. To do this, they use information from the bug report, the faulty version of the code and past changes made to this code, information from programming sites such as Stack Overflow, and help from large language models (LLMs) such as ChatGPT, Llama and Mistral. “We also look at hundreds of software bugs that others have reported, investigated and corrected for an in-depth understanding,” says Masud.

The team has already had multiple successes with its work and developed several new tools. “These include Bugsplainer, which explains faulty software code in plain language, and DEFault, which detects and diagnoses faults in deep learning models,” says Masud. These tools have attracted new industry partners and funding, and one of Masud’s tools was even featured on the **Stack Overflow** blog.

Where is Masud’s work going next?

Although there are challenges associated with deep learning bugs, AI brings exciting opportunities too. “LLMs have an impressive understanding of software code and text, indicating their strong potential to support software debugging, including deep learning bugs,” explains Masud.

As developments in software engineering go on, researchers like Masud have a lot of work to do to leverage the potential of AI models and help create reliable and sustainable software for years to come.

About software engineering research

At the intersection of computer science and engineering lies software engineering, an advancing field which involves designing, developing, testing and maintaining software applications. Software covers a huge variety of tools, including web browsers like Google Chrome and Mozilla Firefox, operating systems such as Windows and Android, productivity software such as Microsoft Office, and graphic design tools such as Adobe Photoshop. Software engineering is a massive field with wide-reaching applications which will only continue to grow as technology and computers become even more involved in different aspects of our lives.

While working in software engineering involves a significant amount of programming and fixing errors in code, there is much more to it than this. “Software engineers spend a lot of time working alongside product managers, customers, end users and other developers, so gaining soft skills such as communication and team-working is super important,” says Masud.

How will AI change software engineering?

“Over the last few decades, software systems have been developed by human developers who wrote programming code themselves to solve many business problems,” says Masud. “However, with the rise of AI models capable of writing programming code (e.g., ChatGPT, Claude, Gemini), software engineering is expected to evolve significantly. That is, most of the code in future software systems will be written by AI models under human oversight.”

“AI developers (a.k.a., AI agents) have different strengths and weaknesses, which will shape in part how the future software is developed and maintained,” adds Masud. “Thus, the next generation of software engineering researchers will study the challenges faced by AI developers and design novel ways and methods to combine AI capabilities with human strengths or specialities to build better software. Incorporating human values – ethics, fairness, universal human rights, equity, diversity and inclusion – into the AI-written software systems will be another challenge.”

Pathway from school to software engineering

During high school, build a strong foundation in mathematics, computer science and physics.

Visit websites such as w3schools.com to learn the basics of coding in your spare time.

At university, study a bachelor’s degree in software engineering or computer science. “Foster critical thinking, problem solving, design abstraction, teamwork and soft skills,” says Masud. After graduating, you will need to pursue a PhD to work in research like Masud.

Watch this video on computer science at Dalhousie University: youtube.com/watch?v=VYVfZVW1nls. The Faculty of Computer Science also has three student societies (dal.ca/faculty/computerscience/about/student_life.html) – one for graduate students, one for undergraduate students, and one for female students in technology degrees.

During summer breaks when you are at university, get hands-on experience by doing an internship at a software company and working alongside professional developers. “Most of the major tech giants offer summer student internships – have a look at Google Careers (google.com/about/careers/applications/buildyourfuture/internships), Amazon Careers (amazon.jobs/content/en/career-programs/university/internships-for-students), and Meta Careers (metacareers.com/careerprograms/students),” says Masud.

Masud recommends exploring the SuperNOVA programmes (supernova.dal.ca), which advance STEM education for young people. He also recommends HereWeCode (herewecode.ca), a computer science outreach programme at Dalhousie University.



Meet Masud

Explore careers in software engineering

Read this interview about what it is like to work as a software engineer: hbr.org/2021/07/career-crush-what-is-it-like-to-be-a-software-engineer

“Software Engineering is supported by two major professional societies – IEEE Software (computer.org/csdl/magazine/so) and ACM SIGSOFT (sigsoft.org),” explains Masud. “They do a great job connecting software engineering practitioners, large companies and academic researchers from all over the world. They also offer student membership, which is a great opportunity for students to network and prepare for the job market.”

Have a read of the Stack Overflow blog, where Masud’s work was featured, to learn more about the world of programming and computer science: stackoverflow.blog

“Knowledge about algorithms, data structures, programming, software design and architecture, and AI will be crucial to working in software engineering. Although AI models will write the majority of the code, humans will need the expertise to review and enhance them. Knowledge about other computer science branches – operating systems, database systems, networking, cybersecurity, and human-computer interaction – will also be extremely valuable for a comprehensive understanding of software systems,” says Masud.

According to Indeed, the average annual salary for a software engineer in Canada is CA\$100,000.

Download Masud’s resources from futurumcareers.com/bugs-and-artificial-intelligence-what-is-happening-in-the-field-of-software-engineering



I was introduced to personal computers back in 1997 when I was a high school student at Jhenidah Cadet College, Bangladesh, and I have been fascinated by these machines ever since. My father bought me my first computer in 2004 when I started my bachelor’s programme in computer science at Khulna University, Bangladesh.

