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dressCode

Bridging the gender gap and challenging stereotypes in computing science

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ISSUE 33
Science shapes us all

WELCOME

"I love that technology is integral to every sector and is so creative. You can turn ideas into reality, solve real-world problems and make a difference," says Toni Scullion, a computing science teacher based in Scotland. With a passion for computing science and a determination to tackle the gender gap that persists in the field, Toni is Co-lead of Scottish Teachers Advancing Computing Science (STACS) and founder of dressCode.

STACS (p 46) is a teacher-led initiative championing computing science and offering practical support to teachers. We hear about the organisation's commitment to inspiring students, amplifying teacher voice and growing the vibrant STACS community.

With an emphasis on creativity and collaboration, Toni set up dressCode (p 46) to foster a nurturing environment where girls can thrive in the world of coding. As Toni highlights, "computing science can be combined with any interest, such as data, medicine or art", and the skills acquired through computing science education, such as critical thinking and logical reasoning, are invaluable in any field.

Sharing the belief that science impacts and provides opportunities for us all, Dr Agueda Gras-Velazquez, Science Programme Manager at Scientix® and Head of the Science Education Department at European Schoolnet®, talks us through the Scientix® online platform (p 88). She enthuses, "Science shapes every aspect of our daily lives, from the food we eat to the technology we use. It opens up a world of infinite possibilities for everyone."

We love talking to passionate people who are doing their bit to inspire young people. From computing science to oncology, cell biology to archaeology, there is much to be inspired by...

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Championing computing science

STACS

Scottish Teachers Advancing Computing Science (STACS) is a teacher-led initiative working to advance computing science in Scotland. Co-lead **Toni Scullion** tells us about the organisation's commitment to raising the subject's profile, amplifying teacher voice, inspiring students and growing the vibrant STACS community.

Why is computing science a vital field for students to learn about – and for Scotland's economy?

Computing science is undeniably a vital field for students today, and its importance is deeply rooted in the economic landscape of Scotland. The tech sector has emerged as a cornerstone of the Scottish economy, driving innovation and generating high-value employment. With strengths in areas like financial technology, data science and software development, Scotland's digital economy is poised for continued growth. Critically, equipping young people with robust computing science skills is not just about immediate economic benefits; it's about nurturing the tech talent pipeline within our schools. If we can get this right, we will establish a sustainable source of skilled professionals, ensuring Scotland remains competitive on a global scale. Beyond these economic advantages, computing science opens up a wealth of diverse career paths for young people. From software development and cyber security to data analysis and artificial intelligence, the opportunities are vast. And the skills acquired through computing science education, such as problem-solving, critical thinking and logical reasoning, are invaluable in any field, fostering innovation and adaptability in an increasingly digital world.

© STACS

What are some of the issues facing computing science in Scotland at the moment?

While vibrant, Scotland's technology sector faces significant challenges, primarily rooted in the tech talent pipeline and the persistent gender gap. These issues are deeply connected to the state of computing science education at the school level.

One of the most pressing concerns is the chronic underrepresentation of women in computing science. This subject exhibits the largest gender disparity amongst traditional STEM disciplines, a problem that has persisted for over a decade. This disparity is not merely a statistical anomaly; it reflects a significant challenge in providing equitable access and opportunities for female students.

A significant number of students are being left behind due to a lack of equity of access to computing science provision in schools. This problem is not confined to remote areas like the Highlands and Islands; it's prevalent across Scotland. The issue isn't simply a matter of discouragement; in many

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cases, there is literally no opportunity to study computing science at all. This lack of equity of access significantly impacts overall uptake and is heavily influenced by teacher recruitment challenges, highlighting the interconnected nature of these problems. While this lack of access affects all students, it disproportionately impacts female students, exacerbating the existing gender gap.

Computing science often suffers from a perceived lack of importance compared to other STEM subjects. For instance, some schools offer only one period of computing science per week for students in their first year of secondary education, amounting to approximately 38 periods per year. After accounting for administrative tasks, holidays and other disruptions, the actual teaching time can dwindle to as few as 30-32 periods. Some schools even offer no periods at all within certain year groups. While computing science may be nominally offered, the equity of access is severely compromised.

How is STACS working to tackle these issues?

To address these challenges, a sustained, long-term investment at the grassroots level is crucial, starting from early years through to secondary education. Closing this gender gap and expanding the talent pipeline requires a dedicated, long-term commitment. At the current pace, this disparity will not be resolved within a generation. Every student deserves the opportunity to experience high-quality computing science education and make informed choices about their future.

> **“Computing science opens up a wealth of diverse career paths for young people.”**


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Who makes up the STACS community?

The STACS community is a diverse and growing network comprising computing science teachers, primary teachers delivering computing science, teachers from other subject areas who deliver computing science and faculty heads – it is a growing community of educators.

Given the geographic dispersion of teachers across Scotland and the often-isolated nature of single or small-person departments, the STACS community serves as a vital hub for connection and collaboration. STACS recognises that teachers are the experts in their field and are key to improvement on a national level. Our international footprint is also growing, with teachers who have signed up from countries such as Greece, Norway, USA, Australia, America, United Arab Emirates, Italy, India, Canada, Vietnam and South Africa, demonstrating the real value of our resources.

Our community is united by a shared love for computing science and a passionate commitment to improving the subject. Members come together to learn from each other, share knowledge and inspire more students to choose computing science at school and consider careers in the tech sector. This collaborative community spirit is fundamental to STACS' mission. The tech talent pipeline starts in our classrooms, and computing science teachers, along with all teachers delivering computing science, are fundamental to that solution.

What support does STACS offer teachers?

STACS provides a wide range of practical support and **resources** for teachers. Central to this is a teacher-led national upskilling programme, where experienced teachers share their knowledge and best practices with the wider community. Teachers can also access an extensive library of free 'pick-up-and-play' resources. Specifically, there are over 250 hours of materials for secondary schools and over 160 hours for primary schools. These resources are designed by computing science teachers, incorporate research and are aligned with established computing science pedagogy. They include detailed lesson plans, slides with teacher notes to support non-specialists, activities and answer keys. We also provide a directory to connect teachers for knowledge sharing, up-to-date information on student opportunities and teacher courses, and curated lists of coding websites, classroom tools, and over 290 classroom videos.

As a core mission of STACS is to address the gender gap, all resources feature female role models and include research-driven practices. Our commitment to gender equality is recognised through STACS' resources being featured on UNESCO's science **hub** for promoting inclusive science.

Essentially, STACS offers a practical and supportive network for teachers, facilitating collaboration and empowering them to advance computing science in Scotland. At the core of everything STACS does are the students and a commitment to enhance their learning experience and inspire them.

© STACS

> ***"Our community is united by a shared love for computing science and a passionate commitment to improving the subject."***

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What does a STACS Connect event involve?

Whether virtual or in person, **STACS Connect** events are dynamic and highly interactive, offering a collaborative and enriching space for computing science teachers from across Scotland and beyond.

We specifically welcome current trainee and newly qualified computing science teachers to our annual in-person STACS Connect event. Attendees share best practice, pose questions, and discuss challenges and solutions with their peers. This peer-to-peer learning environment allows teachers to gain fresh perspectives and actionable ideas that directly benefit their classroom practice. We provide crucial networking opportunities, helping to build a strong, supportive community, including those single person departments who might otherwise feel isolated in their subject area.

A key component of every STACS Connect event is the teacher-led national upskilling programme. These aren't your typical 'chalk and talk' presentations; they are engaging and interactive sessions where experienced teachers share their knowledge, teaching techniques and classroom activities. The focus is on practical strategies that attendees can implement immediately.

The overarching goal of every STACS Connect event is to empower teachers with the knowledge, confidence and resources needed to deliver engaging and effective computing science education, ultimately enhancing the learning experience and inspiring the next generation of students.

STACS is teacher-led. What do you want teachers to tell you about?

At STACS, the teacher voice is paramount, as we firmly believe that teachers are the experts in their classrooms and understand the needs of their students best. We want to hear about what is working well in their computing science departments and in the delivery of computing science in primary schools. We want to know what challenges they're facing, and what resources or support would be most beneficial to them.

We don't just listen; we also amplify the voices of teachers delivering computing science in our annual report and through crucial meetings with the Scottish Government.

To gather these vital insights, we regularly run initiatives like our **STACS Survey**, which is currently live! This survey is designed to collect honest data directly from computing science teachers to understand the current state of computing science provision in Scottish schools. Teacher responses are critical for helping us identify key factors that contribute to a thriving computing science curriculum, which is absolutely essential for the long-term success of our subject. (It's important to note that this survey focuses on the provision of computing science in the respondent's school, not individual teachers, and anonymity is guaranteed.) The survey covers factors both outside and within the teacher's control, followed by open-ended questions for valuable insights. All findings will be shared with the STACS community to inform and empower teachers, ultimately benefiting pupils across Scotland.

Beyond the survey, teachers can share their voices through dedicated feedback mechanisms on our website, and by engaging with us through **STACS Connected**, our exclusive community platform.

> ***We remain intensely focused on tackling the persistent and alarming gender gap in computing science, and accelerating change so all young people feel inspired and empowered in the subject.***

What has STACS achieved so far?

Despite being a relatively young initiative, STACS has already achieved significant milestones in advancing computing science education in Scotland. One of our proudest accomplishments is the rapid growth and engagement of our community, demonstrated by over 1500 sign-ups on our platform. Since our website launch in November 2022, we've achieved impressive representation, including 94% of secondary schools and 38% of independent schools across Scotland. We're proud that 98% of registered computing science teachers in Scotland are part of our network. This widespread engagement underscores the profound need for and value of a teacher-led initiative. Critically, this has cultivated a vital space where teachers are genuinely connecting with and supporting each other. Beyond Scotland, our community boasts a thriving international reach, with educators participating from countries around the world.

From the development and dissemination of our extensive, free, 'pick-up-and-play' resources and our national teacher upskilling programme, STACS is having a tangible impact on strengthening computing science education and fostering a vibrant community for educators.

What does the future hold for STACS?

The future for STACS is one of continued growth, deeper impact and unwavering commitment to our core mission: to advance computing science in Scotland. The tech talent pipeline starts in our classrooms, and our work is essential to create a sustainable tech talent pipeline for Scotland, directly addressing the significant challenges it currently faces. We envision a future where every student has equitable access to high-quality computing science education, a vital step for Scotland's digital future that is currently hindered by disparities in provision.

We remain intensely focused on tackling the persistent and alarming gender gap in computing science, and accelerating change so all young people feel inspired and empowered in the subject.

Looking ahead, STACS will intensify its advocacy efforts to amplify teacher voices. We'll also deepen our vital industry connections, creating even more opportunities for students to gain real-world exposure and insight into the tech sector. By leveraging data-driven insights, we'll continue to highlight areas of concern and drive evidence-based improvements across the country.

These future ambitions build upon STACS's core pillars, which include:

Fostering a Strong Community: Facilitating and nurturing robust networks among computing science teachers across all stages and regions of Scotland, promoting the exchange of knowledge and best practices.

Driving Professional Development and Collaborative Expertise: Leveraging the collective knowledge within the teaching network to offer streamlined shared learning, resource exchange, and professional growth opportunities.

Advocating for the Subject: Representing the voice of computing science teachers and pupils in national discussions, with a crucial focus on championing equity of access to high-quality computing science for all pupils in every Scottish school.

Strengthening the Teacher Pipeline: Proactively working to attract, support, and retain dedicated computing science teachers in Scottish schools to ensure a robust and sustainable educator base.

Connecting Education and Industry: Bridging the gap between schools and the technology sector to enrich learning experiences with real-world insights and prepare pupils for future careers.

Ultimately, STACS will champion the essential role of computing science and its teachers, ensuring Scotland's young people are truly equipped with the critical thinking abilities necessary to thrive in an increasingly technology-driven world, securing our nation's economic future.

Connect with STACS

- **stacs.scot**
- **STACS Annual Report 2024/25**
- **STACS Survey**
- **STACS**
- **@stacshq**
- **STACS**

Can robot teams work together and adapt to solve problems and save lives?

From saving lives in disaster zones to inspecting infrastructure and exploring distant planets, teams of robots are beginning to transform how we tackle complex challenges. But will these robot teams be able to learn, adapt and work together in the same way that humans can? **Dr Hao Zhang** from the **University of Massachusetts Amherst** in the US is exploring how robot teams can become more resilient, intelligent and cooperative by learning from human teamwork.

Dr Hao Zhang

Associate Professor of Computer Science,
Director of the Human-Centered Robotics Laboratory,
University of Massachusetts Amherst, USA

PROFILE

Field of research
Robotics

Research project
Autonomous Group Introspective Learning and coopEtition (AGILE) for Cross-Capability Multi-Robot Adaptation

Funders
US Defense Advanced Research Projects Agency (DARPA); National Science Foundation (NSF)

Website
hcr.cs.umass.edu

doi: 10.33424/FUTURUM623

Talk like a ...
roboticist

Coopetition — engaging in both cooperation and competition to improve performance and outcomes

Cross-capability multi-robot adaptation — the ability of a group of robots with different skills and specialisations to work together, solve problems and adapt to new situations

Fault tolerance — a system's ability to continue operating effectively when some of its parts fail

Introspection — the ability to observe and examine one's own thought processes and motivations

Lifelong autonomy — the ability of a robot to continually adapt and learn throughout its lifetime, without input from humans

Robots provide many services for us, from delivering packages to exploring other planets; however, many tasks are too complex for a single robot to handle alone. Teams of robots, especially those with complementary abilities, could tackle much bigger and more difficult challenges in a range of situations and environments.

For example, in the aftermath of a natural disaster, such as an earthquake or a tsunami, teams of robots could search areas that are too dangerous for humans to enter. "Drones can scout an area from above, ground robots can navigate through debris or rough terrain, and specialised robots can manipulate objects or access confined spaces," explains Dr Hao Zhang from the University of Massachusetts Amherst. "Robot teams can offer efficient, robust and adaptive solutions to societal challenges, not just in disaster response but also in space exploration, agriculture, manufacturing and infrastructure inspection."

Lifelong autonomy

For robot teams to be truly useful in the real world, they need to be made up of robots that can learn from experience, adapt to new situations and improve their performance over time without human input – a concept known as lifelong autonomy. "This is essential for long-term deployment outside of controlled settings, enabling robots to handle unforeseen situations, recover from failures, and evolve alongside changing tasks and teammates," explains Hao.

Developing lifelong autonomy is difficult and involves creating robots that can accurately perceive the world

Robots housed in Hao's research laboratory.

around them, reflect on and assess their own performance, and continually learn and adapt to new situations. Robots must have these abilities of perception, introspection and adaptation if they are to work effectively as part of a team.

Assembling a team

For robot teams to succeed, they must coordinate a range of different abilities, communicate effectively and make joint decisions – all while avoiding errors and working safely. The robots must adapt to the evolving behaviour of their teammates in real-world environments where conditions can change quickly and robots can malfunction. This level of problem solving and improvisation is difficult enough to achieve in single robots, let alone teams of robots with a range of skills and capabilities.

To develop successful robot teams, Hao is drawing on key insights from social psychology and human teamwork. "Humans are the most adaptable species on Earth," says Hao. "Collective intelligence, emerging from collaboration, shared effort and internal competition, allows human teams to adapt swiftly to unexpected changes in their environment or composition." Whether in sports teams, multi-national companies or academic research groups, functional heterogeneity – the useful range of skills and abilities within a team – enables people to tackle complex tasks effectively.

In contrast, robot teams lack this level of adaptability. "One project that we are working on, called Autonomous Group Introspective Learning and coopEtition (AGILE) for Cross-Capability Multi-Robot

> ***"Robot teams can offer efficient, robust and adaptive solutions to societal challenges."***

Adaptation, aims to enable diverse robot teams to respond effectively to novel situations and complex failures," says Hao.

Group introspection

One of the key goals of AGILE is to help robots reflect on how well they are working together as a team. "Autonomous group introspection refers to the ability of a team of robots to collectively monitor, analyse and understand their own behaviors, roles and performances without human intervention," explains Hao.

By sharing what they see, what they are doing and how their tasks are progressing, robots can collectively figure out if something is not working, adjust their roles and come up with new plans. For example, if one robot malfunctions, group introspection would allow the team to replace the broken robot with another teammate that has similar capabilities. This kind of shared awareness enables resilient, flexible and efficient teamwork, allowing robot teams to work together effectively on complex tasks in the real world.

Coopetition

As strange as it may seem, a healthy level of competition within a team can improve teamwork. "Cooperative competition – or coopetition – allows robots to collaborate toward a shared goal while simultaneously competing to pursue individual objectives and optimise their own performance," explains Hao. Cooperation allows the team to tackle objectives that are too complex for individual robots to solve by themselves, while competition encourages each robot to continually improve their performance. "This balance allows the robot team to efficiently allocate tasks to individual team members when solving complex problems, enhances its resilience to individual failures and improves its adaptability in evolving environments," continues Hao.

Looking to the future

Currently, AGILE focuses on developing teams of robots that can collectively make decisions and coordinate their actions effectively. But the project's next steps aim even higher. Hao hopes to develop collaborative perception, enabling robots to use their own sensors to monitor the health and abilities of their teammates in real time. The AGILE project will also explore human-robot teaming, allowing people and robots to work together safely by combining their unique strengths. "If successful, AGILE will mark a critical step toward building resilient robot teams capable of near human-level adaptability, transforming multi-robot applications through greater fault tolerance, agility and adaptability," says Hao.

About *robotics*

"Robotics is an exciting field at the intersection of engineering, computer science and artificial intelligence (AI), with the potential to transform nearly every aspect of society," says Hao. "It is a field where cutting-edge innovation directly shapes real-world impact." As robots become more intelligent and autonomous, the next generation of roboticists and engineers will play a crucial role in shaping how they are developed and used. Career opportunities in robotics range from designing robotic hardware and developing AI software to working in research labs, startups, industry or government.

However, robotics is not without its challenges. "One of the most challenging aspects of robotics is mastering its interdisciplinary nature," says Hao. "Another major challenge lies in handling the complexity and unpredictability of real-world environments." The real world is full of obstacles, noise and changing conditions, and is far more complex than controlled lab environments or computer simulations. "Overcoming these challenges requires deep expertise in a core discipline, such as AI for robot adaptation, alongside the ability to synthesise knowledge across fields and build integrated systems through interdisciplinary collaboration," explains Hao.

To support the next generation of roboticists, Hao leads the Program for Robotics Outreach on Gender and Racial Equity in School and Society (**PROGRESS**) which is dedicated to promoting robotics among young and underrepresented aspiring roboticists. "PROGRESS offers a variety of engaging educational activities designed to spark interest in robotics and STEM across many age groups," says Hao. "Key components include hands-on introductory robotics workshops, lab tours and live demonstrations, mentorship for school robotics teams, and school outreach events." PROGRESS also supports teachers with training and resources to bring robotics into the classroom. By making the field more inclusive and accessible, Hao and the PROGRESS team are helping to ensure that the future of robotics reflects diverse perspectives and talents.

Pathway from school to *robotics*

"To work in robotics, you need to to build a strong foundation in mathematics, physics and computer science at school," says Hao. "At the college and university level, pursue courses in programming, AI, control systems, mechanical and electrical engineering, or robotics."

Experiences such as internships, robotics clubs or summer programmes can provide valuable hands-on skills and insight into real-world robotics applications.

The Robotics Education & Competition Foundation (**recf.org**) offers student-focused events like the VEX Robotics Competitions and VEX IQ Challenge, where teams design, build and program robots to compete in themed challenges.

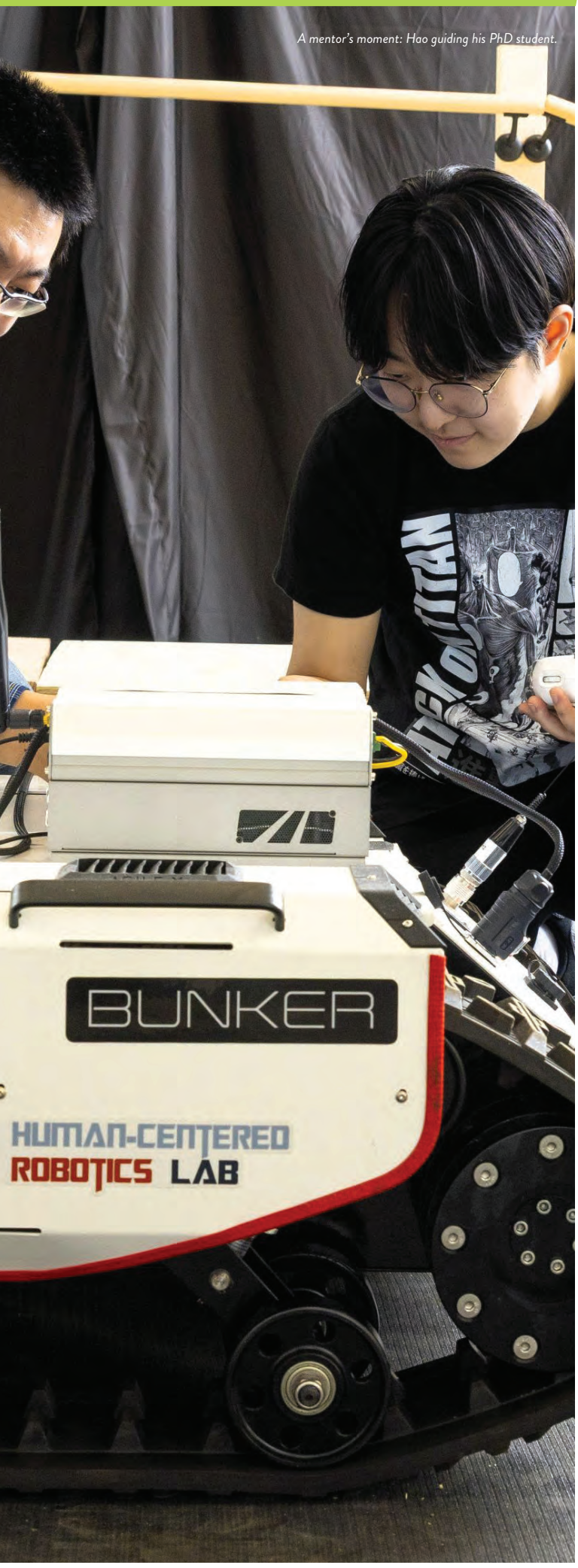
Explore careers in *robotics*

"Roles in this field include robotics engineers, AI specialists, mechanical engineers and human-robot interaction designers, with opportunities in industries such as manufacturing, logistics, healthcare, space and research," says Hao.

The IEEE Robotics and Automation Society (**ieee-ras.org**) provides insights into the latest research, publications and professional development opportunities in robotics.

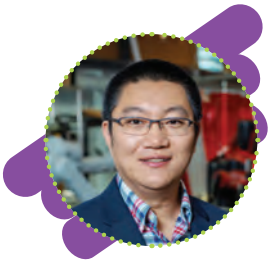
NASA's Robotics Alliance Project (**robotics.nasa.gov**) shares educational programmes, competitions and internship opportunities for aspiring roboticists.

The Robot Report (**therobotreport.com**) is a leading source of news, trends and analysis about the robotics industry, ideal for keeping up to date with the latest advances and career opportunities.



A mentor's moment: Hao guiding his PhD student.

Download Hao's resources from **futurumcareers.com/can-robot-teams-work-together-and-adapt-to-solve-problems-and-save-lives**



Meet *Hao*

I have been a huge fan of robots since I was a young child, inspired by comics and TV shows like *Transformers, Knight Rider, Gundam* and many others. I was captivated by the imagination and futuristic technology they portrayed, and as I grew older, I became fascinated by the deeper questions about humanity that these stories explored. This passion has been a driving force behind my decision to pursue a career in robotics.

I love that my job gives me the opportunity to help shape the future of robotics in ways that positively impact society. I also find it incredibly rewarding to work with students; they bring fresh perspectives, creativity and energy that constantly inspire me and help me stay curious and open-minded.

Strong motivation, curiosity, persistence and being a team player have enabled me to lead a successful career as a roboticist. I have a deep, long-standing passion for robotics that continues to drive me forward. Curiosity fuels my desire to explore new ideas, learn continuously and stay at the forefront of a rapidly evolving field. Persistence has helped me navigate the inevitable challenges and setbacks that come with complex research and development. And being a team player has been crucial, as robotics is inherently interdisciplinary and collaborative.

I like to unwind by spending time outdoors. I'm a big fan of skiing in the winter. In the summer, I enjoy tennis, biking and short hikes. These activities help me reset both physically and mentally, and they give me the energy and clarity to stay focused when I return to work.

Hao's *top tips*

1. Stay motivated and curious, and don't be afraid to learn from others, or from your own trial and error.

2. Growth in robotics often comes from persistence and a willingness to explore the unknown.

Making metals: how are engineers developing new composite materials and manufacturing processes?