My software engineering journey started in 2009 when I joined a software company. As a freshman software developer, I not only learnt valuable problem-solving and professional skills but also identified the opportunities for research and innovations in software engineering. This first-hand experience as a professional software developer significantly shaped my career choice as a software engineering researcher. In 2012, I started my graduate studies and research in computer science and software engineering at the University of Saskatchewan, Canada.

My proudest career achievements so far are receiving two gold medals: the Chancellor’s Gold Medal in 2010, which is the highest academic award for an undergraduate student in Bangladesh, and the Governor General’s Gold Medal in 2020, which is the highest academic award for a Canadian PhD student.

To date, I have co-authored 58 peer-reviewed articles, with 14 top-tier publications and a TCSE Distinguished paper award. I have been awarded substantial funding over the last 5 years by various agencies, which reflects the value and relevance of my work. I am also proud to have attracted many brilliant graduate students, academic collaborators and industry partners (e.g., Mozilla Firefox, MetaBob) to work with.

An academic career is a long journey with many ups and downs. In other words, it’s a marathon, not a sprint. I have aimed for a long, impactful academic career where I can challenge myself with exciting, new challenges every day and grow with a lasting legacy.

To quote computer scientist Andrew Ng, “AI is the new electricity”. I want to use this ‘new electricity’ to build innovative, useful things for the software engineering community and beyond. I believe we are witnessing the biggest transformative period of digital innovation and computation after the World Wide Web. I am super-excited about the future and what it holds!

Masud’s top tips

1. Dream big. To quote A. P. J. Abdul Kalam (aerospace scientist and former president of India), “Dream is not that which you see while sleeping, it is something that does not let you sleep.” Big dreams bring motivation, confidence, responsibilities, accountability and resilience.
2. Failure is inevitable. However, a person is not defined by failure, but by how they overcome it. Each life will experience a fair share of disappointments and frustrations, but the dreams and ambitions should overpower them!
3. If a task cannot be completed in its entirety, break it into small parts and distribute them across multiple working days.

Is it harder to buy a house these days, or have young people been eating too many avocados?

Today's younger generations are finding it harder to buy homes than previous generations did. So, are younger people being less responsible with their money, or is it genuinely more difficult to become a first-time buyer? What can be done to make things easier for those hoping to take their first steps onto the property ladder? At **Curtin University** in Australia, **Professor Rachel Ong ViforJ** is studying intergenerational housing inequality and using her findings to inform and advise policymakers with the hope of helping younger people buy their first homes.



Professor Rachel Ong ViforJ

John Curtin Distinguished Professor and Australian Research Council Future Fellow, School of Accounting, Economics and Finance, Faculty of Business and Law, Curtin University, Australia

Fields of research

Housing economics, intergenerational housing

Research project

Using data to study intergenerational housing inequality and suggest solutions

Funder

Australian Research Council (ARC)

doi: 10.33424/FUTURUM638

Talk like a ...

housing economist

Economics — the study of how people, organisations and governments use limited resources to meet their needs and desires

Government grant — financial assistance (that does not need to be paid back) provided by the government to help individuals or organisations engage in activities like buying a first home or starting a business

Intergenerational housing inequality — the difficulties faced by younger generations in the housing market compared to older generations

Inflation — the rise in overall prices of goods and services, reducing the value of money over time

Mortgage — a loan that is used to buy a property

Supply side measures — policies aiming to increase the number of homes available, such as easing planning rules or funding new construction

Tax concession — a benefit from the government that reduces the amount of tax an individual or organisation must pay

Buying your first home is one of life's key milestones, but for many young people, this step seems entirely out of reach. In 2016, a social commentator in Australia suggested this was due to young people spending too much money on little luxuries such as smashed avocado on toast. This sentiment was echoed in the media, and it seemed like the 'smashed avocado generation' only had themselves to blame.

However, while aspiring homeowners should be responsible with their finances, there are many other factors in play. "House prices have been spiralling

upward at faster rates than young people's incomes, and the housing wealth gap between the young and old is widening," says Professor Rachel Ong ViforJ from Curtin University. "Australia also offers generous tax concessions to property owners, which pushes up demand for buying property as an investment. Investors compete with young first-time buyers, and the latter often miss out because their financial positions are not likely to be as strong as property investors."

What does the data tell us?

"Since the mid-1980s, the average house price to income ratio in Australia has risen by over 200%," continues Rachel. "Back in the mid-1990s, the average house price to income ratio in Australia was around 3:1. Now, it's around 8:1 and even exceeds 10:1 in some parts of major cities." Traditionally, house prices increase because of economic booms, strong population growth and low interest rates, which make mortgages



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more affordable. However, the COVID-19 pandemic caused disruptions to global supply chains, and housing supply has struggled to keep up with demand, creating competition and increased prices.

“There are many datasets that allow us to analyse patterns and trends in the Australian housing market,” says Rachel. “For example, we have national household surveys, such as the Household, Income and Labour Dynamics in Australia (HILDA) Survey, which are rich sources of information on homeowners as well as renters.” HILDA is an annual survey that tracks respondents from year to year, shedding light on how their housing opportunities change as they get older.

Smashing the avocado narrative

“Far from spending all their money on smashed avocados, young people in Australia are actually saving more than they used to,” says Rachel. “In 2006, around 66% of non-homeowning adults aged 25-44 saved regularly. By 2020, this had risen to around 80%. More young non-homeowners in Australia are also planning ahead financially. In 2006, 47% were planning more than a year ahead. By 2020, this share had risen to 55%.”

Even with these increased saving habits, young people are still struggling to buy their first homes. However, for some young people, these struggles can be alleviated by ‘the bank of mum and dad’. “Receiving parental cash assistance of more than AU\$5,000 quadruples the chances of a young person becoming a homeowner,” explains Rachel. “Parents may also be able to

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To put it simply, housing touches the life of every single person in the world.

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help by providing free accommodation in the family home or a second property.” This can more than double the chances of a young person becoming a homeowner compared to a situation where the young person has to rent privately.

“As the bank of mum and dad becomes more important, this will widen the gap between young people with parents who are able and willing to help them buy a home and young people whose parents cannot or will not help,” says Rachel. “In general, young people’s chances of becoming homeowners are very low if they live in public housing or co-reside with parents who are renters.”

How can the government help?

Government policies can have a significant impact on the housing market, however as with most economic issues, there are no simple solutions. “A key policy measure that could be helpful is tax reform,” says Rachel. This could involve removing the tax concessions that benefit high-income property owners and make things harder

for young first-time buyers. However, tax reforms can be politically divisive, so many governments are reluctant to introduce them.

“Government grants for first-time buyers are also helpful, but if they are not properly targeted, they can also fuel demand and push prices up, unless the supply of houses also increases,” says Rachel. “Supply-side measures could help, such as government incentives that boost housing supply targeted at first-time buyers.”

Rachel has shared many reports with policymakers that include analyses on the challenges that first-time buyers face as well as ideas for making homeownership more affordable. To take this further, Rachel has also developed a model to show the potential outcomes of different policies. “I am a co-designer of Australia’s first and only dynamic housing policy simulation model,” she says “I have used this model to simulate the impacts of different policies on homeownership outcomes.”

In 2023, due to her extensive policy-relevant housing research, Rachel was appointed as a member of the National Housing Supply and Affordability Council, a group that provides advice to the Australian Government on matters relating to supply and affordability. “It is extremely rewarding to work in this field because you are engaging with an issue that is important for the well-being of everyone in the population,” says Rachel. “To put it simply, housing touches the life of every single person in the world.”

About *housing economics*

Economists study how people, businesses and governments make decisions about how to use limited resources to meet unlimited needs and wants. They also study how these decisions shape markets, policies and everyday life. Rachel specialises in housing economics – how homes are built, bought, sold, rented and financed, and how factors such as income, interest rates, government policies and population growth affect housing supply and demand. As someone who works with data and modelling, Rachel expects that artificial intelligence will become an important tool in the near future.

Since the early 2000s, there has been a surge in house prices in many countries,

so housing unaffordability has become a persistent problem and is one of the top voter concerns during elections. “Housing touches the lives of everyone, and governments can be wary of making major reforms to alter housing outcomes as they do not want to alienate voters,” says Rachel. “For instance, if governments were to implement reforms to try to lower house prices, this would benefit non-homeowners who are looking to buy, but it would be met with opposition from current property owners.”

Despite the challenges, Rachel is very passionate about her work. “Global research has shown that secure and affordable housing is vital for sustaining our well-being and health,” she says.

“Living in secure housing in a good location also provides a really important base from which people can look for jobs and go to school. Conversely, those who do not have access to secure and affordable housing, or those who are homeless, will find that their health, relationships, education and job prospects are all negatively impacted. So, working in housing economics is very rewarding as you can use your research to find ways to improve population well-being.”

Pathway from school to *housing economics*

Studying economics and mathematics at school will help you build a solid foundation for studying economics at university. “Many students think that they don’t need mathematics to do well in economics in university, however that is a myth,” says Rachel. “Economics is quite a technical subject and therefore requires a strong foundation in mathematics.”

Taking courses such as finance or property studies alongside economics could deepen your understanding of the field.

“Develop strong technical skills, a strong grasp of economic theories, and excellent verbal and written communication skills,” advises Rachel.

Subjects such as human geography, urban planning, sociology and architecture can help you learn more about different aspects of housing.

Explore careers in *housing economics*

A qualification in housing economics could lead to a range of careers. You could work in areas such as infrastructure planning for local government, property development, banking finance in home lending, property consultancy, or research analysis for property data provider companies. You could even work in a university researching or teaching housing economics.

The Australian Housing and Urban Research Institute (ahuri.edu.au), the Joint Centre of Housing Studies of Harvard University (jchs.harvard.edu) and the Cambridge Centre for Housing and Planning Research (landecon.cam.ac.uk/cambridge-centre-housing-and-planning-research) all have a wealth of information and resources on their websites.

You can read more about Rachel and her colleagues’ research on the theme of healthy people and economics at the Faculty of Business and Law at Curtin University here: research.curtin.edu.au/businesslaw/our-research/key-research-themes/healthy-people-and-economics



Meet Rachel

I was initially interested in physics as a teenager. In my final year of high school, I took up economics as a subject and was fascinated with studying supply and demand in the economy. When I went to university, I decided to pursue my interest in economics by enrolling in an economics and finance double degree. I enjoyed economics more than finance, but the combination of the two helped develop my technical skills.