New composite materials are pushing the boundaries of what we can create. At the **University of Wollongong** in Australia, **Distinguished Professor Zhengyi Jiang** is at the forefront of this innovative pursuit. He is using his skills in materials and manufacturing engineering to create new metals that have a range of industrial applications and to improve metal manufacturing processes to make them more efficient, economic and environmentally friendly.

Distinguished Professor Zhengyi Jiang

Director, Australian Research Council Industrial Transformation Training Centre for Innovative Composites for the Future of Sustainable Mining Equipment, School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, Australia

PROFILE

Field of research
Materials and manufacturing engineering

Research interests
Developing new composite metals and metal manufacturing technologies

Funders
Australian Research Council (ARC) and world leading steel manufacturing companies such as Baosteel (China)

doi: 10.33424/FUTURUM610

Talk like a ...

materials and manufacturing engineer

Annealing — a process in which a metal is heated and cooled to make it less hard and more ductile

Casting — a process in which liquid metal is poured into a mould

Composite material — a manufactured material created by combining two or more substances which retain their original characteristics

Graphene — a material made of a single layer of carbon atoms

Lubricant — a substance that reduces friction and wear (e.g., oil)

Ore — a naturally occurring material containing economically extractable metal deposits

Roll bonding — a process in which metal layers are passed through rotating rollers to fuse them together

Rolling reduction — a process in which metal is passed through rotating rollers to reduce its thickness

Smelting — a process in which metal is extracted from ore by heating

Steel — an alloy of iron and carbon (different types of steel contain different additional elements which give them different properties, e.g., stainless steel contains chromium and is resistant to rusting)

Welding — a process in which metals are joined together by heating the areas to be joined

The invention of new materials unlocks exciting possibilities for what we can create. Composite materials have a long history, from the construction materials developed by ancient civilisations to the components required in modern technologies. "Composite materials are made by combining two or more different substances to create a new material with improved material properties and functions," explains Distinguished Professor Zhengyi Jiang, a materials and manufacturing academic at the University of Wollongong. "Each component retains its own characteristics, but together they form a new material that may be stronger, lighter or more durable than the individual components."

Zhengyi is an international leader in developing innovative metallic composite materials. Not only does he invent new metals, but he also improves their manufacturing processes to make them more efficient, effective and environmentally friendly.

How does Zhengyi start to create a new material?

For most of human history, new composite materials have been created through trial and error, but today, simulation technologies make the process easier and more efficient.

"To help predict what will happen to materials before we carry out physical experiments, we use numerical modelling and simulation techniques," says Zhengyi. "These are essentially virtual experiments done on a computer."

Zhengyi uses several simulation techniques to test potential new composite metals. For example, finite element analysis involves breaking a simulated metal object down into tiny individual parts, and testing how each part responds to stress, strain and temperature changes. "Computational fluid dynamics is another technique I use, which simulates how liquid metals flow and cool, which is useful in casting or welding processes," explains Zhengyi. And molecular dynamics examines how the atoms inside a material move and interact, for example as the metal heats or cools. "Together, these techniques help us understand how metals behave during manufacturing processes," says Zhengyi.

What new metals has Zhengyi developed?

Zhengyi and his team have developed many new composite metals that are now being used for a variety of industrial applications. For example, they have developed new types of high strength, wear-resistant steel. "For one steel, we combined stainless steel and carbon steel using rolling reduction at 950 °C followed by annealing at 850 °C," Zhengyi explains. "For the other, we combined manganese steel with low-carbon steel using vacuum welding and roll bonding at 800-1100 °C." These composite steels are ideal for heavy-duty applications in the mining industry, such as constructing the beds of trucks and conveyor chutes, which are constantly exposed to rocks and harsh environments that would quickly wear down other materials.

The team has also produced a new lightweight, corrosion-resistant steel. "We combined a strong carbon steel base with a thin corrosion-resistant layer of stainless steel by roll bonding," says Zhengyi. "The resultant composite is suitable for many industrial applications in challenging environments. For example, its resistance to corrosion makes it ideal for ships and offshore platforms that are exposed to salt water."

Additionally, Zhengyi has devised a new self-lubricating composite material. "This material is designed to reduce friction and wear for moving parts in machines, without the need for oil-based lubricants," he says. "To create it, we mixed nano-sized powders of titanium carbide and graphene in a process known as powder blending, then heated the blended powder and pressed it into a solid shape, forming a strong, dense composite." This self-lubricating material is ideal for making a wide range of machinery components, such as turbine blades for the aerospace and aviation industries, engine systems in cars, and for machines that operate in extreme environments where it is difficult to use oil-based lubricants, such as in space or underwater.

How is Zhengyi revolutionising manufacturing processes?

As well as developing new composite materials, Zhengyi and his team are also specialised in improving their manufacturing processes. One project aims to reduce the energy needed for steel production. "Traditional hot-rolled steel production relies on oil-based lubricants," says Zhengyi. "Our method, on the other hand, uses water-based nanolubricants combined with controlled oxidation and wear mechanisms." These techniques include improved oxide scale-controlled hot rolling process, as well as innovative applications of water-based nanolubrication. "This reduces energy consumption and production costs, lowers CO_2 emissions, and enhances the surface quality and durability of the steel. Our approach balances performance, cost-efficiency and environmental responsibility in steel production."

The team has also advanced the stainless steel manufacturing process. "Some stainless steels are created by rolling reduction," explains Zhengyi. "However, oxide scale builds up on the rolled material and this damages the surface of the steel and creates friction which reduces efficiency and causes the rollers to wear out prematurely." To address this issue, Zhengyi collaborated with Baosteel, the world's largest steel company, to optimise oxidation conditions so that the oxide scale that builds up is easier to reshape. Not only did this reduce friction in the rollers, but it also improved lubrication in the rolling mill. "This led to improved surface quality of the stainless steel being produced and enhanced roller life in the production mills," says Zhengyi. "We helped to make production at Baosteel more efficient and cost-effective."

Through his collaborations with industry partners, Zhengyi is conducting groundbreaking research, making innovative new metals, and leading metal manufacturing processes into a new era.

About *materials and manufacturing engineering*

Materials and manufacturing engineering involves developing new materials and processes for manufacturing purposes. "A typical day might involve designing and analysing materials, improving production processes, conducting lab tests, solving technical issues and collaborating as a team," says Zhengyi. "Communication is not restricted to the team – we often communicate with colleagues and communities all over the world."

Collaboration between academia and industry is crucial, given that it is industrial processes and products that typically stand to benefit most directly from research in the field. "These collaborations combine research expertise with practical needs, leading to faster innovation and development of technologies that provide real-world solutions," explains Zhengyi. "It also involves working with end users to understand their needs and expectations to refine and optimise the end products."

Engineers are constantly innovating and improving materials and manufacturing processes, meaning the realm of possibilities is constantly growing. "For the next generation of engineers, smart materials, sustainable composites and nanomaterials will be big areas of study," says Zhengyi. "New and emerging technologies like 3D printing, intelligent manufacturing and AI-driven process automation and optimisation provide exciting opportunities for the field." Virtually every sector can stand to benefit from these advances in materials and manufacturing engineering. Aerospace, medicine and energy in particular could be on the cusp of dramatic improvements.

Pathway from school to *materials and manufacturing engineering*

Zhengyi recommends developing a strong foundation in mathematics, physics, chemistry, and design and technology at high school.

For an academic career, study an undergraduate degree in materials science and engineering, mechanical engineering, manufacturing processes or industrial design.

For a vocational career, look for apprenticeships, technical qualifications (e.g., at a Technical and Further Education Institute in Australia) or diplomas in engineering or manufacturing, which offer hands-on experience and can lead directly to employment or further university studies.

© University of Wollongong

Download Zhengyi's resources from **futurumcareers.com/how-are-engineers-developing-new-composite-materials-and-manufacturing-processes**

Explore careers in *materials and manufacturing engineering*

A career in materials and manufacturing engineering will allow you to solve real-world challenges by designing, creating and testing new materials and manufacturing processes.

This is Engineering explains what a career in materials engineering could look like and lists the skills and qualifications you will need: **thisisengineering.org.uk/careers/materials-engineer**

For Australian students, Zhengyi recommends looking into professional societies such as Engineers Australia (**engineersaustralia.org.au**), Materials Australia (**materialsaustralia.com.au**) and the Australian Ceramics Society (**ceramics.org.au**) for networking opportunities, industry insights and career development.

The School of Mechanical, Materials, Mechatronic and Biomedical Engineering, where Zhengyi works, runs outreach initiatives for school students: **uow.edu.au/engineering-information-sciences/stem-outreach**

According to **Talent.com**, the average materials engineer in Australia makes around AUS $95,000 per year.

Meet *Zhengyi*

My dream to pursue a career in materials and manufacturing engineering began when I was a teenager. I was interested in science, maths, physics, building things, solving problems and understanding how materials and machines work.

Various teachers, engineers and inventors were inspiring role models for me. They built my passion for innovation and my interest in the design and manufacture of machine components.

As a materials and manufacturing engineer, I enjoy being able to solve real-world problems. I find it rewarding to see my work used in products and technologies that make a difference. For example, I am proud of my contributions to developing sustainable materials and water-based nanolubricants because they solve a wide range of manufacturing challenges and support environmental goals.

The biggest challenges in this field are around balancing performance, cost and sustainability, while meeting strict industry standards and deadlines.

I have a lot of experience in linking academia with industry. This has led to large-scale funding from the Australian Research Council and many industry partners, which means our research outcomes can be directly applied to where they will make the most impact.

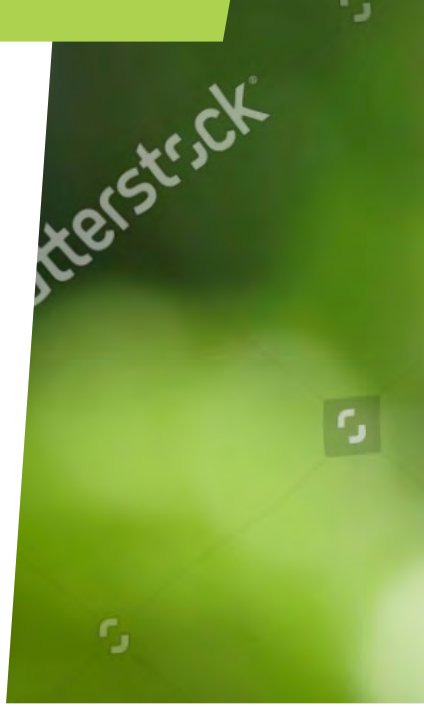
I enjoy training the next generation of engineers and young professionals. Since 2002, I have supervised hundreds of students and research fellows. It's rewarding to see these new professionals go on to secure amazing jobs in industry. As Director of the Australian Research Council Industrial Transformation Training Centre for Innovative Composites for the Future of Sustainable Mining Equipment, I am helping to train young engineers in the technical knowledge and skills needed for careers in advanced manufacturing and sustainable mining technology.

In my free time, I like gardening and other outdoor activities. They help me relax and stay creative. I also love engaging with innovation communities and reading about new technologies.

Zhengyi's *top tips*

1. Try to get as much hands-on experience as possible. This could be through your own projects, work experience or internships with local manufacturers and engineers, or engineering events and competitions. These will build your skills and network.
2. Seek guidance from mentors and stay informed about industry trends.
3. Enjoy the process. The journey is just as important as achieving your end goals.

Environmentally friendly heating: what's the solution?



At **McMaster University** in Canada, Professor of Mechanical Engineering **Dr Marilyn Lightstone** is researching how to reduce greenhouse gas emissions caused by the existing buildings and homes in Canada. Since energy use in buildings generates about 18% of the country's emissions, this work is critical if Canada is to reach its goal of being net-zero by 2050. Could ground source heat pumps be the solution?

Dr Marilyn Lightstone

Department of Mechanical Engineering, McMaster University, Canada

PROFILE

Fields of research
Mechanical engineering, computational fluid dynamics, heat transfer, turbulent flows

Research project
Investigating the role of heat pumps in reducing greenhouse gas emissions

doi: 10.33424/FUTURUM605

Talk like a ...

mechanical engineer

Borehole — a long narrow hole drilled into the ground

Carbon dioxide — a greenhouse gas that affects the climate and environment

Electrical grid — the network that supplies electricity from generators to consumers

Existing building stock — the buildings that already exist in a place

Greenhouse gases — gases in the atmosphere that raise the temperature of the Earth

Hybrid heating — using a combination of heating systems

Net-zero — achieving a balance where no more greenhouse gases are added into the atmosphere

Space heating — heating of spaces for human comfort

Temporal variability — variables (changes or differences) that occur over a period of time

Almost a fifth of Canada's greenhouse gas emissions are caused by energy use in buildings, including heating, lighting and running appliances such as kettles and refrigerators. "Due to the cold Canadian climate, space heating is responsible for nearly 62% of residential energy use," says Dr Marilyn Lightstone, Professor of Mechanical Engineering at McMaster University, who is working on reducing the emissions of existing buildings in Canada. As heating uses more energy than anything else in Canadian homes, making heating systems as efficient as possible is incredibly important for trying to reduce the impact of the climate crisis. "Canada has committed to reduce greenhouse gas emissions by 2030 to 40 to 45% below the levels they were in 2005. It also has a further goal of net-zero emissions by 2050," says Marilyn. "There is a short time window to take action to mitigate the most devastating impacts of climate change."

What is Marilyn working on?

While new buildings must meet special energy regulations, older buildings often have poor insulation and single pane windows (which allow more heat to escape), making it harder to reduce their environmental impact. To reduce the carbon dioxide output caused by heating these buildings, Marilyn is researching efficient household heating systems, such as heat pumps.

Currently, there are air source, water source and ground source heat pumps, all of which work by using electricity to transfer energy from a cold space to a warm space. Note that thermal energy will naturally flow from hot to cold, so electrical

work is required to transfer heat in the opposite direction.

Ground source heat pumps work by taking advantage of the heat stored just below the surface of the Earth. "A ground source heat pump accesses the vast amount of thermal energy existing in the ground and transfers that energy through a refrigeration cycle to the building interior," explains Marilyn.

These heat pumps are extremely efficient. "The thermal energy transferred to the house is close to four times the electrical energy used by the heat pump compressor," says Marilyn. As the ground temperature is unaffected by air temperature and stays about the same all year round, these heat pumps still work well during cold weather – which is perfect for Canada's winters, when daily average temperatures can be well below 0 °C.

However, installing a ground source heat pump is a huge and expensive undertaking, as it requires drilling deep boreholes into the ground. The boreholes contain heat exchangers which allow for heat transfer from the ground to a working fluid. A heat pump is then used to transfer the energy from the working fluid to the interior of a building. "If a ground source heat pump is using vertical boreholes, they need to go down to depths of 100 metres or more – longer than a football field," says Marilyn.

Due to the high installation costs of a ground source heat pump, many homeowners will install air source heat pumps instead. Air source heat pumps transfer energy from the outdoor air to the interior of the building. The challenge with air source heat pumps is that their performance drops as the outdoor temperature declines. That means that when the outdoor temperature is very cold (below -10 °C), a lot of electricity is required to run the heat pump.

> ***A key challenge faced by electricity generators is the large temporal variability in electricity demand.***

Are heat pumps the only answer?

Marilyn's research is now focusing on the benefits of a smart hybrid heating system, where existing high efficiency gas furnaces that are already installed in buildings are used in combination with new heat pumps. While heat pumps are usually the most environmentally friendly option, there are times when using a high efficiency natural gas furnace is the better choice.

To understand this, think about how at certain times of the day everyone wants to use electricity at the same time. The morning shower rush, for example, or the point in the evening when most people start to cook dinner. "A key challenge faced by electricity generators is the large temporal variability in electricity demand – that is, how electricity use varies throughout the day and throughout the working week and weekend. Since electricity is hard to store, electricity generation must equal the demand at any particular time," explains Marilyn. When one of these high-usage moments hits, the increased demand for electricity is usually met by turning on natural gas power plants. "These plants release greenhouse gases as a product of the combustion process," explains Marilyn. As a result, during these times, using electricity (and therefore, heat pumps) produces a large amount of carbon dioxide.

A combined solution

This is when the smart hybrid heating system that Marilyn is researching would work well. These systems would have a smart controller that 'decides' whether to use a building's heat pump or gas furnace at different times of the day, depending on which would produce the least emissions. "For example, during very cold weather when air source heat pump performance degrades, the heat pump would be turned off, and the natural gas furnace would be used for building heating," says Marilyn.

There is still lots of work that mechanical engineers like Marilyn need to do before this work is put into practice – such as educating members of the public and heating, ventilation and air conditioning installers. But keep an eye out for how homes and buildings are heated over the next few years – you just might start to see some changes!

About *mechanical engineering*

Choosing to work in mechanical engineering leads to a wide range of careers and pathways. You might end up working in the renewable energy sector installing wind turbines, the oil and gas industry decommissioning rigs, or the space sector building telescopes! Jobs can range from writing code for software to designing and making new pieces of machinery.

"Mechanical engineering is a broad discipline that includes manufacturing, robotics, energy systems, biomedical engineering and many other topics," says Marilyn. "If you enjoy maths and physics, love brainstorming and problem solving, and are interested in how things are made and how they work, then mechanical engineering might be the path for you."

Working in this field is incredibly rewarding and brings benefits to people all over the world. "With our ageing population, there will be a need for new biomedical devices and systems to help with age-related issues and to enhance people's quality of life," explains Marilyn. Developments in robotics and artificial intelligence are opening up hundreds of new possibilities in this field, making it an exciting time to start a career in mechanical engineering.

Mechanical engineers have a huge role to play in helping mitigate the impacts of the climate crisis too, as they can design new machinery and systems that reduce emissions and manage waste. "Climate change has also created a resurgence in nuclear energy as a reliable low carbon electricity generation method, so opportunities in this area are also likely for the next generation of mechanical engineers," says Marilyn.

Pathway from school to *mechanical engineering*

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

"The Faculty of Engineering at McMaster University offers numerous outreach events including clubs and summer camps for children and young people spanning grades three through 12. These events aim to encourage participants to explore science, technology, engineering and mathematics in a fun and inclusive way," says Marilyn. Find out more: **eng.mcmaster.ca/community/outreach-programs**

Marilyn recommends visiting local universities during their open days and talking to staff and students about mechanical engineering. "University websites also have information about their engineering programmes and related career opportunities," she says.

The New Engineer outlines some of the Canadian universities that offer mechanical engineering degrees: **newengineer.com/advice/the-top-universities-for-mechanical-engineering-in-canada-1382353**

You will also need to complete a master's degree and PhD if you want to work as a professor like Marilyn.

Explore careers in *mechanical engineering*

Indeed Canada has some great information on getting into mechanical engineering and how to become qualified: **ca.indeed.com/career-advice/finding-a-job/how-to-become-a-mechanical-engineer**

The Institution of Mechanical Engineers provides a wealth of information about careers in engineering: **imeche.org/careers-education/careers-information/what-is-mechanical-engineering**

Learn about the range of mechanical engineering breakthroughs over the years to see where the field might take you: **interestingengineering.com/lists/19-mechanical-engineering-listss-that-helped-define-mechanics-today**

Download Marilyn's resources from **futurumcareers.com/environmentally-friendly-heating-whats-the-solution**

Meet *Marilyn*

When I was a child, my brothers and I used magnifying glasses in the sun to burn through leaves – in those days our parents let us run wild, so health and safety was less of a worry back then! I remember being amazed by the power of the sun, and I asked my father why we don't use the sun to heat our homes. He replied that there wasn't a great way to store the sun's energy in the summer for use in the winter. That sparked my interest in solar thermal energy and thermal energy storage. Fortunately, I also had an aptitude for mathematics and physics which made engineering a logical career choice.

I have been lucky to have had outstanding mentors throughout my student years and during my career. These mentors have had a profound impact on my career and in my approach to tackling scientific problems. Before becoming a professor, I worked in the nuclear industry for a few years, focusing on nuclear safety analysis. Bringing that experience into my teaching and research has helped me to be a better professor.

As a Professor of Mechanical Engineering, my day involves teaching both undergraduate and graduate courses in fluid mechanics. I also have graduate students who are working on master's or PhD degrees, and my time is spent on supervising their research. Working with graduate students on research and seeing them flourish in their learning and subsequent careers is truly rewarding. It has been a great privilege to work with young people and to help them develop the skills they will need for successful careers.

From 2013 to 2023, I had the privilege of being Chair of the Department of Mechanical Engineering at McMaster University and spent the bulk of my time on the administration of the department. This role provided some of my proudest career achievements. During those ten years, I oversaw a substantial revitalisation of the department, hired many new faculty members and supported the successful shift to online learning during the pandemic.

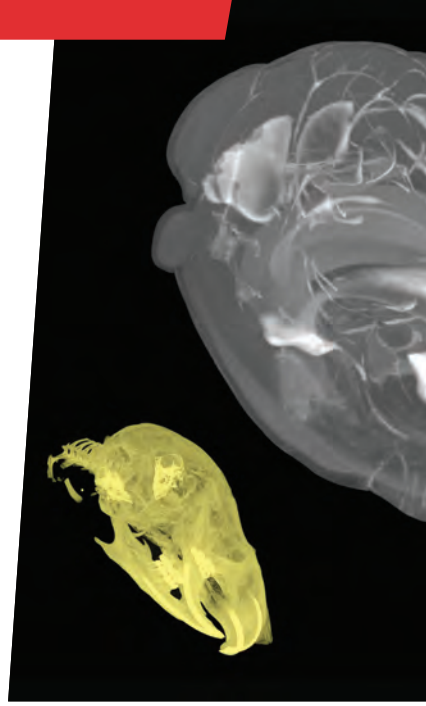
Marilyn's *top tips*

1. Think about what your passion is and what makes you excited. Try and find people who work in that area and learn as much as you can from them.

2. Work hard to get the skills you need.

3. Keep having fun; make time for your family and the things you find enjoyable.

Unlocking new neuroscience frontiers by imaging the intricacies of the mouse brain



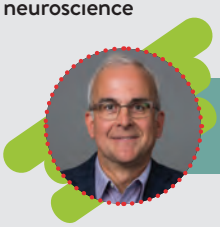
Many mysteries of the brain remain unsolved. At **Duke University** in the US, **Professor Allan Johnson** and **Associate Professor Leonard White** are pushing the boundaries of neuroscience by imaging mouse brains to the highest-ever level of detail. Their **Duke Mouse Brain Atlas** will help neuroscientists around the world reveal more secrets about the brain.

Professor G. Allan Johnson

Director, Duke Center for In Vivo Microscopy

Departments of Radiology, Physics and Biomedical Engineering, Duke University, USA

Fields of research
Radiology, physics, biomedical engineering, neuroscience



Associate Professor Leonard E. White

Associate Director, Duke Institute for Brain Sciences

Department of Neurology, Duke University, USA

Fields of research
Neuroanatomy, neurophysiology, brain development and evolution, medical education

Research project
Using cutting-edge imaging technologies to build the Duke Mouse Brain Atlas

Funders
US National Institutes of Health (NIH): National Institute of Aging (NIA, grant R01 AG070913-01); National Institute of Neurological Disorders and Stroke (NINDS, grant R01 NS120954-01A1)

doi: 10.33424/FUTURUM620

PROFILES

Talk like a ...

neuroscientist

Alzheimer's disease — a neurodegenerative disease that causes dementia (symptoms include deterioration of memory, cognition and behaviour)

Antibody — a protein produced by the immune system that can be engineered to attach to other target proteins

Fluorescence — the absorption of electromagnetic radiation of one wavelength that results in re-emission of radiation at a different wavelength

Histology — the study of cell and tissue anatomy at the microscopic level

Neurodegenerative disease — a progressive loss of neurons leading to impaired brain function

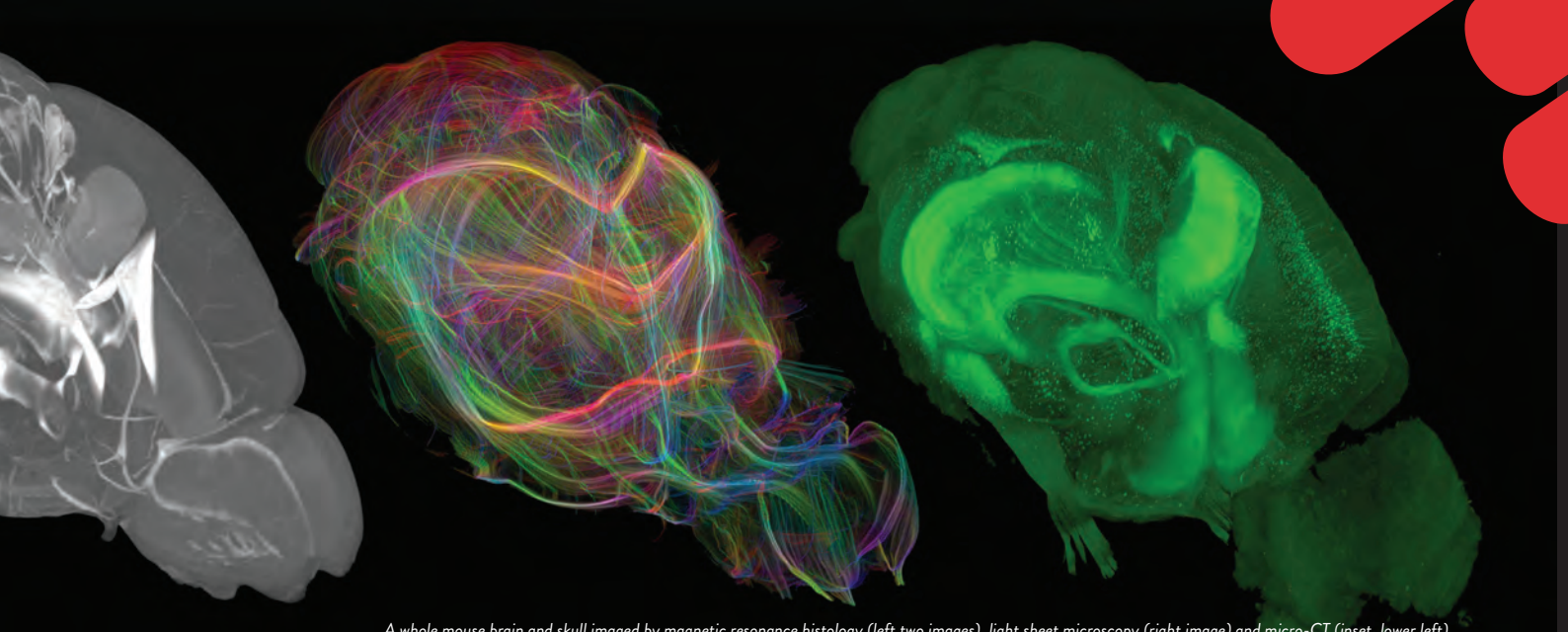
Take a tour through the DMBA: **bit.ly/dmba-2025**

Watch some NeuroTok videos: **bit.ly/DukeNeuroTok**

New and emerging technologies are rapidly accelerating the pace of neuroscience research. At Duke University, Professor Allan Johnson and Associate Professor Leonard White are on the crest of this wave of innovation. They are merging three cutting-edge imaging techniques to build the world's most comprehensive and detailed model of the mouse brain, which will act as a reference tool for neuroscience researchers and students around the world.