When I enrolled in a PhD, I started developing an interest in housing economics. My PhD supervisor was an expert in the field, and he helped me develop a thesis that looked at the housing and employment outcomes of older Australians.

What I love most about my job is delivering research that aims to improve the housing, and therefore the well-being, of people. It's the possibility of making a positive impact on the lives of Australians through my research.

I'm driven by a passion to make a positive difference in people's lives. Knowing that people's housing situations are so important in so many ways – providing shelter, a place of safety, and a strong base to access jobs and schools and raise a family – motivates my work. I'm also motivated by knowing that there's still lots to do in the space of housing economics to meaningfully tackle the challenge of housing unaffordability. This has been a serious problem in Australia for 25 years and shows no sign of abating. If we don't tackle the problem of housing unaffordability soon, future generations will suffer.

A number of things have enabled me to lead a successful career in housing economics: being committed to excellence in my research so that my work will be credible to inform policy development; having perseverance and not giving up when faced with difficult housing problems (whether academic or political); and being willing to collaborate with people from different disciplines.

To unwind from work, I enjoy disconnecting from my emails and going for a walk or a drive. I also love a good dinner – especially pasta!

Download Rachel's resources from
futurumcareers.com/is-it-harder-to-buy-a-house-these-days-or-have-young-people-been-eating-too-many-avocados



Rachel's top tips

1. Commit to excellence so that your work will be respected by others.
2. Study housing economics because you want to make a positive difference to people's lives, not just as an academic exercise.

What causes wrongful prison convictions?

At **Toronto Metropolitan University** in Canada, **Professor Caroline Erentzen** is a social psychologist researching wrongful convictions. With 2% to 5% of serious offences ended in an innocent person being convicted, Caroline's work is playing a huge role in investigating how and why so many people spend years in prison for crimes they did not commit.



Professor Caroline Erentzen

Psychology, Law, & Justice Lab, Department of Psychology, Toronto Metropolitan University, Canada

Fields of research

Social psychology, forensic psychology

Research project

Investigating factors contributing to wrongful convictions in Canada

Funder

Social Sciences and Humanities Research Council of Canada (SSHRC) - grant number: 430-2023-00540

Website

psychlabs.torontomu.ca/pljlab

doi: 10.33424/FUTURUM640

Sadly, being wrongfully convicted for a crime is not as uncommon as it should be. Forensic evidence can be misleading, eyewitnesses can be mistaken, defendants can be pressured into false confessions (often by harsh police interrogations), and people on trial might not have the money to afford strong defence lawyers, to name a few reasons why.

It is difficult to know exactly how often wrongful convictions occur. "Most of our knowledge comes from cases in which a person was exonerated, but

Talk like a ...

social psychologist

Defendant — an individual accused in a court of law

Juror — a person on a jury

Exonerate — when someone is cleared of committing a crime

Jury — a group of people (selected at random) who listen to the evidence and give a verdict in a legal case

Forensic science — scientific techniques that collate, process and analyse evidence for legal cases

Testify — give evidence in a court of law

we don't know how many innocent people remain in prison," says Professor Caroline Erentzen from Toronto Metropolitan University. "Based on the cases we do know about, however, estimates suggest that thousands of people have been wrongfully convicted and remain wrongfully convicted to this day."

Unfortunately, getting a case reopened is a difficult and expensive process, and innocence organisations, such as **Innocence Canada**, receive thousands more requests for help than they can take on. "Only a small percentage of people are given the chance to prove their innocence, as cases can only be reopened if there is significant new evidence that was not available at the original trial," explains Caroline.

"On average, it takes over a decade to get a reopened case exonerated."

What is Caroline investigating?

Caroline is investigating which less-researched factors play a role in wrongly convicting innocent people. Her research involves analysing data from several different sources. As well as conducting archival analysis of court records and news articles that summarise real cases of wrongful convictions in Canada, she has looked at data from the US National Registry of Exonerations. In one study, Caroline asked criminal defence lawyers about their experiences representing innocent clients and the challenges they experienced in achieving justice.



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“One factor for wrongful convictions is the use of jailhouse informants – prison ‘snitches’ who testify against an innocent person in exchange for some personal benefit, such as a reduced sentence or money,” says Caroline. Her research has shown that even when jurors find these witness testimonies suspicious, they are still strongly influenced by them and are more likely to find someone guilty if an informant gives evidence against them.

Caroline’s research also involves working with members of the public, presenting them with different evidence and seeing how they judge a hypothetical case. “This lets us see whether some evidence is biasing to an observer and if this might lead to biased judgements,” she says.

In addition, Caroline researches offence-based stigma. “This is when a person may be found guilty because the jury doesn’t like what they were charged with (for example, in very sensitive cases such as those involving child abuse), even if the evidence is weak,” says Caroline. Risk perception is also a factor, as Caroline’s work has shown many people err on the side of caution when someone is accused of a crime that they do not like. Even an accusation (which can be false) can be enough to stigmatise a defendant and erode the presumption of innocence.

The role of forensics

“Before DNA evidence, many people in the legal community believed that wrongful convictions were a myth or impossibility,” explains Caroline. “But the advent of DNA forensics in 1989 led to an ‘innocence revolution’, showing that many people had

“
Even an accusation (which can be false) can be enough to stigmatise a defendant and erode the presumption of innocence.
”

indeed been convicted of crimes they did not commit.”

However, there is a range of reliability in forensic science, with some elements (such as chemical analyses) being more reliable than others. “Forensic science is not infallible. Hair and fibre analyses, fingerprints, bitemarks, tyre treads, for example, are open to interpretations,” says Caroline. “Before making their expert decisions, forensic scientists are sometimes told whether an accused person has confessed, which increases the chance that the forensic scientists will conclude the evidence suggests guilt.”

One of the reforms that Caroline is advocating is for forensic scientists to be kept unaware of the defendant’s identity and accused crime until after they have their results. “Our research has shown that forensic scientists find evidence in line with guilt more easily if the defendant is non-white, charged with a sensitive offence, and gave a confession that they subsequently recanted,” she says.

Similarly, Caroline’s research has found that jurors will be more persuaded by the testimony of a forensic expert if the expert is white, male or from a prestigious university. “This is true

even if that expert provides inaccurate or weak evidence,” says Caroline. She is also cautious about high-profile experts whose status makes them more persuasive than they should be. “One such ‘expert’ was shown to have lacked any forensic training but developed a ‘god-like’ reputation in the Canadian courts,” she explains. “Tragically, his evidence led to many wrongful convictions of innocent, grieving parents.”

How does money come into it?

Caroline is also campaigning for legal defence and prosecution to be funded equally, as money plays a huge role in wrongful convictions. “While legal aid is available to help with court fees in Canada, the representation available is abysmal,” says Caroline. This aid is also only available to those who are quite poor, and so there is a significant number of people who exist in the middle ground – having too much money to qualify for legal aid but not enough to afford a strong defence lawyer or a trial that goes on for a long time.

“A single defendant without legal training may also have to go against a team of well-heeled prosecuting lawyers,” says Caroline. This means that the quality of defence a person receives in court can depend on the money they can spend funding that defence. “Wrongful convictions rarely target the wealthy,” says Caroline. “Few people can afford the time or expense of proving their innocence, and over 95% of all criminal cases are resolved through a guilty plea.” By funding both sides of a trial equally, each side would have the same resources available to them. Judges and juries would be given a fairer, more accurate view of the facts, and wrongful convictions would be less likely.

About social psychology

Social psychology is the study of how people think, believe, feel and behave in social settings. While psychologists often work in clinical and hospital settings, researchers working in psychology can apply their findings to a huge range of areas.

Psychological research is extremely relevant for investigating the law and justice system, for example, as it helps us uncover why we think the way we do, what assumptions and stereotypes we hold, and what flaws in our legal system arise because of this. “I find this area of research to be immensely rewarding, albeit emotionally challenging,” says Caroline. “Wrongful convictions represent an extreme abuse of state authority, and

there are many potential paths that lead to an innocent person being convicted. I feel that the work we do in this area resonates with many people at a visceral level – those who have been falsely accused, those who fear accusation, and those who know someone caught up in an unfair legal system.”

Being able to communicate well and work with others is a significant aspect of working as a social psychologist. “It is our hope that we may be a bridge between psychological science and the law, communicating what we know about human cognition and behaviour and telling the law where it is wrong,” says Caroline. “This may involve collaboration with other academic researchers, knowledge

outreach to lawyers and judges, and community education.”

The future of social psychology

“There will likely be opportunities for more interdisciplinary work, where people are trained in psychology and law, criminology or neuroscience. It is our hope that there will be increased research in psychology and law both from an experimental perspective and in a clinical forensic context,” says Caroline. “There is also a movement toward better integration of research with the ‘real world’, finding ways to inform judges, lawyers, schools, and so on. A person who is able to make those outreach connections will be a major asset.”

Pathway from school to social psychology

“There is a lot of statistical analysis involved in psychological research, so take courses such as finite math, algebra and geometry. You will also need to write your results into papers, so try to take courses that develop your research writing skills in social sciences,” says Caroline.

Study a bachelor’s degree in psychology or a related social science such as sociology. Afterwards, study for a master’s degree and a PhD if you want to work as a social psychology researcher.

If you are a high school student in the greater Toronto area, you can register for free to attend a lab experiment at Toronto Metropolitan University. The university also has an outreach programme for community members: torontomu.ca/scixchange/education-programs/community-outreach.

Caroline recommends getting experience by volunteering or working in the field early on. “Many groups could use a bit of help. Contact hospitals, charity groups, animal shelters, courthouses, law firms or professors,” she advises.

Download Caroline’s resources from futurumcareers.com/what-causes-wrongful-prison-convictions



Explore careers in social psychology

“Social psychologists often work in universities, but many are able to find work in other industries such as marketing, human resources, business, or forensic settings (courts, prisons),” says Caroline.

Caroline recommends the Society for Personality and Social Psychology (spsp.org/professional-development/career-center) and the American Psychology Law Society (ap-ls.org/resources/job-postings) for ideas on potential career paths into social psychology.