Imaging technique 1: magnetic resonance histology

Magnetic resonance imaging (MRI) is a diagnostic medical technique that creates detailed images of structures within the body. These images are created by placing the patient or specimen in a strong magnetic field that causes protons to oscillate (wobble) at a very specific radio frequency. Radio waves at these frequencies excite the protons, which return a signal that can be used to map the molecular environment of



A whole mouse brain and skull imaged by magnetic resonance histology (left two images), light sheet microscopy (right image) and micro-CT (inset, lower left)

the tissue. Al, Len and their team have developed an incredibly powerful MRI machine to study the mouse brain at the cellular level. "Histology is normally performed using a microscope," explains Al. "With magnetic resonance histology (MRH), we replaced that conventional optical microscope with an MRI microscope to observe the structure of tissues in the brain."

The team's machine operates on a much finer scale than clinical MRI. "Our MRH images are up to 2.4 million times more detailed than medical MRI images," says Al. "To get this level of detail, physicists and engineers in our team spent over 40 years building a unique scanner to provide the most detailed images of the mouse brain ever acquired. The scanner employs a magnet that is up to 6 times stronger than most clinical machines."

Imaging technique 2: light sheet microscopy

Len and Al complement their MRH data with light sheet microscopy (LSM) images. LSM involves shaping a laser beam into a thin sheet of light to create many two-dimensional images that are reconstructed into a three-dimensional representation of the whole sample. "First, we remove any components of the biological sample that scatter light – in other words, we make the mouse brain completely transparent," says Al. "This involves soaking it in a collection of clearing chemicals."

Next, fluorescent antibodies are added, which bind to specific proteins in the brain tissue. "When excited by certain wavelengths of radiation, the antibodies fluoresce," explains Len. "This means we can see exactly where they – and the proteins they're bound to – are in the sample." Different neurons in the brain have distinct proteins, which means they can be targeted and labelled by antibodies at a very fine level. "The same method can also be used to show non-cellular proteins, such as the beta-amyloid protein associated with Alzheimer's disease," says Len. The resultant LSM images are at sufficient resolution to reveal the shape and structure of individual neurons in the mouse brain.

Imaging technique 3: micro-computed tomography

MRH and LSM images have some limitations: "When a mouse brain is removed from its skull, it becomes distorted and there are no longer any external landmarks for reference," explains Al. To address these challenges, the team turned to micro-computed tomography (micro-CT), an imaging technique that takes multiple x-rays from different orientations and combines them to create a three-dimensional digital representation of the mouse skull.

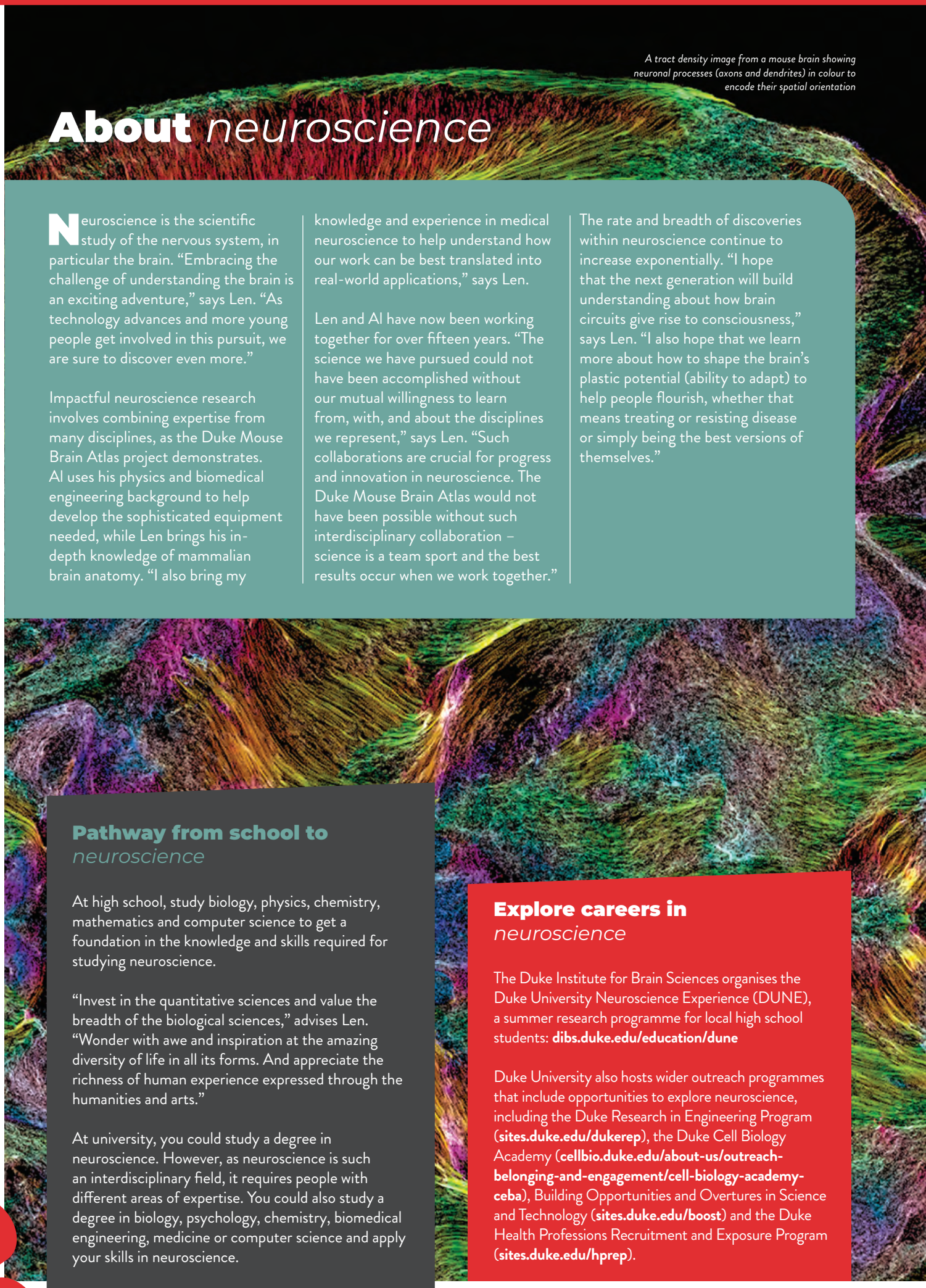
By digitally placing their MRH and LSM mouse brain images inside their micro-CT model of the mouse skull, Al and Len can correct the distortion of the LSM images and provide external references from bony landmarks on the skull. The superb contrast in the MRH images allowed them to label 358 different internal brain structures. "Neuroscientists depend on such labels to share observations," says Al. The result is the Duke Mouse Brain Atlas (DMBA) – a highly detailed three-dimensional representation of the tissues, cells, circuits and connections that together make up the mouse brain.

Insights and applications

Neuroscientists around the world can use the DMBA as a reference tool in their research as it allows them to locate different brain regions and reference changes in mouse models of disease and ageing. "For instance, we are using the DMBA to explore age-related neurodegenerative diseases," says Len. "We've scanned over 100 brains of mice of different ages to assess how different regions of the brain change with age. We've also scanned nearly 500 brains of mice with genes linked to Alzheimer's disease and mapped these onto the DMBA to observe how the brain changes as the disease progresses."

The potential applications of the DMBA are near-endless. The exquisite brain images can be used as a teaching tool to inspire the next generation of neuroscientists. For example, the NeuroTok Initiative is engaging students with the DMBA by encouraging them to create fun and informative educational videos for social media that explain the complex structure of the brain. Researchers can use the DMBA to implant electrodes or probes into specific regions of living brains more accurately. MRI images can be labelled with more confidence. And neuroscientists will be able to answer questions about the relationship between brain structures (seen in MRH images) and specific neurons (seen in LSM images). "Together, these advantages will lead to better science and more precise and replicable results," says Al.

Thanks to the creation of the Duke Mouse Brain Atlas, Len and Al have made the beauty of the brain visible, enabling everyone to appreciate the wonders of this mysterious organ.



A tract density image from a mouse brain showing neuronal processes (axons and dendrites) in colour to encode their spatial orientation

About *neuroscience*

Neuroscience is the scientific study of the nervous system, in particular the brain. "Embracing the challenge of understanding the brain is an exciting adventure," says Len. "As technology advances and more young people get involved in this pursuit, we are sure to discover even more."

Impactful neuroscience research involves combining expertise from many disciplines, as the Duke Mouse Brain Atlas project demonstrates. Al uses his physics and biomedical engineering background to help develop the sophisticated equipment needed, while Len brings his in-depth knowledge of mammalian brain anatomy. "I also bring my knowledge and experience in medical neuroscience to help understand how our work can be best translated into real-world applications," says Len.

Len and Al have now been working together for over fifteen years. "The science we have pursued could not have been accomplished without our mutual willingness to learn from, with, and about the disciplines we represent," says Len. "Such collaborations are crucial for progress and innovation in neuroscience. The Duke Mouse Brain Atlas would not have been possible without such interdisciplinary collaboration – science is a team sport and the best results occur when we work together."

The rate and breadth of discoveries within neuroscience continue to increase exponentially. "I hope that the next generation will build understanding about how brain circuits give rise to consciousness," says Len. "I also hope that we learn more about how to shape the brain's plastic potential (ability to adapt) to help people flourish, whether that means treating or resisting disease or simply being the best versions of themselves."

Pathway from school to *neuroscience*

At high school, study biology, physics, chemistry, mathematics and computer science to get a foundation in the knowledge and skills required for studying neuroscience.

"Invest in the quantitative sciences and value the breadth of the biological sciences," advises Len. "Wonder with awe and inspiration at the amazing diversity of life in all its forms. And appreciate the richness of human experience expressed through the humanities and arts."

At university, you could study a degree in neuroscience. However, as neuroscience is such an interdisciplinary field, it requires people with different areas of expertise. You could also study a degree in biology, psychology, chemistry, biomedical engineering, medicine or computer science and apply your skills in neuroscience.

Explore careers in *neuroscience*

The Duke Institute for Brain Sciences organises the Duke University Neuroscience Experience (DUNE), a summer research programme for local high school students: **dibs.duke.edu/education/dune**

Duke University also hosts wider outreach programmes that include opportunities to explore neuroscience, including the Duke Research in Engineering Program (**sites.duke.edu/dukerep**), the Duke Cell Biology Academy (**cellbio.duke.edu/about-us/outreach-belonging-and-engagement/cell-biology-academy-ceba**), Building Opportunities and Overtures in Science and Technology (**sites.duke.edu/boost**) and the Duke Health Professions Recruitment and Exposure Program (**sites.duke.edu/hprep**).

Download Al and Len's resources from **futurumcareers.com/unlocking-new-neuroscience-frontiers-by-imaging-the-intricacies-of-the-mouse-brain**

Meet *Al*

I have been interested in physics from my earliest childhood. When I was younger, I read *Scientific American* avidly. In seventh grade, I made a model of an oxygen atom and declared to my parents that one day I would become a university physics professor!

As a teenager, I was into music as well as science. I played the clarinet and saxophone in my high school band, sang in my church choir, and played the banjo in a folk trio which was a big hit at the local Rotary.

I finished graduate school in 1974, when CT and MRI technologies were just emerging. I was fortunate beyond my wildest dreams to get a job in the Department of Radiology at Duke University at the right place at the right time. I joined the Biomedical Engineering faculty in 1994 where I have mentored some truly extraordinary undergraduate, graduate and medical students.

I love the beauty of the brain's anatomy. The exquisite detail of our mouse brain images is glorious! I enjoy loading the DMBA into sophisticated software that lets us view the brain in many dimensions. With Len as our guide, we explore the connections between the different structures of the brain.

I enjoy spending my free time in my wonderful workshop in the woods where I make furniture and turn bowls. I am currently learning to use a new computer-controlled cutting machine from my son's company, which involves quite a steep learning curve!

Al's *top tips*

Read as much as you can, walk in the woods and give yourself space to think about what could be.

Meet *Len*

As a teenager, I was interested in music and spending time in the natural world. I grew up playing the clarinet and saxophone but have since realised that my musical soul is best expressed through the acoustic guitar.

I came from a lower-income background. I knew nothing about scientific careers, and my brother was the only person in my family who had graduated from university. I went to university to study biology and marine ecology, where I discovered my love of learning about life and how it works.

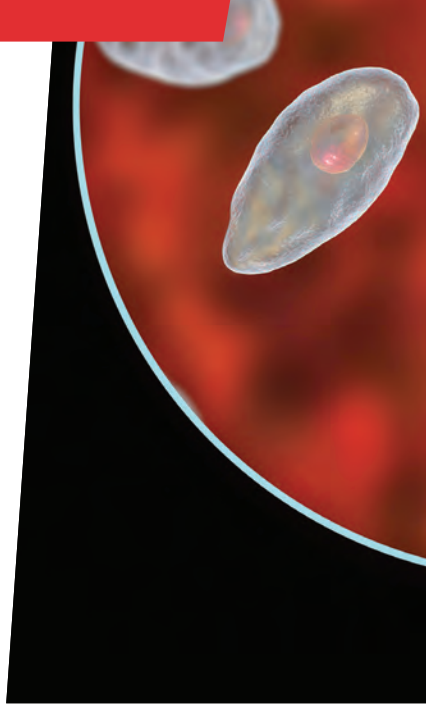
I pursued graduate studies in biomedical science because I had become interested in cardiovascular physiology. But one fateful day, a faculty member told me: "The future is not in the heart, it's in the brain." I took this advice to heart (pun intended!) and decided to check out the neuroscience labs at the other end of the hall. There, I fell in love with the brain. More than four decades later, I remain in wonder and humble fascination with the beauty and mysteries of the brain.

I love to think about how no two brains are identical. Like faces and fingerprints, each is distinctively unique in its size, pattern and complexity.

In my free time, I enjoy spending time with my family. I'm an avid runner, keen tennis player and occasional pickleball player, and I enjoy watching college sports. My classical guitar skills are reaching advanced amateur level, I am a faithful member of a local congregation, and I enjoy hiking and backpacking adventures with my wife.

Len's *top tips*

Cultivate curiosity. Make time for reflection and allow your mind to wander creatively. This is how the best questions are formed, which lead to new discoveries, insights and understanding. These questions may be the start of your greatest adventure.



Targeting the hidden threat: what the cell cycle of *Toxoplasma gondii* can teach us about fighting infection

Toxoplasma gondii is a microscopic parasite that infects nearly every warm-blooded animal on Earth – including humans. Although many people carry the parasite without knowing it, *Toxoplasma gondii* can cause severe illness in unborn babies and those with weakened immune systems. At the **University of South Florida** in the US, **Associate Professor Elena Suvorova** is studying how this parasite reproduces at the cellular level to identify weak points that could lead to new anti-parasitic treatments.

Associate Professor Elena Suvorova

Department of Internal Medicine, University of South Florida, USA

Field of research
Cell biology of apicomplexan parasites

Research project
Investigating how *Toxoplasma gondii* controls its cell cycle

Funder
US National Institutes of Health (NIH)

Website
suvorovalab.com/research

doi: 10.33424/FUTURUM614

PROFILE

Talk like a ...

cell biologist

Centrosome — a structure inside cells that helps organise and control the process of cell division

Cell cycle — the process by which a cell grows, copies its DNA and divides to form new cells

Checkpoint — a control point in the cell cycle that ensures each step happens correctly before the next begins

Encysted form — a dormant, protective form of a parasite that can survive in body tissues for long periods

Fluorescence microscopy — a technique that uses glowing markers to view structures inside cells

Host — a living organism that provides a home and resources for a parasite, virus or other microorganism

Oocyst — a hardy, infectious form of *Toxoplasma gondii* parasite that is shed in cat faeces

Pathogen — a microorganism that causes disease

***Toxoplasma gondii* (or Toxoplasma)** — a parasite that infects warm-blooded animals

Toxoplasmosis — the disease caused by *Toxoplasma gondii*

Parasites have evolved alongside their hosts for millions of years, developing complex strategies to survive, reproduce and spread. While some live quietly without causing harm, others can manipulate their hosts in unexpected – and sometimes disturbing – ways. *Toxoplasma gondii* is one of the most widespread microscopic parasites and is often nicknamed the 'mind control parasite'. It has gained attention for its potential effects on behaviour in infected animals, including humans.

"*Toxoplasma gondii* is a highly successful, opportunistic pathogen because it can invade an unprecedented, wide range of hosts," says Elena Suvorova, an Assistant Professor at the University of South Florida. "It can infect any warm-blooded animal, leading to the disease Toxoplasmosis." Humans can become infected through contaminated water or food, especially undercooked meat. The *Toxoplasma gondii* parasite is typically passed on in a dormant, encysted form – either as oocysts or tissue cysts. Livestock can also carry tissue cysts in their muscles. "Consequently, the consumption of undercooked meat is a major source of infection, particularly in countries whose cuisine includes raw or undercooked meat," explains Elena. "For example, Brazil has one of the highest rates of Toxoplasmosis because Brazilian cuisine includes several dishes involving raw or partially raw meat." Cats also play a key role in spreading the parasite by shedding oocysts in their faeces, which can contaminate soil and crops.

Who is at risk from Toxoplasmosis and why?

Toxoplasmosis can be especially dangerous during the early, or acute, stage of infection. This is when the parasite rapidly multiplies and bursts out of the host's cells, spreading through the body. The infection often begins in the intestines but can quickly reach major organs. In most healthy people, the immune system controls the infection before it becomes serious. However, some parasites hide in places like the brain or placenta – areas where the immune system is less active. There, they slow down and form dormant, protective cysts. In this encysted form, the parasite can remain undetected for years.

"Although the healthy immune system protects us from *Toxoplasma gondii*, the cysts become 'ticking time bombs' that can be activated through age and declining health," explains Elena. Pregnant women are also at high risk, as the parasite can cross the placenta and harm the developing foetus. Doctors advise pregnant women to avoid cat litter, a common source of infection.

What makes *Toxoplasma gondii*'s cell cycle so unique?

All living organisms rely on the cell cycle – the process that controls how and when cells divide – to grow and survive. "Toxoplasma has taken this basic programme and dramatically altered it," says Elena. "It has changed a range of cell cycle regulators and scrambled the cell cycle organisation." These changes help *Toxoplasma gondii* adapt and survive in different environments.

At times, the parasite needs to divide quickly to multiply and outpace the host's immune response. In other stages of its life cycle, it must slow down and form protective cysts. If the balance is off – if it divides too quickly or not enough – the parasite could die. Elena's lab is working to understand how *Toxoplasma gondii* controls these changes at pace, and why its cell cycle is so different from that of other organisms.

How does Elena study *Toxoplasma gondii*'s cell cycle?

To understand how *Toxoplasma gondii* controls its unusual cell cycle, Elena and her team use computer models to search for proteins in the parasite that might behave like cell cycle regulators in other organisms, such as humans. Once they identify possible candidates, they create genetically modified strains of the parasite that let them track and control these proteins.

By switching these proteins on or off, the researchers can see how *Toxoplasma gondii* responds – whether it divides properly, or if things go wrong. The team also analyses the parasite's full set of proteins (called proteomics) and its gene activity (transcriptomics) to understand how the candidate protein regulators fit into a bigger network. Using special imaging tools like fluorescence microscopy, they watch what happens inside the parasite's cells in real time. One of their most useful tools is toxoFUCCI, a fluorescent marker that lights up different stages of the parasite's cell cycle.

What has the team discovered so far?

"Toxoplasma's cell cycle has been studied since the 1990s, and recent progress in developing tools and molecular technologies has intensified this research," explains Elena. Her team has identified several key 'checkpoints' that help the parasite decide when and how to divide. The team has also found that *Toxoplasma gondii*'s cell cycle is organised very differently from other organisms, with unusual proteins and structures taking the lead. One of their biggest discoveries involves a structure called the centrosome, which helps cells divide. In *Toxoplasma gondii*, the centrosome has a unique two-part structure not seen in most other species.

"One feature of Toxoplasma's cell cycle regulators is that they differ drastically from similar molecules that function in humans," says Elena. "This allows us to find specific drugs that will block the parasite's cell cycle without harming the human host."

What does the future hold?

Currently, treating toxoplasmosis remains a challenge. The most common drugs work by blocking the parasite's ability to make folic acid – a molecule essential for replication. While this approach can be effective during the acute stage of infection, it often causes unpleasant side effects and does little to eliminate the long-term, encysted form of the parasite hiding in tissues.

"We're only beginning to understand how the cell cycle is regulated in *Toxoplasma gondii*," says Elena. "As the network of regulatory factors continues to grow, I want to focus on creating a comprehensive map of these regulators and screening them for potential anti-parasitic drug targets."

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About *cell biology*

Cell biology is the study of life at its smallest functional unit: the cell. Every living organism, from single-celled bacteria to complex humans, is built from and powered by cells. These microscopic powerhouses carry out all the essential processes of life – growing, dividing, communicating and defending against disease. Cell biologists investigate how cells function, how they interact with one another and what happens when things go wrong. Their research is central to advances in medicine, genetics, immunology, cancer biology and infectious disease.

Working in this field comes with both challenges and rewards. Understanding how cells operate requires a deep knowledge of molecular biology, genetics and biochemistry – as well as curiosity, patience and problem-solving skills. Experiments often take months or even years to complete, and the tiniest details can lead to breakthroughs or frustrating setbacks. However, for researchers like Elena, the rewards far outweigh the difficulties. "I love solving mysteries," says Elena. "If I can understand how the molecules operate within the cell, I can help other scientists find our bodies' weaknesses and strengths and offer solutions to fighting infectious diseases."

The future of cell biology is full of important questions to explore. "As humans, we have encountered, are encountering and always will encounter infectious diseases," says Elena. "Climate change will make us face new problems. The hidden dangers of the thawing glaciers, the shift of the climate zones, and the new or wider spread of existing microbes will create challenges for the next generation of cell biologists."

Pathway from school to *cell biology*

To pursue a career in cell biology, consider studying a combination of biology, genetics, biochemistry and molecular biology. Together, these subjects will help you understand how cells function, how DNA and proteins work, and how to manipulate molecules in the lab.

"I would also suggest studying philosophy," says Elena. "It shows you the big picture, helps you to formulate the right questions and enables you to create strong arguments."

Explore careers in *cell biology*

Familiarise yourself with the scientific journal Cell (**cell.com**). "It's challenging, but it is at the forefront of cell biology," says Elena. "I recommend taking baby steps by reading the titles first, then progressing to abstracts and to a full study. This simple exercise will help you find your passion and the topic of study you are most interested in."

Useful websites which offer advice and services for various stages of a cell biology career include the American Society for Cell Biology (**ascb.org**) and the European Molecular Biology Organisation (**embo.org**).