Meet Caroline

I have always felt strongly about justice and human rights, and I felt that psychology provided an opportunity to understand these issues better. I completed a master's degree in psychology focusing on prejudice and discrimination and then went to law school to put my knowledge into action. After working for over a decade in law, I felt called back to more academic study, which I believe will ultimately lead to larger and longer-lasting change.

As a lawyer, I found that human rights jobs were far and few between, which made it hard for me to really feel that I was accomplishing what I wanted to do with my career. However, I did get an insight into how the legal system works and how it can perpetuate inequality and injustice. There is an old saying that you shouldn't sit too close to the ballet, as this will spoil its magic. Something similar applies to the law. I've had a few 'eureka' like moments, but these are more so moments of "wait, that's kind of interesting!" I have found repeatedly that the people who claim to be unbiased toward an outgroup are the ones that monitor their behaviour most closely and assign blame most easily to victims of that group. I've found that people will rely on very unreliable witnesses, all while saying how unreliable they think the witness is. I've seen that men experience high rates of stranger perpetrated sexual harassment, but they don't feel they can express dislike of it. There are many ways that psychology can show us that our assumptions about the world may be inaccurate, which is a huge benefit for identifying problems with the legal system.

I feel extremely honoured when another researcher contacts me about collaborating on a project because they are familiar with my work from a publication or conference. I am perhaps most excited when I see a student achieve their own accomplishments, milestones and recognitions.

We will continue the work on wrongful convictions, hopefully connecting with legal scholars and practitioners. Community based outreach will help to disseminate these findings further and, ideally, alleviate some of the problems we see in the legal system.

Caroline's top tip

Don't assume that there is one type of person that law schools or graduate schools are looking for. All diversity has value and there is absolutely no one-size-fits-all approach to knowledge. You have something valuable to add to our understanding of human psychology!



Meet Sarah

Sarah Martin, MA Student, Psychology, Law, & Justice Lab, Department of Psychology, Toronto Metropolitan University

My love for psychology started in high school, and after I chose to pursue an undergraduate degree in psychology, I knew I was on the right path. My undergraduate social psychology courses were so fascinating, and once I took psychology and law, I knew I had found the perfect fit for me.

My role for the last two years has been a master's student and research assistant. A typical day can vary widely. Many days are spent working on coursework, designing and writing my thesis, and working as a teaching assistant. When I'm on campus, I usually work at my lab and spend time with other students in my cohort. Otherwise, a lot of my work can be done from home, and that flexibility is really helpful in terms of balancing my schedule.

The biggest challenge is finding balance. It takes some time after starting the programme to find a rhythm that works for you – managing school, outside work, your relationships and your well-being can sometimes feel like a job itself. Really focusing on time management skills and overcoming procrastination has helped me manage my schedule effectively. And of course, taking time for myself and doing things I enjoy is crucial for keeping up with my demanding schedule!

Very recently passing my master's thesis is one of my proudest achievements so far. I was also awarded a life-changing scholarship for my doctoral work that starts this coming year, which was a huge moment for me.

I aim to work hard in my PhD and conduct research that truly helps people. That is why I got into psychology in the first place – to learn how to help. After my PhD, I would be content to find a career that allows me to be of service in my community and use my passion and skills for the greater good.

Sarah's top tip

Focus on being a well-rounded person. Work hard in your studies, but remember the importance of your health, your passions outside of academia and, importantly, your relationships. I would not be where I am now without the support and guidance of others.

Embracing bilingualism to heal and empower teachers and students

In an era where multilingualism is the norm rather than the exception, many schools still privilege a narrow version of 'standard' English which overlooks the linguistic and cultural realities that bilingual students and teachers bring to the classroom. At **Texas Woman's University** in the US, **Dr Alexandra (Ale) Babino**, **Dr Mary Amanda (Mandy) Stewart** and **Dr Rocío Almanza** bring complementary perspectives to show how care-centred pedagogy and multilingual practices can support students and teachers alike.



Dr Alexandra (Ale) Babino



Dr Mary Amanda (Mandy) Stewart



Dr Rocío Almanza

Division of Literacy and Language,
Texas Woman's University, USA

Field of research

Bilingual literacy education

Research project

Supporting bilingual teachers and teachers of multilingual students

Funder

Jane Nelson Institute for Women's Leadership

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In classrooms across the US and beyond, multilingualism is now the norm. Yet many schools still prioritise 'standard' English, sending subtle messages about whose language (and, therefore, knowledge) matters. This can impact both

Glossary

Bilingual — the ability to communicate in two languages

Biliteracy — the ability to communicate across all communication domains (listening, speaking, reading, writing, viewing and representing images) in two languages

English language arts (ELA) — a classroom that primarily focuses on teaching English language and literacy skills (reading, writing, speaking and listening)

Latina feminist lens — a critical perspective that analyses issues through a Latina view of gender, race, language, class and culture

Latina pedagogies of care — a teaching approach focused on *cariño* (care rooted in love, respect and community)

Multilingual — the ability to communicate in multiple languages

Translanguaging — using all your language abilities

students and teachers, causing identity clashes, missed opportunities for literacy development and preventable disengagement.

At Texas Woman's University, Dr Alexandra (Ale) Babino, Dr Mary Amanda (Mandy) Stewart and Dr Rocío Almanza work with bilingual teachers and those who teach multilingual students. They show how care-centred pedagogies and multilingual practices can create opportunities for healing and empowerment in bilingual and English language arts (ELA) classrooms.