Download Elena's resources from **futurumcareers.com/targeting-the-hidden-threat-what-the-cell-cycle-of-toxoplasma-gondii-can-teach-us-about-fighting-infection**

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Q&A

Meet *Elena*

Who or what inspired you to pursue cell biology?

I fell in love with cell biology during my first research role (after completing my PhD) in Dr Vladimir Lupashin's lab at the University of Arkansas for Medical Sciences. He is a passionate scientist who showed me the magic of cell biology. I became fascinated with the intricate organisation of the cell. I learnt many cell biology techniques in his lab, and the results were overwhelmingly rewarding. I am always grateful for his mentorship, which opened up the world of cell biology for me.

What experiences have shaped your career?

There is one incident that always comes to mind when I think of what I am studying now. One winter night as a graduate student, I rode a train from Moscow to Kazan in Russia. It was a long journey, and I shared a third-class compartment with another graduate student from a different institution. He was a physicist. Being young and enthusiastic, we talked about science and shared our dreams. I talked about the biggest mystery of how the cell in the body knows when to divide and when to stop dividing. We went our separate ways in the morning, and I forgot about this conversation because I thought studying cell division was out of my reach. I didn't know that it was my passion that spoke that night – until years later, when I dissected the mechanisms of cell division in parasites and realised I had reached the dream I had talked about.

What are the challenges and rewards of leading your own lab?

The major challenge is responsibility to the people in the lab. Under the US system, nearly all non-faculty employees are funded with 'soft money' from grants. Thus, there is pressure to have a permanent flow of money from external sources, which requires running several competitive projects. The reward is the luxury of creating hypotheses and testing your ideas.

What are your proudest career achievements so far?

Having my own laboratory and research team, which is my dream team. My lab is my pride, hope and refuge. Many things can change in life, but science has never betrayed me.

What are your aims for the future?

I am a dreamer. I want to reach the translational outcome of my studies. Life gave me a chance to gather so much knowledge that I think it is my duty to give it back. I want to create a compound that will help humans control infections from apicomplexan parasites. I also want to train more young scientists and form a school of my graduates. I want to pass on my knowledge and wisdom and help them grow into great researchers.

Elena's *top tips*

1. Be brave and pursue the most critical questions in the field, even if they seem like unreachable dreams.

2. Learn to think. Many people can do technical tasks, but only a few can comprehend the results and project them into the future.

3. Be patient. Remember that we carry out 'RE-search', emphasising the 'RE'. Scientists perform repetitive, often boring, tasks but, like miners, we keep digging and we find gems!

Targeting the lymphatic system as a new gateway for effective drug delivery

The lymphatic system is a vitally important network within the body. While its most obvious functions have been known for a long time, it plays a range of other important roles that are only just coming to light. **Professor Natalie Trevaskis**, a pharmaceutical scientist at **Monash University** in Australia, is studying one of these new discoveries: how the lymphatic system could deliver drugs more effectively than the bloodstream.

Professor Natalie Trevaskis

Institute of Pharmaceutical Sciences, Monash University, Australia

Field of research
Pharmaceutical science

Research project
Developing novel drug delivery systems to target the lymphatic system

Funders
Advanced Research Project Agency Health (ARPA-H, USA); Australia NHMRC Synergy Grant; Australian Research Council (ARC) Discovery and Linkage projects; Medical Research Future Fund (MRFF, Australia); Moderna; Protagonist Therapeutics

doi: 10.33424/FUTURUM612

PROFILE

Talk like a ...

pharmaceutical scientist

Cardiovascular system — the heart and network of blood vessels that transport substances around the body

Lipid — a fat molecule

Lymph — the clear fluid that drains from tissues through lymphatic vessels

Lymph node — a bean-shaped tissue made up of immune cells that filters lymph

Lymphatic system — the network of lymphatic vessels and lymph nodes through which lymph drains from tissues into the bloodstream

Lymphocyte — a type of immune cell

Prodrug — a medicine that only becomes active after entering the body once the active drug is released

You probably know how blood vessels in the cardiovascular system transport oxygen and other substances around the body, but are you aware of the lymphatic system? "The lymphatic system sits alongside the blood vessels in your body," explains Professor Natalie Trevaskis, a pharmaceutical scientist at Monash University. "It consists of lymph nodes and lymphatic vessels which transport a clear fluid called lymph from tissues into the blood." Natalie and her team are exploring how the lymphatic system could be harnessed for more effective drug delivery.

The weird and wonderful lymphatic system

The lymphatic system has three main functions in the body. It helps balance our bodily fluids by removing excess fluid and waste products from our tissues, it transports fats from the intestine to the blood, and it plays a key role in the immune system as immune cells, including lymphocytes, travel through lymphatic vessels and reside in lymph nodes.

But these are only the tip of the iceberg – recent research has uncovered a wide range of other important and diverse functions of the lymphatic system. "For example, lymphatic vessels have been shown to have an important role in clearing waste products from the brain, and their malfunction has been implicated in Alzheimer's disease," says Natalie. Other exciting discoveries indicate that the lymphatic system can help repair tissue following injury or disease. "After we break a bone or have a heart attack, the cells that line the lymphatic vessels release chemicals that help heal the damaged tissue. This process could be harnessed to develop new treatments that accelerate recovery."

Natalie's lab discovered the lymphatic system's role in the development of type 2 diabetes. "When we eat an unhealthy diet, the lymphatic vessels that drain the intestines leak fluid into surrounding fatty tissues," she explains. "These tissues become inflamed and contribute to the onset of diabetes."

Understanding the many roles of the lymphatic system is essential for designing medicines that target the lymphatic system to manage or prevent disease.

The lymphatic system for drug delivery

Most medicines are delivered via the cardiovascular system – they enter our bloodstream either following an injection or by absorption from the intestines. The lymphatic system provides an alternative delivery pathway that could be more effective for a wide range of drugs. "We know that the lymphatic system plays a key role in immunity and many diseases," says Natalie. "So, if we can deliver medicines directly into lymph, they can reach their targets more specifically."

Natalie's lab developed a system that delivers diabetes drugs directly into lymph, which proved much more effective than delivery into the bloodstream. "Vaccines are another strong candidate, as they work by instructing lymphocytes how to identify pathogens," explains Natalie. "These vaccines are more effective when delivered directly to the lymph nodes."

Getting drugs into the lymph

So, how can drugs be engineered to enter the lymphatic system rather than the bloodstream? "Delivery to lymph is actually very straightforward," says Natalie. "Lymphatic vessels in tissues have large gaps between the cells that line them, while the cells that line blood vessels are tightly joined together." This means that molecules of a large enough size can enter the lymphatic system but not the cardiovascular system. "We can achieve specific delivery to lymph through several pathways," says Natalie. "Either the drug molecule itself can be large in size, or we can attach small drug molecules to large carriers."

> ***"We know that the lymphatic system plays a key role in immunity and many diseases. So, if we can deliver medicines directly into lymph, they can reach their targets more specifically."***

Attaching small drugs to lipids, for instance, means that once they reach the intestine, they will enter the lymphatic system in the same way as fats we eat. Then, when the lipid is metabolised by the body, it can release the active drug. This is known as a prodrug. "In my lab, formulations containing lipids are prepared by drug delivery experts who mix the components in certain ways, often with specific pressure or agitation to ensure they are the correct size," Natalie says. "We then measure drug uptake into the lymphatic system using animal models." Animal models are given the prodrug, and a delicate procedure is then used to collect their lymph and measure drug concentrations within it.

From creation to rollout

Once a drug is created, it is a long road to get it into clinical practice. "First, you need to have data that shows the drug is effective, how it is best delivered in the body, and how it is eliminated from the body to prevent accumulation," says Natalie. "Then, the drug must enter toxicology studies to show it is safe." Human clinical studies can then commence, beginning with small numbers of healthy volunteers. "The dosage might be increased incrementally to determine a maximum tolerated dose," says Natalie. "From here, the medicine will be tested in increasingly larger groups of people, to show it is safe and effective."

Natalie's team began working on the lipid prodrug technology in 2009 and had enough evidence to file a patent in 2017. "The patent was licensed to a pharmaceutical company under a research and development deal to further progress the technology," she says. "In 2024, the company spun out a second company to solely focus on developing this technology. Our lead medicine, a prodrug to treat anxiety and depression, is now in the final stages of clinical trials." Thanks to the work of Natalie and her team, lymphatic drug delivery systems are bringing real benefits to healthcare.

About *pharmaceutical science*

Pharmaceutical science involves the development of new medicines, while the related fields of pharmacology and pharmacy deal with studying the effects of drugs on the body and dispensing medication, respectively.

Natalie began her career working as a clinical pharmacist in a small-town pharmacy, dispensing medicines to patients. "I enjoyed interacting with the community, but I wanted to contribute more to the world," she says. "I felt this could be through developing new medicines, which is why I pursued a PhD in pharmaceutical science." Natalie now runs her own lab, working with a diverse team (including chemists, biologists, clinicians and regulatory scientists) to develop new drugs to improve healthcare. "I love that our work can potentially change people's lives for the better," she says. "And I love working with people from many different backgrounds to collectively solve interesting challenges."

In recent years, new technologies have made it possible to develop gigantic datasets. Natalie believes a big challenge for pharmaceutical scientists lies in working out how to use this data. "There could be a tendency to generate data without thinking about why," she says. "I think the next generation will need to sit and think deeply about how to generate and process genuinely useful data." Artificial intelligence (AI) is likely to be both a help and hindrance in this area. "Medicines are already being developed with AI assistance," Natalie says. "Still, there is a strong need to use human intelligence to consider how our work can best help the world and nuanced ideas that AI could miss or neglect."

Download the team's resources from **futurumcareers.com/targeting-the-lymphatic-system-as-a-new-gateway-for-effective-drug-delivery**

Pathway from school to *pharmaceutical science*

Natalie recommends studying a wide range of subjects at school, to get as broad an education as possible. "Once you begin to specialise in pharmaceutical science at university, you lose the opportunity to study subjects like arts and drama," she says. "But these subjects teach critical skills for scientists, such as creating graphics and public speaking."

Undergraduate degrees in pharmaceutical science and related fields tend to require biology, chemistry and mathematics qualifications.

A range of undergraduate degrees can lead to a career in pharmaceutical science, including pharmaceutical science, pharmacology, pharmacy, biomedical science, molecular biology and chemistry.

While at school, Natalie attended Australia's National Youth Science Forum (**nysf.edu.au**) which allowed her to visit universities.

The Faculty of Pharmacy and Pharmaceutical Sciences at Monash University runs outreach programmes for high school students: **monash.edu/pharm/future/outreach**

Explore careers in *pharmaceutical science*

A career in pharmaceutical science could involve developing or testing new drugs for a pharmaceutical company or at a research institution.

Monash University has a video about the difference between pharmacy and pharmaceutical science, and a quiz to help you decide which career is best for you: **monash.edu/pharm/future/whats-the-difference-between-pharmacy-and-pharmaceutical-science**

Reach out to labs that conduct research that interests you and ask whether they can host you as an intern or give you a tour of the lab.

Meet *Sanjeevini*

Dr Sanjeevini Babu Reddiar,
Postdoctoral Researcher,
Trevaskis Group, Monash University

As a teenager, I was fascinated by how the world works. I was drawn to the fundamentals underpinning everything, from the human body to physical theories. Coming from a family of Indian and Sri Lankan immigrants, I was strongly encouraged to pursue medicine, but through exposure to different fields, I found ways to carve my own path.

I grew up thinking I wasn't creative. It wasn't until university that I realised that creativity was also about noticing patterns others missed or approaching familiar problems in new ways. This fundamentally reshaped how I think and work.

I wanted to study something big and important. Pharmaceutical science seemed perfect – a field where I could explore fundamental biological questions while also developing life-changing interventions.

My days in the lab involve a mix of problem solving and collaboration. I do a lot of troubleshooting and developing analytical methods, as well as designing experiments, contributing to team discussions and helping to shape new research projects. I also co-chair HER Research Matters, a grassroots initiative committed to supporting women in STEM through networking, mentorship and advocacy.

Pharmaceutical science is an intellectually rich career that teaches patience, creativity and resilience. Beyond developing new therapies, it also advances our fundamental understanding of how our bodies work – uncovering insights that can transform medicine, public health and how we approach disease prevention.

In my free time, I'm a passionate reader. I read everything from science and history to philosophy and fiction. I also love hiking, playing tennis and travelling, and I have a soft spot for British murder mysteries!

Sanjeevini's *top tip*

Be open to saying 'yes' – my career path was shaped less by a single 'aha' moment and more by a pattern of saying 'yes' to opportunities that sparked my curiosity. You won't know what energises you until you try.

Meet *Mohammad*

Dr Mohammad Abdallah,
Postdoctoral Researcher,
Trevaskis Group, Monash University

As a teenager, I spent most of my time playing soccer. I played it anywhere and everywhere, regardless of the weather. When I wasn't playing soccer, I was watching it at home on the TV.

Before I started my PhD, I worked as a clinical pharmacist in a hospital intensive care unit. My responsibilities included monitoring patients' responses to drugs, adjusting dosages and conducting research to address gaps in disease management. I decided to develop my research skills by joining a PhD research project specialising in pharmaceutics – the area of pharmaceutical science focused on the design and optimisation of new drugs and their administration to patients.

I'm involved in many research projects in Natalie's lab. I focus on novel drugs to target the lymphatic system, and how they interact with proteins, lipids and cells. Any disturbance in the function or structure of the lymphatic system can cause disease, so these drugs can lead to optimised treatment of lymph-related diseases.

There is no typical day in my role. My tasks include reading scientific literature, designing experiments, conducting studies on lab animals, testing samples, teaching research students on research methods and presenting data. Often, new data changes the direction of our next research plans.

Pharmaceutical science aims to improve patients' outcomes. The people in our communities – family, friends, neighbours – could be helped by our work. I feel huge satisfaction when we make discoveries that can enhance people's quality of life.

In my free time, I enjoy hiking in nature and wildlife photography. I also love cooking – my friends say I'm an excellent chef!

Mohammad's *top tip*

Follow your passion to achieve your dreams. Don't be discouraged by any bumps along the way – patience and persistence will help you face challenges.

Financial toxicity: understanding the costs of cancer care

In many countries, including the US, patients have to pay for their healthcare. When diagnosed with a disease that requires expensive treatment, such as cancer, patients must cope with not only the shock of their diagnosis but also the stress and uncertainty of paying for their treatment. **Dr Arpan Patel** from the **University of Rochester**, USA, is investigating this 'financial toxicity' and using his findings to advise doctors and patients.

Dr Arpan Patel

Associate Professor, Department of Medicine, Hematology and Oncology, University of Rochester, USA

Fields of research
Healthcare economics, financial toxicity, oncology

Research project
Studying the causes, effects and solutions of the financial stress faced by cancer patients

Funders
Patient-Centered Outcomes Research Institute; US National Cancer Institute (NCI); National Institute of Aging (NIA); Wilmot Cancer Institute

doi: 10.33424/FUTURUM624

PROFILE

Talk like a ...

healthcare economist

Area Deprivation Index — a mapping tool that is used to evaluate a region's socioeconomic conditions

Co-pay assistance — programmes that help patients cover the costs of medical care and insurance

Demographics — statistical characteristics of populations, such as age or income

Financial toxicity — the negative impacts of medical expenses on patients' well-being

Oncology — the study, treatment, diagnosis and prevention of cancer

Being diagnosed with a medical condition can be a highly stressful experience. When a person is diagnosed with a serious disease, such as cancer, they will face stress and uncertainty about the disease itself: how it will affect their health, their long-term prospects, and the physical and emotional toll of treatments. On top of this, patients have to consider the financial cost of their treatment, which can be substantial. "When people see their first bill for cancer care, it often causes a lot of emotional distress," says Dr Arpan Patel from the University of Rochester. "The emotional aspect of a cancer journey is extremely challenging. I don't think it's talked about enough." Arpan specialises in researching how this financial burden affects patients and their support networks, and how these stresses can be better addressed to provide the help that patients need.

The high costs of cancer care

The monetary burden related to cancer care, and the negative impact this has on the financial stability of the patient, is known as financial toxicity. "When people think about financial toxicity, they may only focus on the cost of cancer care itself," says Arpan. "However, there are many indirect costs as well." Cancer treatments may involve travelling to the hospital every week, or even every day, which can be expensive. Some treatments, such as chemotherapy, have severe side-effects on health, which can force patients to take leave from work. "Family members may also have to reduce their hours or quit their jobs to care for the patient," says Arpan. "All of these effects lead to reduced income for the family, which puts financial stability at risk."

A 2025 study found that 54% of cancer patients in the US faced financial toxicity. An earlier study also revealed demographic differences, indicating that patients were more likely to experience financial toxicity if they were female, Black, single, lower-income or unemployed, or had a lower level of education. Older people – who make up the majority of cancer patients – are also particularly vulnerable. "The general rule of thumb is that you will spend 80% of your lifetime medical costs in the last 10% of your life," says Arpan. "This interferes a lot with retirement planning, given older adults' income typically comes from pensions or savings."

And it's not just patients that are affected: cancer care has implications for the people around them too. "I often tell people that while cancer is an individual disease, it often affects the entire family and their wider social network," says Arpan. He believes that clinicians may often underestimate these stresses, meaning that they may fail to provide patients with the appropriate resources and support. To understand more about this problem, Arpan is investigating how patients cope with financial toxicity and what clinicians can do to help.

Studying financial toxicity

Arpan talks with patients to find out about the financial hardships they experience. "People often feel nervous telling us their exact salaries and things like that," he says. "Instead, we use Area Deprivation Indexes." These indexes use information about the areas where patients live to make estimates about average levels of income, quality of life, life expectancies and education levels, all of which affect a patient's likelihood of experiencing financial toxicity. "We also do more qualitative cost analyses through discussions with healthcare providers, patients and patients' families," says Arpan. "We then transform the information collected into quantitative data for analysis."

> ***"The more aware people are about financial toxicity, and the more we talk about and research it, the better equipped we are to get the best resources to the patients that need them."***

What can be done to alleviate financial toxicity?

Arpan believes that the first step towards tackling financial toxicity is to talk about it more openly – and that clinicians should lead the charge. "Research indicates that in more than half of discussions with patients, clinicians don't even talk about financial toxicity," he says. "When it is talked about, it's usually the family that brings it up." In his own clinical practice, Arpan makes sure to begin or end appointments talking about the costs of cancer care. "I ask patients and their families if costs are a concern for them, and why," he says. "If it is a concern, I direct them to resources that can help."

There are resources that patients can access to help alleviate their financial burden, but they aren't always easy to find and access. Support can be provided through social workers, financial advisors, support groups, charities and co-pay assistance. While informing patients about these resources can help, Arpan believes a more structured approach is needed for systemic change. He advocates for policy change to train healthcare providers in identifying patients that are at high risk of financial toxicity, and establish a standardised approach across healthcare organisations.

"We are testing out one possible intervention at our own institution," Arpan says. "We have set up a Financial Toxicity Tumor Board, which brings together stakeholders such as clinicians, insurance providers and administrators, social workers, and many others." The board addresses concerns around financial toxicity faced by patients and works on ways to address it, such as processing insurance claims and capitalising on available resources. "Increasing awareness is the principal goal," says Arpan. "The more aware people are about financial toxicity, and the more we talk about and research it, the better equipped we are to get the best resources to the patients that need them."

About *healthcare economics*

Healthcare economics examines the factors that influence the costs and expenditures of healthcare industries. This includes researching the efficiency of healthcare systems, the financial impacts on patients and other stakeholders, and the interactions between financial flows and overall well-being of the communities that these healthcare systems serve. Healthcare is a unique sector, so the factors affecting its economics are also unique.

Within healthcare economics, Arpan believes that financial toxicity is a growing issue, caused in part by the lack of experts focusing on addressing it. "Healthcare systems are often complicated and fragmented," he says. "The costs of cancer care, and healthcare in general, are enormous and rising, especially in the US." This trend puts pressure on patients and healthcare providers alike. "It's really important to dive into this topic with a holistic approach," says Arpan. "We need to understand the issue properly before we are able to do something about it."

Finding courses or research opportunities that focus on healthcare economics can be challenging. "Schools and universities continue to be quite siloed – you choose science or economics, but not both," says Arpan. "Medical trainees are rarely taught healthcare economics at all." Yet Arpan says there are signs of change, and that healthcare economics is emerging as its own discipline. "It's important for future clinicians and researchers to take courses on healthcare economics, to understand the terminology and build awareness about the relationships involved ," he says. "Given that the field is still young, students interested in financial toxicity need to be proactive to learn about it and find opportunities to bring medicine and economics together."

Pathway from school to *healthcare economics*

Arpan recommends getting a good grounding in economics and statistics to understand the terminology and methodologies that underlie healthcare economics. Relevant subjects to take at school include economics, mathematics, biology and chemistry.

At university, courses in medicine, economics, biology, healthcare and public health could all lead to a career in healthcare economics. Arpan recommends seeking courses that specifically address the intersection between medicine and economics.

Explore careers in *healthcare economics*

The University of Rochester School of Medicine and Dentistry, where Arpan works, has various programmes and resources for high school students: **urmc.rochester.edu/education/md/undergraduate-programs**

This article from Johns Hopkins' Bloomberg School of Public Health gives an overview of health economics, and includes a link to careers and opportunities in the field: **publichealth.jhu.edu/academics/academic-program-finder/masters-degrees/master-of-health-science-in-global-health-economics/what-is-health-economics**

Watch these videos to learn more about what health economists do: **youtube.com/watch?v=pQO3EZS9ICw** and **youtube.com/watch?v=1nKjZ-mEaf8**

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Download Arpan's resources from **futurumcareers.com/financial-toxicity-understanding-the-costs-of-cancer-care**

Meet *Arpan*

I've always been a scientist at heart. From a young age, I was fascinated by nature and the ways that people think and act. Later, I got interested in the rules and regulations surrounding healthcare, which seemed at odds with the ideals of medicine and science more generally.

My parents are my inspiration and my mentors. They came to the US from India with very little money. My father worked in Brooklyn and my mother sold blankets on the side of the road to pay for my schooling. Appreciating the prior generations and the work and effort they put in for us is a humbling and meaningful experience.

I found my calling when practicing as a clinician. The thing most dear to me was meeting people and trying to help them. After several years, I understood that people with fewer resources have worse experiences with healthcare. I also saw how my own family was impacted by healthcare costs, which incentivised me to study healthcare economics specifically.

An excellent study by Harvard suggests that happiness principally derives from two important things. One is helping others, and the other is human interactions and connections. Healthcare is a field that offers both of these, through helping and interacting with the people that come to the clinic.

Failure is often a good thing. I struggled a lot early on in my career. That motivated me to study harder and smarter, while remaining humble and making the most of the opportunities that arose. I believe in saying yes to opportunities, even if they're not exactly what you had in mind. Gaining diverse experiences has certainly been tremendously helpful for me.

I go cycling to unwind from work. I have two kids, and we all started learning piano together, which we love. I also enjoy just being outdoors, driving on country roads and not worrying about anything else.

Arpan's *top tip*

Seek mentorship, and not just from mentors in the discipline you want to study. For me, my father was my biggest mentor and role model.

Can a learning health system optimise emergency care?

Hospitals' emergency departments are intense places, where the speed and efficiency of care is key for good patient outcomes. However, these departments often also deal with patients who have non-critical illnesses, which can restrict the resources available for those who really need them. At the **University of Calgary** in Canada, **Dr Catherine Patocka** and **Dr Jessalyn Holodinsky** are creating a feedback-based learning health system to optimise patient care in emergency departments.

Dr Catherine Patocka

Fields of research
Emergency medicine, health professions education

Dr Jessalyn Holodinsky

Fields of research
Data science, health services research

Department of Emergency Medicine, University of Calgary, Canada

Research project
Creating a feedback-based learning health system to optimise emergency care

Funder
Cumming School of Medicine O'Brien Institute Learning Health Systems Catalyst Grant

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PROFILES

Talk like an ...

emergency medicine researcher

Amputation — the surgical removal of all or part of a limb

Data science — a multidisciplinary field that uses scientific methods to extract knowledge from data

Emergency department (ED) — the hospital department that provides immediate medical care for patients with urgent illnesses or injuries

Frostbite — injury to body tissues (typically the hands and feet) due to exposure to extreme cold, which may require amputation of the affected area

Learning health system — a healthcare system designed to continuously improve by integrating new data and knowledge

Healthcare involves making crucial decisions, not just about which treatments to give, but also about which health services are best suited for each patient. However, these decisions are not always optimised. Many patients end up in a hospital emergency department (ED) even if they do not have a serious urgent condition.

Why do non-critical patients end up in the ED?

"Patients are often directed to the ED by other healthcare providers," explains Dr Catherine Patocka, an ED doctor. "Because the healthcare system is so stretched, some people are sent to the ED simply because they can't get help anywhere else." This creates strain on the ED, meaning fewer resources are available for true emergencies. This is problematic because for someone with a critical illness, receiving timely care in the ED can be the difference between life and death. "Many Canadian hospitals struggle to provide quick access to emergency care," says Dr Jessalyn Holodinsky, a data scientist who specialises in ED health services. "Many patients face crowded waiting rooms and long delays, which negatively impact their outcomes."

"Right now, we don't have good ways to measure the scale of the problem of non-critical patients being referred to the ED," continues Catherine. "What we do know is that trying to use the ED to fill gaps elsewhere in the healthcare system is a worrying and harmful trend."

Could a learning health system provide a solution?

Healthcare systems are highly complex, meaning they need highly complex management structures in

place. They need to be able to continuously adapt and deal with new information to offer optimal care. "A learning health system aims to do this," says Jessalyn. "A good learning health system continuously and systematically generates, applies and learns from data and evidence to improve patient care and system performance."

Catherine and Jessalyn are combining their expertise in emergency medicine and data science to develop a learning health system to improve EDs in Calgary. They are tackling the question of how to optimise emergency care by assessing and changing practices across the healthcare system, with a focus on how to use feedback to reduce unnecessary referrals to the ED.

How are Catherine and Jessalyn developing a feedback-based learning health system?

"Catherine's clinical experience helps us understand the real challenges faced by frontline healthcare providers, and her expertise in health education allows her to design feedback that supports learning and professional growth," says Jessalyn. "My knowledge of data science allows me to analyse patterns, test ideas and build systems that can learn and adapt over time."

With this collaborative approach, Jessalyn and Catherine are developing a learning health system for the ED that uses feedback for continuous improvement. "Achieving this vision requires a deep understanding of how individuals and systems within healthcare learn and evolve," explains Catherine. "We propose that feedback is key – using past performance to guide and enhance future performance." To this end, Catherine and Jessalyn are investigating which forms of feedback should be integrated to build an effective learning health system that ensures patients are directed to the most appropriate health services.

> ***"Our aim is to create practical, evidence-informed feedback tools that are tailored to different healthcare settings."***

"My work in feedback began by asking 'What do people mean when they say 'feedback'?'" says Catherine. "Though it seems like a straightforward idea, I quickly found that people define and use feedback in many different ways." Over the course of her PhD, Catherine started to make sense of all these different ideas by exploring social science theories which helped her develop a model to understand the many meanings of feedback. "With this model, we can study different types of feedback and see what works best in different situations," she explains.

Catherine and Jessalyn are exploring how electronic health record systems can give feedback to healthcare providers that refer patients to the ED. "We start by using data to understand the scope – for instance, how many patients are referred to the ED?" says Jessalyn. "Then, through focus groups, we try to understand what type of feedback is reaching healthcare providers and what other information would be useful for them." Jessalyn and Catherine talk to healthcare providers, observe how referral events play out in real time, and analyse data using statistics and computer programs. By collating all this information, they hope to find ways to change how the healthcare system functions, to better allocate resources to those that need them most. "Our aim is to create practical, evidence-informed feedback tools that are tailored to different healthcare settings, especially in the fast-paced world of emergency care," says Catherine.

An example of success

Calgary's new frostbite protocol is a great example of how a learning health system works when data and evidence are implemented to improve how care is delivered. During the winter, doctors were seeing a lot of frostbite cases, particularly among unstably housed people exposed to the extreme cold. Recognising that a new treatment was reducing frostbite amputations in Canada's North, healthcare providers applied the principles of learning health systems to hasten the implementation of this new knowledge and treatment into the regular routines in Calgary. "The results were impressive," says Catherine. "Data analytics have demonstrated that fewer people in Calgary needed finger or toe amputations. Because of this success, other places in the province have started using the same approach."

As Jessalyn highlights, "This shows how a learning health system can take what works, apply it quickly in real-life care, and make a big difference in patient outcomes."

About *emergency medicine*

Emergency medicine involves providing care for patients with critical illnesses or injuries. Catherine and Jessalyn's different career paths demonstrate the importance of diverse professional backgrounds for solving challenges in the field.

When not researching, Catherine is a doctor in the ED – a fast-paced and variable environment. "No two days are the same," she says. "I care for people with all kinds of health problems, from minor injuries to life-threatening conditions. I have to think on my feet, solve problems and stay calm under pressure. Most of all, I try to make sure each patient feels safe and cared for, during what may be the hardest moments of their lives."

Her academic role is a contrast to the hectic ED. "A typical day of research involves a lot of deep thinking, writing and problem solving," says Jessalyn who, as a data scientist, is a full-time researcher. "We spend hours at the computer, reading, analysing data, and writing papers and grant applications." Like any career, research inevitably involves setbacks, but the rewards are worth it. "We get to work with smart, dedicated colleagues and address real-world problems," says Jessalyn.

Catherine and Jessalyn both highly recommend a career in emergency medicine. "The work is fast-paced, challenging and teaches you lots of skills," says Catherine. "It's meaningful, full of variety and truly makes a difference to the lives of others." Jessalyn emphasises that many careers within emergency care do not involve direct patient care. "I work 'behind the scenes' to help my colleagues who are ED doctors to improve patients' lives," she says. "If you get excited by tackling complex problems, emergency medicine research could be for you."

Pathway from school to *emergency medicine*

"We need people from a wide range of backgrounds in emergency medicine," says Jessalyn. "There's no 'right path' to emergency medicine. What matters most is curiosity, compassion and a drive to make a difference."

To work in a hospital ED, you will need to study a clinical degree such as medicine or nursing, which typically ask for high school qualifications in biology and chemistry.

To work in emergency medicine research, you could study a degree in data science, public health or a related field. These may ask for high school qualifications in mathematics, statistics or computing.

At high school, other subjects such as languages and arts can be highly beneficial, especially for developing your communication skills, which will be useful for collaboration and patient interactions.

Explore careers in *emergency medicine*

"Emergency medicine offers lots of career paths," says Catherine. "You can be a frontline care provider, a healthcare system leader, a teacher training the next generation or a researcher working to solve healthcare problems."

The University of Calgary's Cumming School of Medicine offers the Pathways to Medicine Scholarship Program, which supports students from underrepresented backgrounds to pursue medical careers: **cumming.ucalgary.ca/future-students/scholarships/pathways-medicine-scholarship**

ProjectsAbroad provides medical internships around the world for high school students: **projects-abroad.ca/medical-internships-high-school-students**

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Download Catherine and Jessalyn's resources from **futurumcareers.com/can-a-learning-health-system-optimise-emergency-care**

Meet *Catherine*

As a teenager, I competed nationally as a figure skater and did intensive ballet. These experiences taught me a lot about discipline, creativity and managing pressure – skills that I use every day in the ED.

My mom inspired me to become an ED doctor. She worked as a rural emergency doctor, and I grew up watching how calm and capable she was in tough situations. I remember one time, when a woman had a seizure in a hot tub at the gym, my mom immediately took charge until the paramedics arrived. Watching her show up for others with such confidence and kindness really shaped my path.

As an ED doctor, I have the chance to help people when they're at their most vulnerable. It's incredibly meaningful to be there for them at that moment. But the work is getting harder. Our resources are stretched, the system is under pressure and sometimes the emotional weight of the job can really take a toll.

Some of my favourite memories from working in the hospital come from the quiet hours of a night shift, around 3 or 4 am. Everything slows down and you know the people who are in the ED really need our help. There's a strange calm and a deep sense of purpose.

My young family keeps me busy outside of work. I love to relax by rowing on a peaceful lake, stretching out on the couch with a good book or baking.

Catherine's *top tips*

Keep an open mind and enjoy the journey. You don't need to figure everything out right away. Explore different interests, be curious and stay flexible. Some of the best opportunities come from unexpected places.

Meet *Jessalyn*

At high school, I loved math and science. I also competed nationally as a figure skater and was involved in competitive dance, so I was very busy. I think this set me up to handle juggling the many responsibilities of a career in academia.

My mom inspired me to enter the medical field. She was a nurse in a hospital Intensive Care Unit (ICU), and I loved hearing stories about the patients she helped and the lives she saved. I thought I wanted to become a medical doctor, possibly in the ICU. While at university, I volunteered in the ICU to organise its research data. There, I learned about medical research and discovered I could contribute to healthcare in other ways.

As a data scientist, I enjoy knowing my work has an impact and makes a difference to the lives of patients and the healthcare workers who look after them.

I want to make statistics fun! We use data every day to make decisions, but so many people get intimidated by numbers. It's important that people understand statistics but it's hard to get your point across if the content is boring. I want my lessons to make statistics exciting and accessible to spark curiosity in my students.

I love the outdoors and try to spend as much time outside as possible. That means tending my garden and hiking in the foothills of the Rocky Mountains, through both sun and snow.

Jessalyn's *top tips*

Never be afraid to ask questions or try something new. There are so many career opportunities you might not even know about yet. Make sure to take time to really understand what motivates you and makes you happy, so you can find a job that you enjoy and find rewarding.

How philanthropy is improving cancer care and oncology research

Following the death of their beloved husband and father, the Eisenberg family established the **Harold E. Eisenberg Foundation** in his honour. This philanthropic organisation funds vital gastrointestinal cancer research, enabling oncologists to better care for their patients. At **Northwestern University** in the US, **Professor Al B. Benson III**, **Dr Sheetal Kircher** and their fellow oncologists are conducting research ranging from lab-based science to investigations of the social problems faced by cancer patients, highlighting the essential role of philanthropy in improving the lives of those living with cancer.

Professor Al B. Benson III

Dr Sheetal Kircher

Robert H. Lurie Comprehensive Cancer Center, Northwestern University, Chicago, USA

Field of research
Oncology

Funder
Harold E. Eisenberg Foundation
eisenbergfoundation.org

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PROFILES

Talk like an ...
oncologist

Gastrointestinal (GI) system — the digestive system, which includes the oesophagus, stomach, small intestine, colon, rectum and anus, plus associated organs such as the liver, pancreas, appendix and gallbladder

Oncology — the study, diagnosis and treatment of cancer

Philanthropy — the act of giving money, time or other resources to provide long-term support to important causes

Social determinants of health — social factors that can influence health, such as income, education and environment

Tumour — an abnormal mass of cells

In 1999, Harold Eisenberg passed away after suddenly developing gastrointestinal (GI) cancer. He was a loving husband and a dedicated father to his three children. As a leader in real estate, he believed in sharing his knowledge and experience to enrich and empower students. Shortly after his passing, his family and friends established the Harold E. Eisenberg Foundation to celebrate his life and legacy as a mentor. The Foundation has two goals - to fund gastrointestinal cancer research and to support educational initiatives for students.

The Eisenberg family contacted Professor Al Benson, Harold's oncologist and a researcher at Northwestern University, to determine how they could best support other GI cancer patients. "They wanted to help others by raising funds to support GI cancer research," says Al. "As GI cancers account for nearly 20% of cancers worldwide, this is a huge area of research."

What does oncology research involve?

"When you think of research, you might imagine working in a lab to grow cells in petri dishes or test drugs on mice, but there's a whole spectrum of research out there," says Dr Sheetal Kircher, who is also a clinical and research oncologist. Oncology research begins with basic science, the foundational research carried out in laboratories. This leads to translational research, where basic science is converted into practical solutions to improve health and save lives, using methods such as clinical trials to test new treatments. "It's important that we include patients' voices in translational research," says Sheetal. "It's not enough for a drug to stop a tumour from growing – if it harms the patient's quality of life, it's not truly effective. We must understand whether the treatment improves the patient's well-being from their point of view."

The third key area of oncology research is known as 'cancer control research'. "This involves analysing population data to improve health services," says Al. Alongside treating their patients, Al and Sheetal both investigate cancer care delivery. "This involves studying the interplay between the healthcare system, patients and clinicians at different levels to get patients what they need and produce the best outcomes," explains Sheetal, who is especially interested in the long-term effects of cancer treatment. "For example, I have a patient who had neuroblastoma (nerve cell cancer) as a child," she recounts. "She is alive and grateful, but as an adult she's had stomach, breast and skin cancers as a result of her childhood cancer and treatment, and her heart function is decreased. This highlights the importance of understanding health after cancer."

How is oncology research changing?

Previously, cancers were treated based on where they appeared in the body. But now, with tools such as genetic sequencing and molecular profiling, scientists can identify the specific gene alterations driving the cancer, meaning treatments can be tailored to tackle root causes. "Cancer is incredibly complex," says Sheetal. "While developing fully individualised treatments will take time, each step forward brings us closer to personalised treatments."

An equally important topic is cancer control research that investigates how peoples' lives impact their cancer outcomes. "For a long time, social determinants of health (such as income, education or where someone lives) were seen as less important topics of research," says Al. "I'm pleased they have now become integral to cancer research, as social determinants have profound impacts on health outcomes."

Why is philanthropy vital for cancer care and research?

Being diagnosed with cancer is an expensive business. In the US, healthcare costs are typically covered by a combination of health insurance payments and patient payments. Sheetal studies the financial burden on cancer patients, recognising that costs can be daunting and devastating. "The majority of someone's oncology team is covered by their health insurance," she explains. "However, many essential supportive services, provided by nutritionists, social workers and nurses, are not reimbursed by health insurance." As a result, philanthropic organisations that fund cancer care, such as the Eisenberg Foundation, play a vital role in ensuring that patients receive comprehensive high-quality care.

Philanthropy is also vital for social determinants of health research. "Topics like health disparities, access to healthcare and the impact of poverty on health are outside the funding priorities of pharmaceutical companies," says Sheetal. "That's why support from mission-driven organisations is so important in helping us explore these critical issues."

Since 2001, the Eisenberg Foundation has donated over $4 million to advance GI cancer research and patient care. Every year, it supports oncologists at Northwestern University by funding a range of GI cancer research projects. When funding was not available for an oncology nurse to support patients taking part in clinical trials, the Eisenberg Foundation stepped in to fund this vital role. The Foundation supported the establishment of the Harold E. Eisenberg GI Cancer Tissue Bank, a cancer specimen repository used for research and clinical trial purposes. It also funds the OncoSET Program, a personalised medicine programme that studies the biological characteristics of individual tumours, enabling patients to receive drugs which will specifically target their tumour. And junior members of the Eisenberg Foundation create care packages for people who are diagnosed with GI cancer.

In addition, students at Highland Park High School in the north suburbs of Chicago raised $124,000 to support GI cancer research and patient resources at the Robert H. Lurie Comprehensive Cancer Center. This not only informed high school students and staff about GI cancers but also demonstrated how young people can learn about philanthropy, select a worthy cause and become philanthropists themselves.

Today, the Eisenberg family and countless volunteers continue Harold's legacy. His wife (who had cancer herself and was also Al's patient), children and grandchildren are steadfast in their support. Thanks to the committed philanthropy of the Eisenberg Foundation, Al, Sheetal and other oncologists can better understand and care for their cancer patients.

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About *oncology*

Oncologists study, diagnose and treat cancer. This is a huge area of medicine and research. Cancer can occur in any area of the body and many disciplines (e.g., biology, immunology, biochemistry) and healthcare professions (e.g., doctors, nurses, surgeons, geneticists, supportive care staff) are needed to understand and treat it.

Al and Sheetal both work as clinical oncologists, treating patients with different types of gastrointestinal (GI) cancer, and as academic oncologists, conducting cancer control research and studying cancer treatment and clinical trials. "A day in the life of a clinical oncologist involves seeing a lot of patients, and examining their scans and test results," explains Al. "Research will look different depending on whether you're in a lab conducting basic science research, conducting clinical trials for translational research, or analysing population data for cancer control research. Oncology research is such a broad area that it can be focused on whatever you find passion in."

One thing is certain – whichever area of oncology you choose to work in, you will be changing lives.

"When I began my career as a clinical oncologist, I realised my focus wasn't solely on the molecular biology of cancer," says Sheetal. "What mattered more to me was understanding what my patients were going through. Many were deeply worried about how to afford their care, and that shaped my research interests. I wanted to better understand the financial and personal realities of cancer treatment. As cancer care continues to grow more complex, the question becomes: how do we provide it in a way that is thoughtful, efficient and truly high-quality?"

Pathway from school to *oncology*

Getting a good foundation in science will be important, regardless of what area of oncology interests you. Build a strong foundation in biology and chemistry at high school and then take courses in anatomy and immunology at university.

"Learn how the health system works in your country," advises Sheetal. This is likely to be covered in university public health courses.

"Liberal arts subjects are important for understanding social determinants of health," says Al. Study humanities and social sciences to learn about health disparities and how social factors impact health outcomes.

To become a clinical oncologist, you will need to gain a medical degree at university and then spend additional years training in a hospital.

Look for opportunities to take part in research projects, whether basic science in a lab or social science research.

Contact clinical and research oncologists to ask if you can shadow them to see what their work involves.

Explore careers in *oncology*

There is a huge range of career opportunities in oncology. Clinical (medical) oncologists diagnose and treat cancer, oncology surgeons operate on patients to remove tumours, and radiation oncologists treat tumours in the body with radiation. Nurses care for patients through all stages of their treatment, while palliative care workers provide support to improve symptoms and provide end-of-life care to help patients be as comfortable as possible. Fertility counsellors support patients who may have fertility issues following cancer treatment, geneticists examine the genetic mutations in tumours, and research oncologists investigate all aspects of cancer biology and care.

Learn more about cancer and careers in oncology from the American Society of Clinical Oncology (**asco.org**), the American Cancer Society (**cancer.org**), the National Cancer Institute (**cancer.gov**) and the National Comprehensive Cancer Network (**nccn.org**).

Download Al and Sheetal's resources from **futurumcareers.com/how-philanthropy-is-improving-cancer-care-and-oncology-research**

Meet *Al*

I worked as a journalist and editor for my high school and college newspapers. It was a socially turbulent time – I was a senior in high school when Robert Kennedy and Martin Luther King were assassinated in 1968, and the reactions to these events had a significant impact on me. The Vietnam War was also happening – increasingly, people were concerned about the horrors of this war and being drafted to fight in a war that did not make sense to them. Along with many others, I was tear-gassed during protests on campus. In our newspapers, we covered everything from these huge political issues to the music scene. For me, it was both an incredible and unsettling time, but it shaped me as a person and helped pave the path to my medical career.

We talk about the science and art of medicine. A lot of what we do is the art, so being a well-rounded person is helpful. As a journalist, I had to collect information from a whole lot of different people and then synthesise this information to write concise and coherent stories. This gave me invaluable experience and taught me good communication skills. In many ways, a physician is telling a patient's story – they must listen with compassion while they obtain information from the patient about their symptoms, medical history and worries about their illness, then combine this with the scientific results of lab tests to provide the best plan of medical care.

I don't remember a time when I didn't want to be a doctor. I still remember one moment as young child: Dr James Holland (considered a pioneer of oncology) and Dr Jimmie Holland (the founder of psycho-oncology) lived in my neighbourhood and their kids went to my school. One day, James brought in rats to show us – they had been exposed to tobacco tar and had tumours on their skin. I've wanted to be an oncologist ever since. I would also add that my own paediatrician and my uncle were inspirations fuelling my interest in medicine. And I've now been seeing patients for over 50 years!

Meet *Sheetal*

I was very wild when I was younger – I lived my best life and enjoyed college to the fullest! Although I worked hard at my studies, I had a good balance of work and play.

I was drawn to oncology while studying medicine because it is such an intense and diverse field. I get to work with colleagues from a wide range of different professions, and I get to help people when they are at their most vulnerable.

Caring for patients is truly a blessing and a very humbling experience. Cancer is the great equaliser – it doesn't care whether you are rich or poor, or what race or gender you are. It brings everyone to the same place of vulnerability and gives them a sense of their own mortality. Some people, like the Eisenberg family, rise to the tragedy and do great things, which is beautiful to see.

Studying and practising medicine is hard work so it's important to have hobbies – find things that interest you and help you switch off from studying. I try to instil the importance of free time in my kids, especially unscheduled, open-ended time with no commitments, to allow them to relax and think clearly.

> ***"Caring for patients is truly a blessing and a very humbling experience."***

Helping girls to thrive through creativity, collaboration and coding

Running a coding club as a newly qualified computing science teacher, **Toni Scullion** aimed to create an environment where girls could thrive and aspire to enter the world of tech. The ongoing gender gap in all STEM subjects, particularly in computing science, compelled her to go further. **dressCode** was born, and the charity now offers a suite of resources to help teachers inspire their students.

What motivated you to set up dressCode?

In my early years as a computing science teacher, I ran a very popular coding club. However, only three girls attended, and they only came once. When I asked them why, they said it was too male-dominated, and they found the boys "a bit annoying". They agreed to return on two conditions: I brought chocolate, and it was an all-girls club. That was the springboard for dressCode.

During my undergraduate degree in computing science, I was one of the few female students, but I didn't give it much thought. I credit this to my upbringing and the inclusive environment at Edinburgh Napier University. However, when these 12-year-old girls were put off by a coding club, I researched the gender gap in computing science. I discovered it was a global issue and, sadly, still is.

I then examined the situation in Scottish secondary schools, not just in computing science but across all STEM subjects. I was shocked to find that computing science had, and still has, the largest gender gap of any traditional STEM subject in Scotland, by a significant margin, and this has been the case for over a decade. I felt compelled to do something.

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What does a typical dressCode club involve?

A typical dressCode club provides a fun and engaging space where girls can learn about computing science through hands-on activities. They have the freedom to explore areas of interest, such as creating games, stories and animations, building websites, digital art and apps, or exploring cyber security. The emphasis is on creativity, collaboration, problem-solving and fostering a nurturing environment where girls can thrive.

What events does dressCode run?

Alongside our dressCode club portal, we run several other initiatives. We hold annual coding competitions for primary and secondary schools, allowing them to participate independently or integrate them into their school curriculum. We have both team and individual coding competitions.

We also organise dressCode hackathons, typically hosted at tech companies or universities. Participants work in teams to create solutions to themed challenges. No prior coding experience is necessary, as we provide resources and support from senior and industry mentors.

Additionally, we run Computing Science Scotland, which supports and champions teachers delivering computing science. We help connect teachers and facilitate industry support for their initiatives.

What resources does dressCode provide for teachers?

dressCode supports and empowers teachers to promote the subject. We created **Choose Computing Science** to help educators influence parents and guardians, who play a crucial role in shaping students' subject choices. Our website provides comprehensive information to help them nurture talent and raise awareness of the diverse world of computing science.

We also offer a suite of resources for teachers and schools, including posters, information cards, display materials, door signs and postcards. These are ideal for open evenings, parents' nights and school social media.

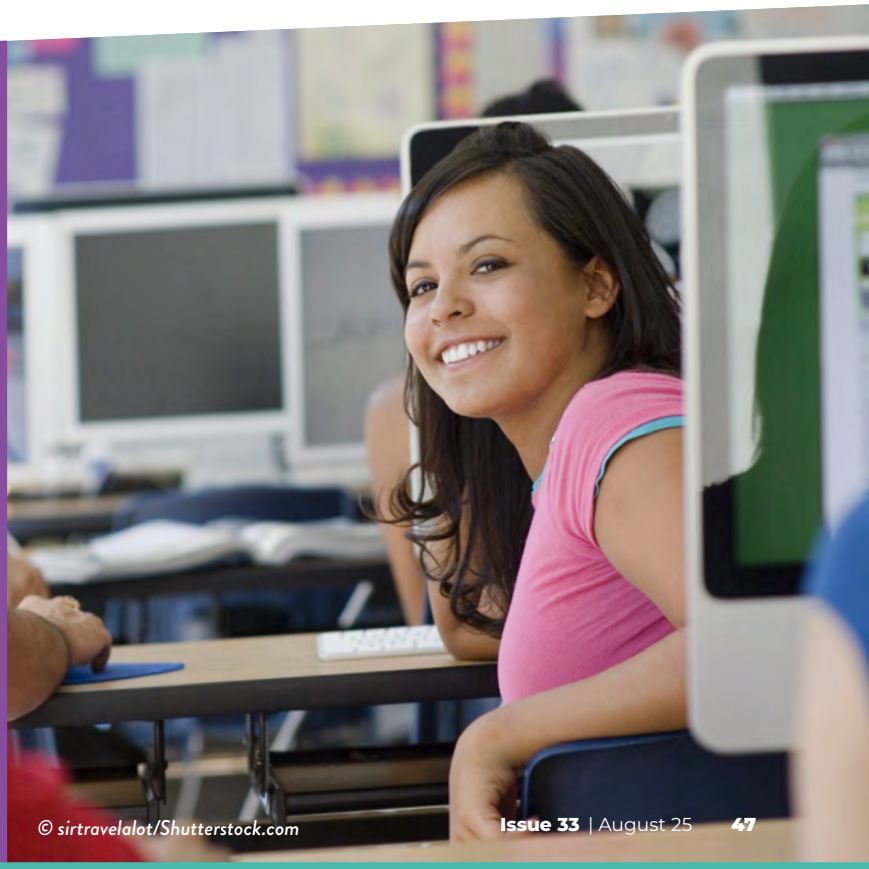
Our **Scottish Tech Role Models** resource helps teachers showcase real-life role models in the classroom, highlighting their backgrounds to provide relatable examples for students.