Why does language dominance create wounds in education?

Systems of power shape how languages are valued, marking some as 'legitimate' and others as less so. "This historically prioritises whiteness and standardised English," explains Ale. "In turn, it marginalises bilingual, community-rooted literacies as illegitimate and, by proxy, bilingual people as deficient." This hierarchy does more than determine which language is spoken at school; it communicates who is valued and who is not.



Download the team's resources from futurumcareers.com/embracing-bilingualism-to-heal-and-empower-teachers-and-students



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In their upcoming book, *Latina Pedagogies of Care: How Cariño Can Give Tired Teachers Power and Hope*, Ale and Rocío describe this harm as an *herida abierta* (open wound) – a deep emotional, spiritual and professional injury caused by being told, implicitly or explicitly, that bilingualism is an aberration. For bilingual teachers and students, language systems shape self-perception. “Because educational and societal systems privilege standardised English and fail to affirm cultural richness, bilingual people may see their biliteracies as deficiencies rather than tools connecting them to their communities,” explains Ale. Rather than serving as a bridge, biliteracy is often positioned as a barrier.

How can bilingual teachers heal this wound?

If the *herida abierta* exposes the damage caused by English dominance, then healing requires new ways of seeing and teaching. For Ale and Rocío, the answer lies in Latina ‘pedagogies of care’, a justice-driven, culturally grounded approach that centres *cariño* (care rooted in love, respect and community) and is shaped by the lived experiences of bilingual Latina educators. Teaching with *cariño* means rehumanising teachers and students while resisting the extremes of toxic positivity and cynical despair that often characterise teacher discourse and professional culture.

Ale and Rocío conduct their research through a Latina feminist lens. “This is a framework grounded in the histories and social realities of Latinas navigating the intersections of racism, sexism, classism, nativism and linguistic discrimination in

US society and schools,” explains Rocío. “This lens centres knowledge and practice emerging from the *nepantla* (in-between spaces) of culture, language, gender and power that values relational and community-rooted ways of knowing.” A Latina feminist lens provides tools to call-out injustice, amplify marginalised voices, heal trauma and transform educational spaces. It combines care with criticality, offering educators strategies to understand the world while actively changing it in culturally grounded ways.

“Our book offers a path towards healing for teachers who feel exhausted or disillusioned by the current educational system,” says Ale. “Grounded in Latina feminist thought, it provides a culturally rooted and spiritually sustaining alternative to dominant approaches, centring *cariño* as a source of power, hope and transformation.” Most importantly, Ale and Rocío’s book affirms that teachers are not alone – their emotions, identities, language and cultural knowledge are not only valid, but vital to achieving educational justice.

Supporting multilingual learners

While Ale and Rocío focus on supporting teachers in official bilingual classrooms, Mandy addresses how teachers can support multilingual students in English language arts (ELA) classrooms. Her book, *The Multilingual ELA Classroom*, follows five teachers who have embraced innovative ways to teach ELA through a multilingual lens, providing case studies of successful strategies.

While students may face challenges in ELA classes if English is not their dominant

language, focusing on opportunities – such as the chance to develop literacy in more than one language – shifts the perspective from limitation to strength. “Multilingual students can receive input and meaning in more than one language through reading and listening,” says Mandy. “They can also express themselves in more than one language, which requires much critical thinking and creativity.” Students’ multilingual abilities enrich collaborative projects, storytelling and problem-solving in the classroom, benefiting all students and creating a more inclusive learning environment.

A practical example of engaging linguistically diverse students

‘Bilingual jigsaw reading’ is a collaborative strategy to develop reading, comprehension and speaking skills. Students are split into groups, and each group is given a different short text to read (in one or multiple languages). Students are encouraged to discuss the text with their group in whichever language(s) they prefer (which is an example of translanguaging) to check their understanding, then are reassigned into new groups with students who read different texts. Students share what they learnt from their text with their new group, and in doing so, each student will contribute a piece to the knowledge puzzle.

During her research, Mandy observed Rena, who teaches the English component of a bilingual education programme, using a bilingual jigsaw exercise. As an English speaker, Rena drew on her own experience of learning Spanish to adapt the well-known jigsaw reading teaching strategy for bilingual learners, allowing her students to fully

engage in her lesson in both English and Spanish.

During the lesson, Rena gave students articles in both English and Spanish, which they discussed and made notes on in either language. “As someone who primarily communicates in English, Rena learnt from her bilingual students and saw how they naturally made meaning using their full linguistic repertoires,” explains Mandy. “Not only did the bilingual jigsaw activity engage

her students, but it also allowed her to learn more about their language proficiencies which then guided her future teaching.”

The benefits of a multilingual approach

“The more I experience people who are living multilingually, the more I am convinced that ‘language is people!’” says Mandy. By prioritising the people behind the language, educators can make more intentional decisions about curriculum, instruction

and classroom management. Multilingual strategies nurture empathy, cultural awareness and flexible thinking, preparing all students to engage with diverse communities. All teachers work with multilingual students, whether they realise it or not. Mandy’s book offers practical strategies to support every learner and shows how seeing language as inseparable from the people you teach will transform your classroom for the benefit of all your students.