How does dressCode celebrate computing science achievement in schools?

dressCode offers **awards** to recognise and celebrate excellence in computing science from nursery to secondary school. We offer the Hopper Award for the best female student and the Turing Award for the best male student in each secondary school in Scotland. These are permanent awards passed on annually. We also maintain a roll of honour on our website.

For primary schools, we provide free Hopper and Turing award certificates. We also have the 'Promising Software Developer of the Year' award for outstanding Advanced Higher projects (usually undertaken by students aged 16 to 18).

> ***"I was shocked to find that computing science had, and still has, the largest gender gap of any traditional STEM subject in Scotland..."***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What collaborations make dressCode's work possible?

As a small team, dressCode relies heavily on partnerships and volunteers for judging competitions and running events. Sponsorship is crucial for our annual competitions and hackathons – currently, we are supported by J.P. Morgan and Skyscanner. We always welcome support with judging, volunteering and sponsorship.

What are dressCode's key achievements?

I am incredibly proud of what we've achieved. My personal highlights include receiving an honorary doctorate for dedication to computing science education and advancing women in technology, as well as being awarded a Point of Light award and meeting the Prime Minister at Downing Street. However, perhaps the most rewarding aspect is seeing dressCode alumni and former students thrive at university and in their careers. It's particularly inspiring to hear how some of them, like Clara O'Callaghan, Rachel Copper, Amina Tahir, Catherine Fitzsimons and Molly Plenderleith, are now championing diversity in tech and inspiring the next generation of students to pursue computing science.

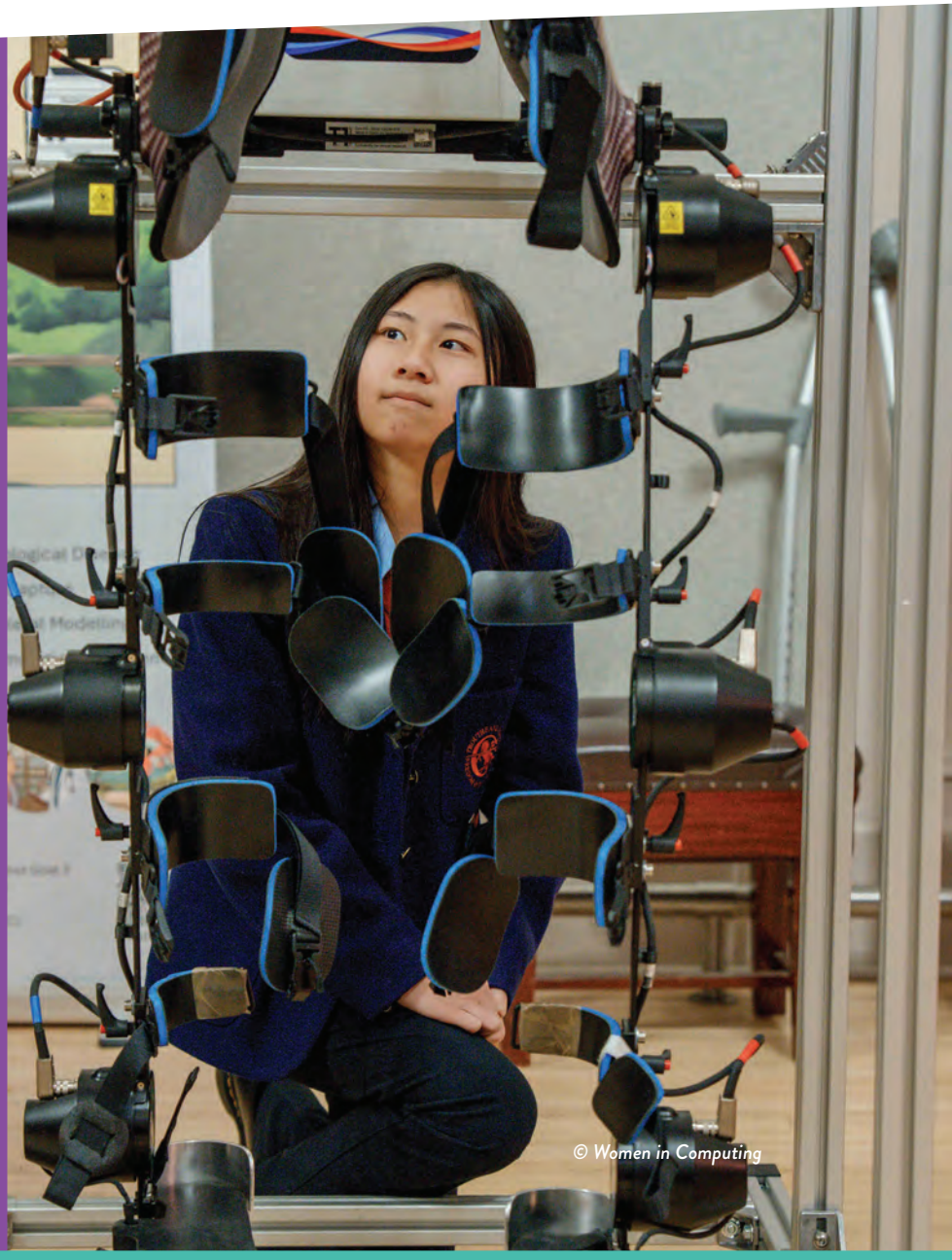
What's next for dressCode?

We are currently redoing our dressCode club platform, which is really exciting, and creating a primary specific version with Scratch Junior. We have lots of new exciting ideas on the way for dressCode clubs! We are also in the process of capturing some students' perspectives of dressCode.

There are two incredible schools who run dressCode clubs. The first is Mearns Primary School – their original 'dressCoders' started in P5 (aged 9-10) and are now in their final year of primary school. The second is St Ninan's Secondary School – their original dressCoders are now in their final year of secondary school. It's exciting to imagine what these dressCoders will go on to achieve in the next stage of their education.

> **"Computing science can be combined with any interest, such as data, medicine or art..."**

> **"The emphasis is on creativity, collaboration, problem-solving and fostering a nurturing environment where girls can thrive."**



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Toni Scullion

Computing Science teacher,
Founder of dressCode,
Co-founder of Ada Scotland Festival,
Co-lead of Scottish Teachers Advancing Computing Science (STACS)

Meet *Toni*

Who or what inspired your passion for computing science?

I've always loved computers. I remember discovering HTML and CSS on the first computer my Dad got me and changing the background colour of a webpage. It felt like uncovering a secret. This sense of amazement and curiosity still drives me. I've also been fortunate to have inspiring mentors, including Mr Donogue, Chris Sinclair, Hazel Hall and David Muir.

What do you find rewarding about working in computing science?

I love that technology is integral to every sector and is so creative. You can turn ideas into reality, solve real-world problems, and make a difference. I enjoy recreating that 'eureka' moment for students and watching them achieve great things.

What challenges does your work pose for you, and how do you overcome them?

Time is my biggest challenge, as dressCode is run alongside my full-time teaching job. However, having done this for over a decade now, I've established a solid routine and learnt to adapt as needed. I overcome this by planning ahead, breaking tasks into smaller chunks, and being consistent.

Toni's *top tips*

1. Give computing science a go and see if you enjoy it! It's an exciting field with constant advancements and diverse career paths.

2. Computing science can be combined with any interest, such as data, medicine or art, so think about where your interests lie and explore their connections to computing science.

Connect with
dressCode

- **dresscode.org.uk**
- **Toni Scullion**
- **dressCode**
- **@ScullionToni**

Beyond grades: rethinking how we measure student success

Although schools and teachers rely on point-based assessments to evaluate individual student and whole school attainment, current research and teacher anecdotes suggest that traditional grading practices can undermine students' learning and motivation. **Dr Karla D. Rivera Caceres** at **Florida International University**, USA, is implementing and studying the effects of alternative grading methods that prioritise the mastery of learning outcomes by providing meaningful feedback and allowing students multiple attempts to correct their mistakes.

Dr Karla D. Rivera Caceres

Associate Teaching Professor, College of Arts, Sciences and Education, Florida International University, USA

PROFILE

Fields of research
Alternative grading, STEM education

Research project
Using alternative grading methods that prioritise the mastery of learning outcomes over the attainment of points

Funder
US National Science Foundation (NSF)

doi: 10.33424/FUTURUM625

The practice of grading began in 18th-century Europe, where schools introduced rank-based systems to foster competition among students for prizes and prestige. As Western education became more formalised in the 19th and 20th centuries, grades evolved into standardised symbols of achievement, designed to simplify the complex process of evaluating learning. Since then, grades have become deeply rooted in classrooms around the world, used to measure understanding, motivate students, sort them into academic pathways and provide feedback. But how accurately do grades reflect what a student actually knows?

At Florida International University, Dr Karla D. Rivera Caceres is investigating alternative grading methods that encourage students to master learning outcomes rather than aim for the highest number of marks. Through her ungraded teaching structures, she is exploring how moving away from traditional grades can improve student motivation and lead to deeper, more meaningful learning experiences.

Why traditional grading falls short

In most summative assessments today, students earn their final grade through a numerical system with clearly defined grade boundaries. While this model offers a straightforward way to evaluate performance, it has significant drawbacks. "Many studies show that traditional grading encourages students to focus on their performance more than their learning, prevents them from paying attention to feedback, increases their anxiety and reduces their desire to take risks," explains Karla. "Instead, they prefer to play it safe and avoid losing points, sometimes even copying homework instead of trying it themselves and risking mistakes that would lower their grade."

If we applied grading to other learning activities outside of school, these experiences would look very different. "For example, learning to do tricks on a skateboard involves a lot of trial and error," says Karla. "If each trial was 'graded' and skaters lost points for each mistake, they would be stressed and focus on what they can do to lose the least number of points. They would probably play it safe and not push themselves to learn the coolest tricks."

Alternative grading

Alternative grading moves away from the traditional system of assigning points and weighted percentages to measure student performance. Instead, it focuses on whether students meet clearly defined learning goals. One common approach is 'ungrading', which removes points entirely and prioritises clear communication about what students need to learn, along with providing targeted resources to help them succeed. Rather than relying on numerical scores, instructors assess if students have mastered the expected skills or content and clearly communicated this progress. If students have not yet met the learning objectives, they receive detailed, constructive feedback explaining how to improve. Crucially, alternative grading encourages multiple attempts, allowing students to revise and demonstrate mastery over time, promoting a growth mindset.

Ungrading is not the only type of alternative grading. Some teachers use 'specification-based grading' approaches that may still use points but adhere to the same principles of clear learning targets, feedback and opportunities for improvement. "As different subject areas measure learning in different ways, there is a wide diversity in approaches to alternative grading," explains Karla. "Proficiency in art will be measured differently than proficiency in science, and evaluating a small group is very different from evaluating a large cohort."

Shifting student motivation

Karla believes that alternative grading strategies can shift student motivation from 'performance goal orientation', where the goal is to appear competent to others, to 'mastery goal orientation', where the focus is on understanding and improving. Traditional grading systems often push students toward performance goals – prompting them to demonstrate what they know or hide what they do not. "Research shows that in graded environments, students focus on getting the highest number of points to show their peers, parents or university admissions teams that they did well in the course, and they focus on preventing the loss of points by any means to avoid showing that they performed poorly," explains Karla. "The idea with ungrading is that if you remove the points, you remove the source that causes students to focus on performance, to the detriment of their learning."

The benefits

The main goal of alternative grading is to eliminate the negative effects associated with traditional grades. It aims to reduce anxiety, encourage students to focus on learning rather than just performance, promote engagement with feedback and support risk-taking in learning.

While research measuring the effectiveness of these methods is still limited and sometimes inconclusive, many educators report qualitative improvements in their courses. Despite mixed data, the positive impacts on student motivation and learning experiences are clear enough to inspire ongoing study – including Karla's National Science Foundation (NSF)-funded research investigating these benefits in depth.

Putting ungrading into practice

"Most of my courses include over 100 students, so I have designed a unique way to implement an ungraded structure," says Karla. In her genetics course, the structure is centred around learning outcomes – clear statements of what students need to learn. For example, one learning outcome reads: "Identify the difference between a gene and an allele." Students are provided with resources, such as recorded lectures and quizzes, and take part in group discussions to support their learning. These activities carry no points to ensure that learning is not driven by rewards, but by understanding.

Students demonstrate mastery of learning outcomes in multiple ways. They can explain their understanding in live discussions, answer questions in online quizzes or submit videos where they explain concepts they initially misunderstood. If their explanation is incomplete or incorrect, they are encouraged to try again. A final evaluation at the end of the course gives students one more opportunity to show their progress.

This structure creates space for trial, error and feedback. "None of the 'mistakes' that students make throughout the assessments count against their final standing in the course," explains Karla. "Mastering a learning outcome on the final attempt counts just as much as if it had been mastered on the first try." This removes the pressure of one-shot assessments and supports students in developing a deeper, more confident understanding.

The impact

To better understand the impact of her ungraded teaching structures, Karla is conducting a research project in two phases.

In the first phase, she is using pre- and post-course surveys to measure four key variables: 1) how valuable students find the course, 2) whether they feel that the course is focused on learning or performance, 3) how concerned they are about doing well or badly, and 4) how focused they are on learning. These surveys are conducted in both traditionally-graded and ungraded courses. "I am also collecting information about where students are in their academic journey, as well as any factors that might classify them as non-traditional students," says Karla. "I will then examine whether these factors influence their focus and perceptions differently compared to traditional students."

In Phase 2, Karla will assess actual learning outcomes by using subject-specific questions to measure students' content knowledge at the beginning and end of the course. This will allow her to compare learning gains between students in graded and ungraded environments.

By examining both students' attitudes and their learning outcomes, Karla's research offers valuable insights into how grading practices shape educational experiences. While traditional grading remains the norm in most classrooms, her work highlights the potential of alternative approaches to reduce anxiety, promote deeper engagement and prioritise meaningful learning. As educators continue to question long-standing practices, Karla's findings could play a key role in rethinking how we define success in education and how we support students in achieving it.

Advice *for teachers*

Implementing alternative grading in any subject

While Karla's work focuses on biology, alternative grading can be applied across disciplines. "The most important step in transitioning a course to an ungraded structure is to have a clear set of learning outcomes that are measurable," explains Karla. "For example, if one learning outcome of the course is 'Write a good paragraph' or 'Understand Mendelian genetics,' it is very hard to see whether the student has mastered that learning outcome, because 'good' and 'understand' are somewhat subjective." Instead, try breaking these outcomes down into specific, observable skills. For example, 'write a good paragraph' could become 'construct a paragraph with a clear thesis statement and supporting arguments'.

Once these specific outcomes are defined, you can design appropriate resources (e.g., lectures, demonstrations and activities) to help students work towards mastery, and develop assessments (e.g., essays, projects or skill demonstrations) that allow students to show what they have learnt.

Offering students multiple opportunities to demonstrate learning is a key principle of ungrading, but it can be time-consuming. To manage this, critically evaluate your course content and consider removing non-essential material. This frees up time to support second-chance learning opportunities for high-priority outcomes.

The challenges

One of the biggest challenges in implementing alternative grading is that traditional grading – especially points-based systems – is incredibly convenient. In large classes, learning management systems automatically calculate scores, making it quick and easy to assign final grades. Points are also familiar to students, and many have come to associate them with accountability and motivation. Removing points, then, presents a twofold challenge: you must find new ways to assess student performance, and students must adapt to a new system where their learning is not reduced to a number.

"Small classes are usually easier to transform to ungrading because you can check if a student has met the course requirements," says Karla. "Larger classes usually rely on multiple choice quizzes, so designing questions that really address the desired learning outcomes is key."

Another significant challenge is helping students understand that just because a resource or activity does not carry points, it is still valuable. This shift in mindset can be difficult for students who are used to equating effort with rewards. "Convincing students that 'no points' doesn't mean 'no value' depends a lot on how strongly you believe in it and how effectively you can communicate it to your students," says Karla. "I've had great success convincing most students that focusing on learning, regardless of the points, is better for them."

Finally, implementing the second-chance element can present its own difficulties. It requires time, feedback and infrastructure. "I wouldn't be able to do it in my large courses without intentionally focusing on the content I really want students to learn and ditching anything else!" says Karla. "And I definitely couldn't do it without the support of learning assistants who help provide feedback in smaller groups."

Rethinking what's possible

Many educators express frustration with traditional grading, yet often see it as an inevitable part of teaching. But grades are not immutable. For those considering a shift, the first step is to recognise that meaningful alternatives are not only possible, but that they're already being used successfully in many classrooms. Transitioning to an ungraded or alternative grading system does take effort, but so does conventional grading; the difference is that one is simply more familiar.

You do not need to start from scratch. There are existing resources, such as clearly defined learning outcomes, sample assessments and community-shared strategies, that can ease the transition. And those who have already made the shift are often enthusiastic about offering support. "I would say that anyone that has a clear understanding of what they want their students to learn, and a clear idea of how to transmit that knowledge, can overcome the challenges of transforming their courses," says Karla. Taking the first step, however small, can open the door to a more meaningful, student-centred approach to learning.

Download Karla's resources from
futurumcareers.com/beyond-grades-rethinking-how-we-measure-student-success

Karla during her first field season as a PhD student, holding a scarlet-rumped tanager (Ramphocelus passerinii)*, in Costa Rica.*

Meet *Karla*

From ornithology to the classroom

I have always been fascinated by behaviour in both humans and animals. I was captivated by the similarities between the development of song in songbirds and speech in humans, so I studied a PhD and Postdoc in ornithology.

Even before starting my PhD, I was invested in the problem of how to teach science effectively. I did some teaching during my PhD and felt the need to understand why my students weren't engaging with the content I was trying to teach and only stressing about getting an A.

As a postdoc (still working on bird behaviour), I taught an animal endocrinology course to 60 students and decided to remove all tests and try to convince students to learn the content because it was interesting and useful, not because they would be graded on it. I devised some projects and thought students would enjoy them. Instead, they complained about lectures being worthless because there were no tests.

After that, I decided to leave my ornithology career and focus on developing effective science courses, both at college and K-12 levels. I was not planning on doing research anymore, but when I learnt about the benefits of ungrading, and saw few studies quantifying them, I decided to try to generate data that could convince more teachers to embrace the practice.

I think of my time as an ornithologist as a fun detour from my true calling: teaching. However, being able to roam around the tropical forests in Costa Rica was an experience that I will never forget!

Karla's *top tip*

Encourage your students to participate in activities outside of school, because sometimes those are the most meaningful.

Ocean soundscapes: how do fish hear?

To our human ears, the sounds of the ocean can be strange and disorientating. Fish, however, have ears that are adapted to life below the surface, and rely on the buzzes, clicks and whistles of the ocean soundscape to survive. At **La Trobe University** in Australia, **Dr Lucille Chapuis** is using groundbreaking and innovative techniques to study the hearing systems of fish and to understand how they are affected by human-made noise.

Dr Lucille Chapuis

Department of Ecological, Plant and Animal Sciences, School of Agriculture, Biomedicine and Environment, La Trobe University, Australia

PROFILE

Fields of research
Marine bioacoustics, neuroecology, animal behaviour

Research project
Studying the hearing systems of fish to understand how they are affected by human-made noise

Funders
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Website
sharkslikejazz.com

doi: 10.33424/FUTURUM596

Talk like a ...

marine bioacoustician

Acoustic niche — the frequency range that a species has evolved to use, often unique within an ecosystem to avoid interference with other sounds

Anthropophony — sounds generated by humans and our technology

Bioacoustics — the study of how living organisms produce, transmit and respond to sound

Elasmobranchs — a group of fish, including sharks, rays and skates, that have skeletons made of cartilage instead of bone

Hydrophone — a microphone that is used underwater

Soundscape — the collection of sounds in an environment, including both natural and human-made sounds

As you stand waist-deep in the cold, salty surf, you listen to the sounds of the beach around you: children laughing and splashing in the waves, parents chatting on their deckchairs, seagulls squawking as they dive-bomb for chips. Plucking up the courage, you dive headfirst below the surface, and instantly the world becomes muted, muffled and quiet.

Your ears are designed to make sense of sound travelling through air, so, when you submerge them in water, they are of little use. If, however, you were a fish, your hearing system would have evolved to suit your underwater home. "Fish ears differ significantly from human ears in both structure and function, largely due to the contrasting physical properties of air and water," says Dr Lucille Chapuis from La Trobe University. "Sound travels more efficiently in water, making it a vital source of information for aquatic species in marine environments, where visibility is often limited."

Lucille is studying the hearing systems of elasmobranchs, a group of fish that includes sharks, skates and rays. "Elasmobranchs are particularly sensitive to low-frequency sounds, and use this sensitivity to detect environmental cues relevant to their survival, such as the sounds of their prey or predators," explains Lucille. Unfortunately, the widespread introduction of human-made noise in marine environments — generated by activities such as shipping, seismic exploration and underwater construction — can interfere with elasmobranch hearing and put these fish at risk.

The impact of anthropophony

"Human-made noise, or anthropophony, has become a pervasive and increasingly disruptive force in marine ecosystems, fundamentally altering the underwater soundscape that many animals rely on," explains Lucille. "The result is often a disruption of normal behaviours such as mating, foraging and predator evasion." This is particularly true for elasmobranchs, as a lot of marine anthropophony, such as noise from ship engines, occupies the low-frequency range, masking important natural sounds that elasmobranchs rely on. "Experimental studies have shown that exposing elasmobranchs to artificial sounds can alter their swimming behaviour and increase stress indicators," says Lucille.

In order to fully understand the impact of anthropophony on elasmobranchs and other fish, we need a better understanding of fish hearing systems. "Elasmobranchs are ideal for studying fish hearing because they represent an early evolutionary branch of jawed vertebrates, meaning their auditory systems have had over 400 million years to diversify and adapt," explains Lucille. "They occupy nearly all marine environments, from shallow coastal nurseries to the deep sea, providing a wide ecological gradient to test hypotheses such as the eco-acoustical constraints hypothesis."

The eco-acoustical constraints hypothesis

Compared to other animal groups, fish have a remarkable diversity of inner ear structures. This diversity has puzzled scientists for years, but Lucille is hoping to solve the mystery. "One compelling explanation for this variation is the eco-acoustical constraints hypothesis which proposes that fish auditory systems have evolved in response to the specific acoustic properties of their environments," explains Lucille. "According to this hypothesis, fish inhabiting quiet environments, where background noise levels are low, may evolve enhanced auditory structures to increase sensitivity to faint or distant sounds. In contrast, species living in noisy habitats, such as turbulent coastal zones or reef environments, may not benefit from such specialisations because background noise would likely mask any subtle auditory cues."

The eco-acoustical constraints hypothesis predicts that fishes living in noisy environments would gain less advantage from evolving sophisticated hearing structures, and so are more likely to have simple auditory systems. "Historically, testing this hypothesis has been challenging due to the complex and modular nature of the fish inner ear and limited physiological data," says Lucille. However, recent technological advances are allowing researchers like Lucille to study this problem in depth for the first time.

Solving marine mysteries with technology

Lucille plans to combine innovative new tools such as 3D bioimaging, artificial intelligence (AI) and biomechanical modelling to test the eco-acoustical constraints hypothesis and explore the relationship between ear structure and function in elasmobranchs. For example, advanced, high-resolution 3D bioimaging techniques will allow her to reconstruct and compare the inner ear anatomy of different elasmobranch species living in different habitats. She will then use hydrophones to record the soundscapes of each species' habitat and use AI to identify each habitat's key acoustic features, before analysing whether these features can be used to predict the inner ear structure of the fishes living in each habitat.

"We will then develop the first biomechanical model of a fish inner ear," says Lucille. "This model will simulate how sound-induced forces cause displacement and stress within inner ear structures, allowing us to identify which anatomical elements are most functionally significant." The last step in Lucille's research project will involve raising shark embryos in tanks with different soundscapes to see if this affects the development of their inner ear structure. "This not only offers a novel test of the eco-acoustical constraints hypothesis in living animals, but also explores how flexible or vulnerable elasmobranch hearing systems are in the face of changing acoustic environments," says Lucille.

From research to conservation

"By illuminating how elasmobranchs hear and how their auditory systems are shaped by their habitats, this research provides a much-needed foundation for protecting these vulnerable species (and other fish) from the growing threat of underwater noise pollution," says Lucille. "With the right regulatory frameworks and adoption of quieter technologies, we can restore healthier ocean soundscapes and allow marine life to regain their acoustic niches. Ultimately, this project creates a robust scientific basis for understanding and managing the auditory ecology of elasmobranchs, a critical step toward ensuring their resilience in a rapidly changing world."

About *marine bioacoustics*

"Marine bioacoustics is an incredibly exciting field because it allows us to explore one of the least understood sensory worlds: sound in the ocean," says Lucille. "This field is still relatively young, and there is a tremendous amount yet to discover." Every research project has the potential to uncover something previously unknown about underwater sound and marine animals, and how they interact with each other and their environments.

"Marine bioacoustics can have real-world impacts by informing conservation strategies, shaping environmental policy and helping to protect vulnerable marine life from the rapidly increasing threat of noise pollution," continues Lucille. "There's something deeply fulfilling about contributing knowledge that can guide efforts to preserve the health and diversity of the oceans. In a field where much remains a mystery, even small insights can make big waves."

To study this unique environment, marine bioacousticians collaborate with experts from a wide range of disciplines, including physics, ecology, biology, engineering and data science. "Collaboration is not just helpful, but absolutely essential to advancing the field," says Lucille. "These partnerships allow us to tackle questions that no single discipline could answer alone."

Fieldwork can be central to a career in marine bioacoustics. "Fieldwork often means living and working closely with colleagues around the clock, sometimes for weeks at a time," says Lucille. "These intense shared experiences have forged some of my closest friendships. The bonds formed in the field, through challenging days, shared discoveries and lots of laughter, are absolutely invaluable."

"Science is a team effort, and the friendships and collaborations you build along the way are just as valuable as the discoveries," continues Lucille. "I've been fortunate to work with incredibly supportive mentors and collaborators who believed in my ideas and gave me space to grow."

Pathway from school to *marine bioacoustics*

Build a strong foundation in biology, maths, physics and computing at school to support understanding of areas such as animal behaviour, ecosystems, acoustics, coding and data handling.

At college and university, courses such as marine biology, zoology, ecology, acoustic engineering, physics, computer science and environmental science can all lead to a career in marine bioacoustics.

Lucille says, "Hands-on experience is key: volunteering with marine labs and getting involved in student projects at aquariums or universities, field courses at marine research stations, internships in acoustic monitoring, or even citizen science projects that involve underwater sound recordings can be valuable."

"Practising communication skills is just as important as mastering technical ones," says Lucille. "Outreach and communication are absolutely vital to raise awareness about how human-made noise can affect marine life."

Lucille suggests following the tags #bioacoustics and #oceanacoustics on social media to discover scientists and research laboratories. You could even reach out with questions.

Explore careers in *marine bioacoustics*

Explore the websites of the International Bioacoustics Society (**ibac.info**), the Australian Acoustical Society (**acoustics.org.au**) and the Acoustical Society of America (**acousticalsociety.org**) to read about the latest research. You could even become a student member and attend events and conferences.

A career in marine bioacoustics could see you working as a teacher or researcher, as an engineer developing the next generation of sensors or software, or in non-profit roles, working to change marine policies or communicate with the public.

"A career in marine science is possible even if it seems difficult at the start," says Lucille. "I grew up in landlocked Switzerland, and now I study the sounds of the sea. If I can do it, so can anyone else!"

Fishes in New Zealand. © Paul Caiger

Download Lucille's resources from **futurumcareers.com/ocean-soundscapes-how-do-fish-hear**

Meet *Lucille*

Growing up in landlocked Switzerland, I saw the ocean as a place of wonder and mystery, accessible only during holidays. It became a passion the moment I encountered marine animals firsthand. Having learned to dive in Switzerland's cold freshwater lakes, my initial dives in the sea were truly eye-opening experiences. I felt honoured to witness such vibrant ecosystems teeming with life. Sharks, in particular, captivated me with their magnificent presence.

What I love most about my job is the constant sense of discovery. Whether it's uncovering how a shark perceives sound, listening to the rhythms of coral reefs at night or developing new ways to study underwater soundscapes, each project brings a chance to learn something entirely new about the hidden lives of marine animals.

I deeply enjoy the interdisciplinary nature of my work. I collaborate with physicists, engineers, ecologists and neuroscientists from all over the world, pushing the boundaries of what's possible and making the science more robust and exciting. And then there's the fieldwork: being in the ocean, diving and recording sounds, reminds me why I started on this path.

My research has allowed me to live and work in multiple countries including Switzerland, Australia, the UK and New Zealand. Experiencing different cultures and ecosystems has enriched my personal and professional life in countless ways: it's a constant reminder of the diversity of both people and the natural world.

Persistence and a sense of humour have helped me weather the less glamorous side of research: equipment failures, hours of data analysis and long days at sea. These moments can be tough, but they also make the breakthroughs all the more rewarding.

To unwind from work, I run, often for long hours and over great distances. It's a space to clear my mind, reconnect with nature, reset both mentally and physically, and it reminds me of the strength that comes from pushing boundaries, whether on trails or in science.

Lucille's *top tips*

1. Follow your passion. Let your fascination with the ocean and sound guide you.
2. Stay curious, ask questions and read widely. Don't be afraid to explore tangents as they often lead to the most interesting discoveries.
3. Say yes to opportunities, even if they feel a bit scary! Travel, join a research cruise, go to conferences, talk to scientists. These experiences help you grow, and they often open doors to future collaborations or projects.
4. Be patient and persistent. Science doesn't always move quickly, and progress takes time. But if you stay motivated and passionate, the path can be incredibly rewarding.

How can innovative ethnomusicology research help foster diversity, inclusivity and equity in the music industry?

Music is an integral part of human experience, and every culture has its own unique creative practices. **Dr Marcia Ostashewski** is the founding director of the **Centre for Sound Communities** at **Cape Breton University** in Canada, an arts-based social innovation hub that uses collaborative, participatory ethnomusicology research to work with and support equity-deserving communities and facilitate decolonisation and reconciliation within the music industry.

Dr Marcia Ostashewski

Founding Director, Centre for Sound Communities, Cape Breton University, Canada

Field of research
Ethnomusicology

Research project
Serving and supporting Indigenous and diaspora communities through collaborative ethnomusicology research

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

Website
soundcommunities.org

doi: 10.33424/FUTURUM598

PROFILE

Talk like an ...

ethnomusicologist

Culture bearer — a person who practises and passes on cultural traditions and knowledge to future generations

Decolonisation — the process of dismantling the structures and systems that reinforce colonial worldviews

Diaspora — a group of people who originate from, identify with and maintain connections with a specific country or community, but have since moved elsewhere

Ethnomusicology — the study of how people create, interact with and appreciate music in different ways, how they make it meaningful in their lives, and how it can be used to effect change

Hegemonic — the ruling or dominant group in a society

Indigenous — the original inhabitants of a land from before the arrival of colonists or people of different places and cultures

Mi'kmaw — an Indigenous nation whose unceded, ancestral and traditional territories are on the eastern coast of Turtle Island (North America), along parts of the Atlantic coast of both Canada and the US, including Unama'ki (Cape Breton Island)

Participatory research — a collaborative approach to research that actively includes the people involved with and affected by the matters and issues being investigated

Reconciliation — the process of restoring respectful relationships between Indigenous and non-Indigenous peoples, acknowledging the harm caused by colonisation, and working towards a future where Indigenous rights are recognised and respected. This includes ongoing efforts to address the legacy of residential schools, land disputes and systemic discrimination.

In communities all around the globe, music is created and listened to at many of life's key moments. "We make music together in our homes and communities, and we sing at birthdays and funerals and to our babies," says Dr Marcia Ostashewski, founding director of the Centre for Sound Communities (CSC) at Cape Breton University. "Music is crucial for communities' and individuals' ways of living, being and knowing, for healing and well-being, and for our senses of community, belonging and identity."

How does the CSC conduct research?

"The CSC is an arts-led social innovation lab that works to effect positive social and cultural change with, by and for the communities we serve," says Marcia. "We carry out research through creative practices, including

Marcia singing with the women of the choir of Holy Ghost Ukrainian Catholic Church at a multicultural festival in Unama'ki Cape Breton, November 2024. © Cyrus Sundar Singh

music, dance, poetry, theatrical performance, filmmaking, audio recording, storytelling, craft-making and visual arts, as well as conventional research methods across a range of disciplines." At the CSC, creative practices are not just the subject of research - they are integral to the research process itself. "Through these creative practices, we are able to engage with people from many different sectors and communities, and everyone brings their own background and knowledge to the table," says Marcia. "We are able to learn from and draw on all of this as we carry out the research, which is always collaborative and developed in partnership with culture bearers and communities, producing research and materials that respond to their needs in ways that are relevant to them."

This type of research, based on community-engaged and community-led methodologies, aims to disrupt historically inequitable research relationships in which researchers focused on their own interests, rather than what was useful for the communities they were studying, and rarely shared their results with these communities. "Our processes involve researchers deliberately working with and for Indigenous and equity-deserving communities, engaging with them and nurturing these relationships through research to make amends for historical wrongs and challenge inequitable power structures," says Marcia.

The CSC projects that engage with youth encapsulate this approach. "At the start of each project, Elders and other culture bearers share their knowledge and experiences of a given topic with the youth," says Marcia. "This is followed by a period of collaborative creation that expresses the youths' understanding of the topic and includes aspects relevant to their own lives." These research methods may be informed by Indigenous practices such as storytelling and sharing of oral histories (by learning and singing songs together, for example) and aim to understand more clearly the needs, interests and concerns of communities and musicians.

Who does the CSC work with?

The CSC works with many diverse communities and people from many different backgrounds within these communities. These include local Indigenous Mi'kmaw or L'nu people, historically underrepresented groups such as African Nova Scotians and Central and Eastern European diaspora communities, and vulnerable demographics such as LGBTQ youth. Marcia and other researchers associated with the CSC are committed to responding to the needs of communities that face injustice and inequity.

One such researcher is Dr Afua Cooper, a poet, author and scholar based at the University of Toronto. Her most recent collaboration was part of a CSC-supported project called *Trans-Atlantic Pilgrimage: African Histories, Poetry, and Music*. "This was a beautiful and brilliant project which saw collaboration between music, literature and history scholars from across Canada and African musicians from Mali, Guinea and Canada," says Afua. "The project included music, poetry, performances, lectures and community tours in West Africa, and its impacts are still being felt."

Another ongoing CSC project is *Songs and Stories of Migration and Encounter*. This project is founded on the centre's relationship with Membertou First Nation, including a Mi'kmaw drum group called the Sons of Membertou, who use music to strengthen community bonds and practise Mi'kmaw language and culture, ensuring that it will thrive long into the future.

Through processes of colonisation, European settlers forcibly displaced and disrupted Mi'kmaw communities. For example, in the 19th and 20th centuries, Mi'kmaw and other Indigenous children were forced to attend residential schools that were designed to separate them from their communities and destroy Indigenous culture. The effects of these schools and other actions carried out by settler groups over the past 500 years continue to impact Indigenous people and communities. Through *Songs and Stories*, Marcia and her team work with Mi'kmaw musicians and communities to challenge systemic racism and inequities, and to foster meaningful relationships and reconciliation.

"We have also been investigating the role that music plays in Ukrainian diaspora communities now living in Canada," says Marcia. "Traditional music from Ukraine, new music created in Canada by people of Ukrainian ancestry, music related to the experiences of the newest Ukrainian immigrants (those who have fled Russia's recent invasion of Ukraine), and related practices including dance, poetry and filmmaking help connect previous immigrant groups with newer ones, and with people living in Ukraine. We are learning about how people of Ukrainian ancestry are connecting with aspects of their family histories and nurturing strong healthy individuals and communities through shared practices. At times, we also support such community and creative activities."

At the end of 2024, Marcia and the CSC team won the Social Sciences and Humanities Research Council of Canada Impact Award. This award recognises their collaborative, participatory research that supports the many communities with whom they work, their aim of creating space for a greater diversity of people in the music industry across research, education and business sectors, and for their work fostering meaningful reconciliation in Canada.

What's next for the CSC?

Marcia and the team at the CSC are currently working with Smithsonian Folkways Recordings to produce a new series of music and spoken word recordings. "The series features diverse artists telling stories of the lands, waters and peoples of Canada," explains Marcia. "Along with recordings, this initiative creates and shares open-access learning resources, including films, podcasts and resources for teachers to use in their classrooms. We are also engaging in community outreach and education events and activities, sharing and celebrating the musics, histories and experiences of diverse groups. This documentation, preservation and dissemination of music helps sustain cultural diversity and inclusivity and promotes diverse artists and communities, allowing their artistry, traditions and practices to be appreciated by a wider audience."

Pathway from school to *ethnomusicology*

At school, there are no specific subjects that are necessary for further education in ethnomusicology, though knowledge around creative practices including music, dance and media can help.

Get involved in volunteer work that exposes you to a range of cultural backgrounds, and work with equity-deserving and marginalised groups. This will help build your understanding of cultural contexts and the needs and concerns of different communities.

At the undergraduate level, ethnomusicology is often taught as a module within degrees such as music or anthropology.

Postgraduate courses in ethnomusicology, available at many universities and institutions, will allow you to specialise and take a deeper dive into this rich field.

About *ethnomusicology*

Ethnomusicologists are interested in how different people and communities create, perform, listen to, feel, think and write about music, and all of the many ways in which we make music useful and meaningful in our lives. It is a highly interdisciplinary field that draws on knowledge from many areas of academia including social sciences, anthropology, history, dance and media studies, as well as business and economics, natural and health sciences, engineering, and more. "We know that music and related practices have an important role in all of our lives and communities," says Marcia. "Ethnomusicology allows us to understand how music is made and how it is a part of and shapes our lives in different social, cultural, political, economic, environmental and geographic contexts."

Marcia conducts applied ethnomusicology research, meaning that her work is guided by social responsibility and the needs of the communities with whom she works. Conducting research with and for these communities - rather than on them - is the best way to ensure that the research serves their needs and interests. "Ethnomusicology can show us how equity-deserving groups experience and resist oppression and work towards health and well-being for their communities, languages, and traditional and creative practices," says Marcia.

Beyond academia, there are a range of other careers available for ethnomusicologists. "Many work in education, while others work in community projects in NGOs, facilitating and developing music and cultural education projects," says Marcia. "Elsewhere, ethnomusicologists can work at museums creating and curating exhibits, occupy government positions, get involved in policy and development work, or be professional musicians, producers, communicators or writers."

Explore careers in *ethnomusicology*

CareersinMusic.com offers a detailed and accessible insight into ethnomusicology:
careersinmusic.com/ethnomusicologist

This YouTube playlist features interviews with dozens of ethnomusicologists, including Marcia, explaining their research and passions:
youtube.com/playlist?list=PLSZjnH1UkjCWFmylFjAqrhhJqTATegMBk

Graham Marshall, a member of the Sons of Membertou drum group, standing next to a tipi with a traditional Mi'kmaw drum. © Alyssa Rose

Meet *Marcia*

I grew up on a farm in northern Alberta at the centre of the largest settlement of Ukrainians living outside of Ukraine. As a community, we worked, prayed, sang and danced together. Our mother, who was an advocate for Ukrainian language education, taught me and my siblings Ukrainian music, language, cooking and other traditions. These practices were part of our daily home life.

Every summer, my family would go camping and visit First Nation communities. My parents instilled in me a great respect for Indigenous people, and I learned about their special relationship with the land. Through cultural events, I learnt about their histories, experiences and cultural practices.

I am grateful for the opportunities that I have had to learn from and work with Elders, knowledge holders, artists, practitioners, culture bearers and community leaders. These relationships are the most important and affirming aspects of my work. Often, in the time that we spend with one another, people share their most precious, joyful and sometimes painful songs, stories and memories. Our relationships and shared experiences bring meaning to my life, and through them I continue to learn about how to live with respect, care and in a good way with Indigenous communities and the land.

I love to sing! Most weekends, I attend our local Ukrainian church where I can practice my Ukrainian language and participate in traditional singing – this is the exquisite music of my childhood, through which my life took shape. I also enjoy singing, dancing, and participating in the traditions and practices of the communities I work with. These special opportunities are the gifts of the work that we do together.

Meet *Afua*

Dr Afua Cooper

Poet, Author and Professor of Black Studies and Women's Studies, University of Toronto

I grew up in Jamaica in a large extended family. My older relatives were great storytellers and told us younger ones stories at every opportunity. Sometimes, these were folk tales rooted in the African-Jamaican tradition. At other times, they were factual stories about our history and our family. For example, my paternal grandmother told us about the riots and protests during the anti-colonial struggles of the 1930s. The British soldiers killed many poor, Black people. My grandmother, who became widowed at the age of 29, told us of her heartache when her 33-year-old husband died. She told us stories and anecdotes about her husband, our grandfather, so we came to know him through her eyes.

Later, I went to live in Kingston, the capital of Jamaica, an urban environment with cinemas, sound systems, art and culture. Music was everywhere - reggae music was being born and flourishing. My family even knew some of the reggae stars! At school, we studied poetry, performed in plays and sang in choirs. I started writing poetry and began combining the words with sounds and music. That is Dub Poetry! My poems were about African history, slavery, struggles, family, place and spirituality.

Books fuel the imagination. Read, read and read. If you are not able to read, listen to audio books. As a young kid in Jamaica, I read a lot. The library was my best friend. In books, I saw many possibilities for my life.

If you can, find a mentor — someone who believes in you and loves you. It could be a parent, a family member, a schoolteacher, a religious leader, a neighbour or your sibling. Have that person be a witness to your life, and your cheerleader.

Mi'kmaw *language*

Starr Paul

Mi'kmaw language instructor, Cape Breton University

Starr Paul has been teaching Mi'kmaw language for over 25 years. In her family home in Eskasoni First Nation, Starr and her parents spoke to each other only in Mi'kmaw. Her mum, Elizabeth, who passed away in 2019, spent her whole life championing and teaching the Mi'kmaw language. "My mom was a language warrior who taught at Cape Breton University, and I am proud to be able to teach the Mi'kmaw language at university level, just like she did," says Starr. "She inspired me, and still does to this day."

Starr takes influence from other communities when thinking about new ways to teach the Mi'kmaw language. "I am interested in how the Māori in New Zealand have been able to revitalise their language using 'language nests'," she explains. "I am working towards building a language nest in Eskasoni, which is the largest Mi'kmaw speaking community in the world." Language nests are educational programmes that immerse young children in their native language and provide them with a safe space to interact with Elders from their communities who are fluent speakers.

"Currently, I am working with Marcia and the CSC to make music with Mi'kmaw artists," continues Starr. "This includes working to create new Mi'kmaw language songs that young children can listen and sing along to." Learning, playing and creating Mi'kmaw music is a vital part of ensuring the Mi'kmaw language and culture continue to thrive. "Mi'kmaw is the language of our ancestors," says Starr. "They were given this gift of language, and we must continue to speak it, listen to it and live it."

Download the team's resources from **futurumcareers.com/how-can-innovative-ethnomusicology-research-help-foster-diversity-inclusivity-and-equity-in-the-music-industry**

Sons of Membertou performing at a Wapna'kik (2025) album release concert in the Great Hall at the Canadian Museum of History (Gatineau, Quebec), February 2025. © Marcia Ostashewski

Decolonising *music education*

Dr Jody Stark

Associate Professor of Music Education, University of Manitoba

Although European settlers first colonised Canada hundreds of years ago, the impacts and processes of colonisation are still ongoing. Through the seizure of land, forced or cheap labour, and efforts to erase Indigenous people, histories, languages, knowledge and cultural practices, settlers enforce their world view upon native peoples.

At the Centre for Sound Communities (CSC), Marcia and Dr Jody Stark, a music educator from the University of Manitoba, are working towards decolonising music education. "By continuing to place Western European cultural productions at the centre of curricula, the education system reinforces racial hierarchy and racist worldviews," says Jody. "On the other hand, being exposed to multiple worldviews enriches students' experiences, allows those who are not part of the hegemonic group to be seen and reflected back, and provides valuable tools for thinking in different ways."

The difficulties of decolonising

Decolonising is a difficult process. "When you are part of the hegemonic group, it is hard to see your privilege and to understand that your experience is not universal," explains Jody. "Those of us in the hegemonic group often try to ignore our feelings of guilt once we begin to become aware of inequity, as this helps us avoid having to give anything up or having to put energy into changing the systems and practices that reinforce the inequity."

These attempts to avoid responsibility are known as 'settler moves to innocence'[1]. "One example of a move to innocence is framing colonialism only as something that happened in the past," explains Jody. "By framing settler colonialism as being a historical event rather than an ongoing system, people feel that they can let themselves off the hook."

Colonialism in music education

While most approaches to music education are not explicitly racist, many of them are based on a colonial world view. For example, Western classical music is often valued more than other types of music, instruments of the symphony orchestra are often emphasised more than other instruments, and white, male composers are often idolised more than their contemporaries with different gender and cultural identities.

"It is important to note that learning to read Western music notation, sing or play a piece by Schubert, and recognise the instruments of the orchestra are not inherently bad things to do," says Jody. "But, without context around these musical practices and pieces, and without exposure to other perspectives, these lessons reinforce a colonial worldview."

Decolonising the music classroom

So, how can we begin to rid our music lessons of this colonial worldview? Well, we can start by shifting our mindset. "An idea that has been helpful to me is the idea of decentring Western music," says Jody. "We don't have to remove European classical music from our classrooms, but we should include, for example, Inuit throat singing or West African polyrhythms too."

Another important shift in mindset is to move away from extractivist thinking. "Extractivism is a mindset where land, resources, people and cultural productions are viewed as being 'there for the taking'," explains Jody. "When we extract a piece of music from its context and remove it from the web of relationships involved in its creation, we remove its purpose and meaning, resulting in cultural appropriation."

For example, in many Indigenous communities, songs and the teachings that accompany them are remembered and safeguarded by song keepers and community Elders. Understanding a song and how it can be used requires understanding Indigenous worldviews and protocols, which requires being in relationship with Indigenous musicians and cultural teachers. While this may not be possible in all circumstances, it is unethical to teach songs without context and some understanding of the cultural significance.

Decentring Western music and avoiding extractivism are just two ways in which we can work towards decolonising our classrooms. By opening our ears to the full richness and diversity of musical traditions and cultures, we can learn more, not just about music, but also about each other.

[1] **Tuck, Eve, and K. Wayne Yang. "Decolonization Is Not a Metaphor." Decolonization: Indigeneity, Education, & Society 1, no. 1 (2012): 1–40.**

Project spotlight 1
Songs and Stories of Migration and Encounter

Bandurist Julian Kytasty performing in a Yara Arts Group theatre production, New York City, 2014. © Waldemart Klyuzko

"Through *Songs and Stories*, our research group has been investigating the experiences and impacts of the forced relocation of the Membertou First Nation, an event whose history and impact on the displaced residents are finally being addressed," says Marcia. "Since 2017, Membertou-based researchers and CSC-based faculty have worked together to recover local Mi'kmaw histories, honour Mi'kmaw traditions and practices, and move towards meaningful reconciliation with local people of non-Indigenous ancestry."

Songs and Stories has seen four phases so far. The first was a one-day pilot project, where Indigenous and non-Indigenous community members shared songs and documentaries that they had created based on their lived experiences. "The second phase was a six-week in-community workshop that culminated in a shared song and dance performance," says Marcia. "The CSC team met regularly with local research team members and participants. These teams comprised community Elders, knowledge-holders and culture bearers, local youth, and university-based artist-researchers."

The third phase, shaped by a request from Membertou First Nation, involved the participatory development of a theatrical production, entitled Kun'tewiktuk, that communicated the events of the community's forcible relocation and its long-lasting effects. "Through this process, Mi'kmaw youth and Elders engaged with and creatively articulated their community's history from the perspective of its own members," says Marcia. "Through the process of creating and staging a play, the wider community was invited to help remember and share this heavy and difficult knowledge with future generations."

The most recent phase of *Songs and Stories* was a four-day multi-community event that shared and developed project outcomes through music. "The event began at a gathering in Membertou with traditional songs and drumming and the sharing of a short documentary film about our process," says Marcia. "International scholars shared their research on the theme, building dialogue among artists, scholars and community leaders from all over the world." Since that time, local community members in Unama'ki have continued to build relationships and share knowledge at events such as symposia, conferences and community gatherings. The project follows the CSC's approach of facilitating and supporting research with, by and for Indigenous people and communities to redress historical inequities in research and ensure that Indigenous people are at the helm of studying and sharing knowledge about their histories and experiences.

You can watch some of the creative outputs from *Songs and Stories* through the links in the 'More Resources' section of the

Project spotlight 2
Ukrainian Diaspora

As a granddaughter of emigrants from Ukraine, Marcia has a personal, as well as a professional, interest in the role that music plays in Ukrainian diaspora communities in Canada. "In 2022, the CSC hosted a festival of Ukrainian heritage featuring performances from Ukrainian musicians, talks from researchers and academics about Ukrainian dance, history and language in Canada, and workshops on traditional music, dance, bread-making, beading and textiles," says Marcia. "But our work with Ukrainian diaspora in Canada goes back much further."

Since 1997, Marcia has been working with Julian Kytasty, a third-generation bandura player. His family came from Ukraine to Detroit after being displaced from their homeland due to the Second World War and Russian Soviet aggression. Playing the bandura, a traditional Ukrainian instrument that resembles a lute, had been a part of life for his family in Ukraine, and so it became for Julian when he was born in their new North American home. Through the bandura, Julian's family also connects with a centuries-old Ukrainian tradition.