Advice for teachers

Supporting multilingual students and/or nurturing your own bilingual identity starts with reflection and intentional action.

Healing and valuing your bilingual identity

- Name the *herida abierta* caused by systemic racism and linguistic oppression, and honour all parts of yourself, especially those silenced or shamed.
- Embrace Latina pedagogies of care rooted in *cariño*, spiritual activism and *movidas rasquaches* (strategic, resourceful moves).
- “By knowing yourself deeply (*seguir conociéndote*), cultivating your faculties (*seguir aprendiendo*), and building community with others who share your values (*seguir en comunidad*), you can resist deficit narratives and find power and healing in yourself,” says Ale.

Supporting bilingual students and affirming biliteracy

- Encourage students to use their home language(s) in discussions, reading and writing.
- “In Poland, I work with teachers who are teaching Polish to Ukrainian refugees,” says Mandy. “My colleague, Dr Barbara Muszyńska, and I developed the **HEART** strategy as we noticed that teaching for biliteracy comes from the heart.”
 - **H**: Home language invitations
 - **E**: Engage all language domains (reading, writing, listening, speaking)
 - **A**: Authentic curriculum that centres on students’ interests and cultures
 - **R**: Reinforcement through sentence stems for vocabulary and language structures
 - **T**: Teacher-created mentor texts

Strategies for teachers who do not speak students’ languages

Not speaking your students’ languages does not have to be a barrier to supporting their learning – it can be an opportunity to

expand your practice. The key is to approach multilingualism with openness and curiosity.

- Learn about your students’ languages. Ask what language(s) they speak at home and learn a few words or phrases.
- Position students as experts. Invite them to teach you, and each other, about their language, culture and lived experiences. Incorporate this knowledge into reading, writing or small group work to validate their identities and deepen engagement.
- For reading activities, select books and texts that connect to your students’ languages and cultures.
- “Don’t be afraid of languages you don’t speak,” says Mandy. “Include them in anchor charts, classroom libraries and discussions.”
- Encourage students to use all their languages in activities that connect language learning with personal expression, such as multilingual name poems, identity boxes and bilingual book writing.



Meet Ale

As an Associate Professor, I teach university students who are mostly heritage speakers of Spanish (they have a cultural connection to Spanish but may have varying levels of proficiency) and who speak varieties of Spanish and English.

My research aims to illuminate how bilingual students and educators navigate identity, agency and biliteracies within under-examined spaces of bilingual schooling, particularly where policy and ideology conflict with programme goals.

My passion stems from my own background as a second-generation Mexican American and former bilingual teacher. I recognise the emotional and systemic toll caused by deficit language ideologies and seek to counteract these through research and advocacy.

Even though the maelstrom of forces in the educational landscape is fierce, there is hope. When nurtured with

cariño, teachers are powerful agents and stewards rather than passive conveyors of language policy.

My own language abilities are integral to understanding who I am. They've provided a deeply personal lens through which I view identity, power and education, and have motivated my commitment to mentoring others as they embrace their own bilingual selves. My bilingual abilities are not just instrumental tools but forces of cultural identity that shape my sense of belonging.



Meet Rocío

I am a kindergarten teacher, and my students speak varieties of English and Spanish. I teach using a 50:50 mix of both languages, and I leverage translanguaging to help students develop biliteracy skills. But despite my efforts, students are exposed to the power

dynamics between the languages and gravitate towards English. Therefore, I strive to create a school-wide culture that embraces bilingualism, even for students not in bilingual classrooms.

As an Adjunct Professor, my research explores teacher's perceptions of translanguaging and literacy. I explore how writing is a tool to empower students and how teachers can implement effective biliteracy practices. I also study how teachers resist monoglossic practices and nurture students' languages beyond the academic scope.

I had to learn English at the age of 12 during the era of 'sink or swim'. This painful process created in me a language

deficit perspective and cultural fissures. As a result, I am passionate about teaching young children and pre-service teachers because I find joy in supporting others as they develop their biliteracy and biculturalism assets.

My bilingual abilities are fluid and serve many purposes – they are my voice, a source of knowledge and an interaction tool. Because my language is context dependent and organic, I can perceive power dynamics that impact my personality, emotions and self-perception. At times I have felt shame, but at other times my language gives me empowerment and community connections.



Meet Mandy

I work with teachers who teach their country's dominant language (e.g., English in the US, Polish in Poland) to immigrant and refugee students. I hope to promote language equity by helping

teachers who don't speak their students' languages to teach through a multilingual lens.

I fully recognise the irony of the 'multilingual English language arts' classroom. Just putting the words 'multilingual' and 'English' together can seem a little crazy. But the teachers I work with are genuinely making a difference for their multilingual students and I've seen how their students respond to them. I've also seen the renewed sense of purpose and joy the teachers have discovered in their multilingual ELA classrooms. I hope other teachers will join our crazy

little movement! The road might not be easy, but you just need to keep going and persist despite setbacks. We need to support students to use all their languages so they can be their full selves in the classroom.

I grew up speaking English and have acquired Spanish and French as additional languages. This gives me insight into the process of acquiring additional languages, which helps me support teachers whose students are developing proficiency in additional languages.

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