"Julian and I have worked together on a number of research, performance, public engagement and education projects," says Marcia. "In 2014, as part of the collaborative *Singing Storytellers* project that explored the lives, music and artistry of bards from around our world, I produced an album of traditional songs, featuring Julian, called '**Songs of Truth**'. In 2025, we will re-release the album through Smithsonian Folkways Recordings on our new Sound Communities series along with content-rich learning resources that teachers can use in their classrooms, sharing the story of Julian's family, who brought this precious music from Ukraine to North America, and many different aspects of Ukrainian music in Canadian diaspora communities."

Other projects have captured different aspects of Ukrainian music, dance and language in Canada. "I was especially interested in the role of dance practices, festivals and cultural memory of Ukrainians in diaspora communities," says Marcia. "During the early years of immigration to Canada, when discrimination was often overt, the new immigrants danced together and shared their songs and other creative practices with their new neighbours in Canada. This provided a sense of pride whilst also offering an opportunity for people of Ukrainian ancestry to create community and connection through creative and language practices." Marcia has also investigated the role of congregational singing among Ukrainians in Canadian church communities. "Singing together helps create a sense of community and belonging, and is a way to continue to practice the Ukrainian language," she says. "Children of immigrants have frequently told me how this was vital to their families as they endeavoured to make a new home." Her research suggests that these shared community activities helped immigrants create relationships, new possibilities and life

Research training

With such a range of research projects and disciplines, the Centre for Sound Communities (CSC) is a great place for new researchers to learn the ropes. Research assistants at the CSC benefit from a collaborative community of researchers to learn from and unique opportunities to grow professionally and intellectually by creating research and engaging with different communities. But it's not just the research assistants who benefit from this commitment to training and mentoring. Experienced researchers and established musicians and artists also find new opportunities and audiences thanks to an atmosphere of knowledge sharing, collaboration and support.

The CSC team is proud of their commitment to provide high-quality training, support and career development for Indigenous, Black and People of Colour (IBPOC) and equity-deserving students and researchers. With a mutually-supportive network that spans international, cultural, religious and linguistic borders, the CSC has become a hotbed of knowledge sharing, collaboration and innovation.

Research Assistant Mark Parselelo working collaboratively with the CSC field research team to create new recordings with Lassana Diabaté and other local musicians in Kindia, Guinea; leading a public musicmaking workshop; and presenting with Dr Jody Stark to share knowledge with school teachers about how to work with the CSC's curriculum resources in their classrooms.
© Marcia Ostashewski

Meet *some of the CSC's current research assistants*

Eric Escudero

Growing up in Brazil, there was always music in our home. My father was a great fan of British rock music from the 60's and early 70's, Bob Dylan, and other singer-songwriters. He occasionally wrote his own music, and was always playing the classical guitar. I grew up in a house in which music was considered central to human expression, and great musicians were revered as great artists and geniuses. As a result, music became important to me, before I could even realise it.

I have been in many different roles at the CSC, including project manager for the **Bala project**, developed in partnership with Malian musician Lassana Diabaté. I've also supported the creation of bibliographies and research ethics applications, and created written content, conference presentations and videos.

I love discovering exciting new music and the many ways in which it can be meaningful for communities. I love the fact that we get to learn with so many different culture bearers and communities that partner with the CSC.

Music has always played a central role in my life. That is why I study, research, write about and perform music. Since I was a child, I've always been fascinated by how music can communicate feelings and ideas in a unique and deep way.

If you find music meaningful, if you want to write about it, think about its political implications and how it helps communities, and to talk to musicians, then this might be the profession for you.

Selina Kibanda

I grew up in a home and family in Tanzania that loved music. My parents love and appreciate music, especially gospel music. Most of my family members either sang or played instruments. My elementary school held events every year that included music from different cultures, including songs from South Africa, Nigeria and the Congo, so I was introduced to different types of music at a young age.

I love exploring and learning about music from different cultures. The more you explore different viewpoints and cultures, the more you learn and understand. I started working with Marcia and the CSC in 2024, and I was happy to be part of the *Trans-Atlantic Pilgrimage* project events, where we were able to play drums, teach, dance and sing. I am always excited to help with any of the CSC's projects.

When I want to relax, I listen to music, which helps me enjoy the moment. When I am happy, I listen to music, because it brightens my mood. When I am new to a church, I will always involve myself with praise and worship, because I sing and I love music. Wherever I end up, I get involved in music. It just finds me, no matter what.

Don't be intimidated by the word 'ethnomusicology'. When I first heard that word, I had no idea what it meant. But, when you get into it, you realise that it's pretty straightforward, and if you work with the right people, the experience becomes even more enjoyable. I am not an expert in ethnomusicology; in fact, I am also learning and hoping to improve. Be open-minded and, when you're stuck with something, ask for help.

Mark Parselelo

Growing up in Kenya, I was surrounded by music. In church, we often sang hymns and worship songs in multiple languages (Swahili, English and local dialects). This gave me an ear for different sounds and rhythms, and I loved how music could bring people together, no matter their background. At home, we sang together as a family, and I learned how to play the piano and guitar. These early experiences made me fall in love with music. It wasn't just something I listened to — it was something I lived, felt and shared with the people around me.

Currently, I'm working on my PhD, which focuses on migrant musicians working in Nairobi's music industry. I'm following their stories, the challenges they face and how they contribute to shaping the unique 'Nairobi Sound'. I'm also co-directing a film about research and balafon making (a traditional African xylophone) for the CSC's *Trans-Atlantic Pilgrimage* project under the guidance of Marcia and Afua.

I come from a tradition where music and movement aren't seen as separate — they are one and the same. In my language, we use the word 'Ngoma' to mean dance, music, singing and drumming, all woven together. Dance, in particular, has always fascinated me. My training in dance anthropology and ethnochoreology (the study of dance and culture) has given me the tools to study dance not just as an art form but as a cultural lens. Through dance, I get to see deeper layers of people and their traditions — the intangible parts of their culture that words alone can't capture.

Ethnomusicology is a fascinating field with countless subfields to explore, allowing you to find your own unique research path. What makes it so special is that you don't just study music and dance — you live and experience it as part of your research.

Leena Mascarenhas

Growing up in Goa, India, and being raised in a Catholic household, deepened my relationship with music, making it an integral part of my childhood. I learned to play the organ and flute during my formative years. Our radio played music all day in the kitchen, including American, Bollywood and Konkani music, all of which had a profound impact on my musical taste and development.

Currently, I'm working on projects that explore the concept of 'Two-Eyed Seeing', which integrates Indigenous and Western knowledge systems, using music and arts to promote emotional well-being. Additionally, I'm involved in an exciting project focused on simplifying complex research topics into accessible formats like podcasts, crafting a narrative story that engages a diverse audience and makes the information more relatable.

What excites me about the research I am involved in is that it is conducted within communities for their own benefit. Additionally, I enjoy using unconventional methods to share and narrate the research, making it accessible to a wider audience. I am eager to learn more about the integration of music and arts into health and explore their potential impacts.

Music has been an integral part of my life since childhood. It has been my companion in moments of joy and sadness, a source of motivation, and a way to celebrate. This connection has only deepened as I've lived away from home while pursuing my education and career.

Ethnomusicology is a highly interdisciplinary field that offers the flexibility to connect your area of interest with music, sound and movement. These connections can lead to unconventional approaches such as linking ethnomusicology to health, advocacy, business or other fields. Think creatively about these intersections, and explore how music and movement can enhance understanding in your chosen area of study.

Leim Joe

Music was always present in my life growing up in Eskasoni First Nation. My family listened to popular music and I also listened to Mi'kmaw chants at school and with my family. My great grandmother, Sarah Denny, still sang even when she was in the later stages of Alzheimer's, and memories of her remind me of certain Mi'kmaw chants like the 'Treaty Song', the 'Welcoming Song' or my grandmother's famous ko'jua dance songs, like 'Wapikatji'j'.

My research includes collaborative projects with other research assistants to document Mi'kmaw chants, dance, language and other aspects of culture. Some of my work with the CSC has involved filming, documenting and performing Mi'kmaw music and dance. Currently, I'm working on a podcast that highlights the relationship between our Mi'kmaw colleagues and Māori people who we interacted with on a recent field course in Aotearoa (New Zealand), and a subsequent trip to participate in the 2025 International Council for Traditions of Music and Dance Conference.

I love the in-person interactions I have with people through my research. When you hear people express such passion for a culture in an intimate environment, you retain the knowledge and information more easily than you would from reading an article on the same topic.

Immerse yourself not only in the music you are interested in, but find ways to participate in other musical events too. The most authentic form of learning comes from participant observation. Music workshops at your school, community events like ceilidhs or open mics, and Indigenous gatherings like powwows are great opportunities to learn about the musical culture you are surrounded by, and can foster positive perspectives on culture, music and dance.

Beauty is more than skin deep: how African American women used beauty to change history

Beauty is often dismissed as superficial, but for African American women, it has long been a powerful form of resistance, identity and self-expression. **Dr Laila Haidarali**, a historian at **Queen's University** in Canada, is investigating how beauty practices – through fashion, modelling and media – played a vital role in shaping Black women's public image and political engagement during the 20th century.

Dr Lalia Haidarali

Department of History (cross-appointed to the Departments of Gender Studies and Cultural Studies), Queen's University, Canada

PROFILE

Field of research
20th century African American women's history

Research project
Investigating how African American women used beauty to shape their public image during the mid-20th century

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

doi: 10.33424/FUTURUM601

Talk like a ...
historian

Civil Rights Movement — a mass movement in the US (especially during the 1950s and 1960s) aimed at ending racial segregation and discrimination against African Americans

Haute couture — high-end fashion, often associated with Paris fashion houses

Respectability politics — a strategy, leveraged by different groups of African Americans, to assert equality and access to civil rights and economic opportunities by enacting middle-class values and behaviours

From hairstyles and skin tones to fashion and public image, beauty was a form of political resistance and self-definition for many African American women throughout the 20th century. This intersection of beauty and politics – so often overlooked – forms the foundation of Dr Laila Haidarali's project, 'Beauty and The Unfinished Business of Democracy'.

What shaped African American women's beauty in the mid-20th century?

"The inspiration for my project comes from my scholarly interest in drawing a longer line between two important developments in the history of African American women's civil rights activism," says Laila, a historian at Queen's University. "I want to show how the respectability politics that characterised the Civil Rights Movement are intertwined with the claims of an increasingly radical Black Power movement that, in 1966, asserted 'Black is Beautiful'."

Laila's research is set during the 1940s and 1950s, when millions of African Americans left rural Southern USA and moved to cities in the North, Midwest and West. These growing urban communities became hubs of Black life, creativity and enterprise. In cities like New York, Chicago and Philadelphia, African American women were at the heart of a booming beauty culture – working as hairstylists, entrepreneurs and fashion designers. For them, beauty was more than appearance – it was a tool for self-expression, pride and political resistance. Laila's research shows how beauty was used as a positive protest and as leverage to enter the integrated urban, job market.

How does Laila study the history of African American women's beauty?

To understand how African American women shaped media and beauty culture, Laila uses historical sources such as records from the first Black-owned modelling agencies that opened in the late 1940s. These institutions played a key role in creating new opportunities and images of beauty during a time of great change.

Brandford Models on tour in Jamaica in September 1956
© The Gleaner Company Ltd

"For scholars of Black history, archival research presents rich opportunities, but also poses significant limitations," says Laila. "The historic exclusion of Black voices and perspectives from official repositories of knowledge undermines the historian's reliance on archival evidence in various important ways. Black scholars speak powerfully about 'the violence of the archives'." Laila addresses this by digging deeply into different types of records and reading between the lines to find overlooked or hidden figures. She also turns to the Black press, especially influential magazines like *Ebony* and *Jet*, which proudly showcased beauty, success and everyday life. These publications, created by and for African American communities, were powerful tools of self-representation and cultural resistance.

How did ideas of African American beauty change?

Laila's research shows how, after World War II, a new image of beauty – focused on 'Brown-skin' African American women – began to take shape in Black magazines and community fashion shows. This image was carefully crafted by a growing network of Black editors, business owners, models and everyday women who worked together to create a more positive and glamorous portrayal of African Americans.

Brown-skin models became a symbol of elegance, dignity and modern Black womanhood, offering a bold alternative to racist stereotypes. Laila frames this display of beauty as a 'positive protest' against white supremacy. These models combined style with values like good manners and hard work. Although their beauty often aligned with conservative ideas about gender, they offered a powerful challenge to public ideas of who could be seen as beautiful in mid-20th century America.

> **"Brown-skin models became a symbol of elegance, dignity and modern Black womanhood."**

How did African American women reshape their public image?

"Firstly, it was hard work," says Laila. "My research shows how many different groups of women, independently of each other, laboured to produce new images or public visions of themselves, and that labour held great importance on personal, professional and community levels." Entrepreneurs like Barbara Watson, who ran the first modelling agency for Black women (Brandford Models), travelled abroad to bring high-quality fashion to Black communities, challenging the poor-quality clothing typically marketed to them. Her work showed how fashion could be a powerful tool for economic independence, self-respect and entry into the integrated workplace.

"Individual women who worked as models also demonstrate how that labour role was fraught with obstacles to attaining success on the mainstream stage," explains Laila. For example, Dorothea Towles was the first African American model to achieve acclaim as an 'haute couture' model in Paris. Through fashion and modelling, such women didn't just challenge beauty norms – they created new paths for empowerment and representation. However, when Dorothea returned to the US in the early 1950s, she found few opportunities for work. In her words, 'doors remained closed to her as a Black woman'.

What can modern society learn from Laila's research?

Laila's research challenges the idea that beauty is superficial. "At first glance, the history of African American women as Brown-skin models may seem to celebrate a narrow, middle-class, heteronormative version of beauty, and may lead some to judge this cohort of women as mimicking whiteness, or 'wanting to be white'," says Laila. "However, this history is more complex. It was a way to express racial pride rather than to deny it – it was a positive protest."

In a segregated society that devalued them, African American women used beauty to assert self-worth, professionalism and belonging. Their carefully composed appearances helped them claim visibility in a world that rendered them invisible. Studying this history shows how race, gender and class have long shaped ideas of who is worthy. It reminds us that while beauty may not be everything, it has real power – and that power, historically denied to Black women, has been used by them as a form of resistance and pleasure.

About *African American women's history*

African American women's history studies the lives, voices and contributions of Black women throughout US history. It explores how they navigated systems of racism, sexism and classism while shaping politics, culture, communities and movements. Often overlooked in mainstream historical narratives, African American women's experiences provide a more inclusive and complex understanding of the American past. The field is highly interdisciplinary, drawing from history, gender studies, literature, art, sociology and cultural studies to explore how identity and representation have developed over time.

Understanding African American women's history is important for everyone – regardless of gender or race – because it challenges long-standing assumptions about who shapes history. "Traditional narratives have often positioned men, especially white men, as the main actors of the past," says Laila. African American women's history disrupts that view, revealing how Black women have always played essential roles in resisting white supremacy, supporting their communities and advocating for equality.

African American women's history helps explain how deeply race and gender shape our society – from legal structures and political systems to cultural norms and ideas of beauty. It shows that race is not a biological fact but a social construct with real, lived consequences. "The way Black women have been judged based on appearance, behaviour and perceived respectability tells us much about the values of the society around them," says Laila. "Yet, their strategies of self-definition, resistance and creativity have also paved the way for new ways of being seen and heard."

Pathway from school to *African American women's history*

"As I often tell my students, African American history is US history!" says Laila. "So, we need to start there to begin understanding the Black experience; we need to have a good grounding in US history and ways to question and trouble that meta-narrative."

Study history at high school, then at university take courses in history, women's/gender studies and Black/African American studies.

Women's/gender studies will provide tools to analyse power, identity and social structures through a feminist lens, while Black/African American studies are vital for understanding the history and experiences of Black people.

Laila recommends engaging with Black expressive culture through subjects such as literature, art, music, drama and fashion, which will help you understand how African American women have expressed themselves and been represented through time.

Explore careers in *African American women's history*

With a background in African American women's history, career opportunities will be available in academic research, education, museum/archive curation and advocacy.

"Go to museums," advises Laila. "Question, think and reflect on the ways that the past has been represented." Visiting museums not only builds your historical understanding but also improves your awareness of how history is constructed and displayed. These spaces are also potential workplaces for historians interested in public education, curation and storytelling.

Explore the websites of the Association of Black Women Historians (**abwh.org**), the Organization of American Historians (**oah.org**) and the Schomburg Center for Research in Black Culture (**nypl.org/locations/schomburg**), which offer educational resources, essays, interviews, digitised archives and internships.

Explore your local and national archives. Seek out documents and texts relevant to the Black experience.

Sylvia Fitt Jones, a Brandford Model, prepares for a photo shoot in 1954
© Our World

Download Laila's resources from **futurumcareers.com/beauty-is-more-than-skin-deep**

Meet *Laila*

I was a busy teenager. My parents made sure I participated in non-academic activities such as swimming, tennis, piano and ballet. Yet, my main interests were reading fiction and poetry, writing stories and poems of my own, and drawing and painting.

I've always enjoyed history. I grew up in Trinidad and Tobago and it was my high school history teacher who piqued my interest in US history. It was new to me and lent itself to great storytelling. Of course, history is more than storytelling, though the telling of a good story remains a cornerstone of the historian's craft.

Growing up as a Muslim girl in a predominantly Christian country was not always easy, but I am thankful to have been born and raised in a multicultural, multiethnic and diverse society. My Catholic convent school education played an important part in my understanding of faith, gender roles and racial identities. At the age when most adolescents want to fit in and belong to their peer group, I felt my otherness quite acutely. For example, unlike my classmates, my name was not Anglicised. This highlighted my difference (and still does today).

When I was nineteen, my family relocated to Canada, and I went to university in a different city from where they settled. It was exciting to be on my own for the first time in my life, but it was also challenging. As a Caribbean immigrant woman of colour on a largely white campus, I was not completely at ease, nor happy. Yet, my greatest academic achievements began there.

My interest in US history deepened during my time at university because it was the main field of history where race and gender appeared as important aspects of the historical narrative. I credit the pioneering work of Black feminist scholars for positioning women, gender, race and class as central to a deeper understanding of US history.

Poetry remains my primary form of personal expression. It's my dream to publish a collection of poetry! I enjoy the creative process of making something out of nothing and crafting words to shape meaning and bring ideas to life.

Laila's *top tips*

1. Read books. And then read more books.
2. Look for mentors and role models and reflect on why you admire them.
3. Embrace your own unique qualities and perspectives, but don't close yourself from engaging with other points of view.
4. Listen carefully. When the time is right, speak up. Learn how to articulate what you mean. Keep in mind that it takes time to develop your own voice.
5. Question what you don't understand, and don't expect everyone to have all the answers. But we can always work to find them!
6. Don't give up – don't allow any failure or obstacles to limit your reach. Find purpose in your passion.

How can portraits and podcasts change perceptions of disability?

Disability is often portrayed as something undesirable, something that prevents people from living a happy, healthy and fulfilling life. Creating and championing positive depictions of disability can help to change this misguided narrative. **Dr Pamela Block** from **Western University** in Canada, **Dr Nádia Meinerz** from the **Federal University of Alagoas** in Brazil and **Bruna Teixeira** from the Brazilian feminist art collective **Ateliê Ambrosina** are exploring disability and identity through portraits, podcasts and visual activism.

Dr Pamela Block

Professor, Department of Anthropology, Western University, Canada

Field of research
Disability anthropology: cultural perceptions of disability, disability culture and activism

Dr Nádia Meinerz

Associate Professor, Institute of Social Sciences, Federal University of Alagoas, Brazil

Fields of research
Health, gender, sexuality and disability studies

Bruna Teixeira

Founding Director of Ateliê Ambrosina

Fields of research
Visual arts, queer bodies, disabled bodies

Website
retratosdeficas.com

doi: 10.33424/FUTURUM618

Talk like a ...

disability anthropologist

Ableism — discrimination, prejudice or social bias against people with disabilities, based on the belief that disabled lives are less valuable or desirable

Albinism — a rare genetic condition characterised by a lack of melanin pigment in the skin, hair and eyes, often resulting in vision impairments and sensitivity to sunlight

Creative participatory research — a collaborative approach to research that actively involves participants to co-create knowledge and represent lived experiences, often using artistic or expressive methods

Visual activism — the use of visual media such as photography, film or art to challenge injustice, raise awareness and promote social or political change

Research project
Exploring disability and identity through portraits, podcasts and visual activism

Funders
Social Sciences and Humanities Research Council of Canada (SSHRC); Wenner Gren Foundation; Brazilian National Council for Scientific and Technological Development (CNPQ); Coordination for the Improvement of Higher Education Personnel (CAPES); Federal University of Alagoas (UFAL); Western University

From the gigantic oil paintings of kings and queens to the glamorous photographs of modern-day celebrities, portraits have always been a symbol of power, status and wealth. Through exposure to these depictions, we build an image of what a happy, healthy, successful person should look like.

In contrast, people with disabilities are often depicted in the context of sadness or suffering. Charities show us images of disabled people and ask us to help,

support or pity them, while healthcare and medical advertising shows us the problems caused by disability and how they can be fixed or 'cured'.

"Disability is usually portrayed as something undesirable; as the opposite of health, beauty, professional success, parenthood and happiness," says Dr Nádia Meinerz from the Federal University of Alagoas. "Creating positive depictions of disability is important for changing the way we feel about and look at disabled people." She collaborated with Dr Pamela Block from Western University and Bruna Teixeira from the feminist art collective Ateliê Ambrosina on a creative participatory research project called Retratos Defiças, or Defiant Portraits in English.

This project empowered disabled people to co-create self-portraits using visual media and podcasts. "The goal of Retratos Defiças was to create a space for disabled people to represent themselves the way they want to be represented, to be seen as they want to be seen," explains Pamela. "These are strong, creative, resourceful, funny and interesting people, and it was such a pleasure to work with them in bringing their portraits to life."

Portraits and podcasts

During Retratos Defiças, 22 co-creative duos created **11 pieces of visual art** and **11 podcast episodes**. "In each duo, one or both of the co-creative partners were disabled," explains Pamela. "In some cases, they had previous experience of making art, but for others it was an entirely new experience."

"Before starting the project, I did extensive research into the potential of using visual art for disability activism during my master's in anthropology," says Bruna. "I discovered vibrant contemporary artworks made by disabled women, which showed the value of self-portraits as a way for people to be the protagonists of their own images."

The idea of using podcasts as 'sound portraits' was partly inspired by the Disability Visibility Project, founded by Alice Wong, a disabled activist. "This project includes a podcast channel where disabled people tell their stories, and listening to that kind of autobiographical narrative allowed us to think about portraits from another point of view," says Nádia.

Co-creation and participatory research

Throughout the project, Bruna and her team of disabled artists at Ateliê Ambrosina were on hand to support the co-creative duos through their creative process as well as ensure disability access. "We are a 'hands on' organisation, and we helped bring this project to life," says Bruna. "Making a creative participatory research project work in the 'real world' requires a different approach to projects that take place in the academic community within the walls of a university. We needed another language, another way of doing things and communicating that allowed us and our participants to improvise and be spontaneous." Artists from Ateliê Ambrosina, Lart Malta and Olga Aureliano, who have lived experience with visual disability and deafness, took the lead in ensuring that the process of co-creation and the portraits themselves were accessible by creating audio-description and transcripts.

As this was a creative participatory research project, the co-creative duos were not just participants but also collaborators with the researchers, influencing the aims and methods of the project and adapting and improving Pamela and Nádia's original vision. "Originally, we had planned that disabled people would be paired with researchers, but our participants pushed back and told us that was too limiting," explains Pamela. "In the end, we let them choose who their partners would be."

This co-creation required co-operation and equal ownership, and for the members of each duo to reflect on their own positions. "The disabled person needed to break out of a cycle of seeing themselves as a patient of a diagnosis by taking ownership of their story and their creation," explains Nádia. "The able-bodied partner had to face the issue of ableism and connect with their disabled partner in a positive way. In the same way that gender issues involve both men and women and race issues need to be faced by white people, disability needs to be thought of as something that affects everyone, not just those who are labelled as disabled."

Libellum © Amanda Bambu and Gabi Amorim

Sharing the portraits

The portraits and podcasts were exhibited in an online digital art gallery. They were made accessible to blind and low-vision people through audio descriptions and to deaf people by the transcription of each podcast episode. All this content is available in both Portuguese and English. The team hosted in-person art shows in Brazil and Canada, where the artists were able to attend remotely and answer questions. The team also hosted four online discussions around themes such as sexuality, Indigeneity and accessibility. "We chose one work of visual art and one podcast for each of these discussions and assembled groups of Brazilian and Canadian scholars, artists and activists to reflect and create works in relation to these pieces," says Pamela. The team also published **a journal issue** showcasing artwork and presentations from the online discussions.

"This project encompassed a very important period in Brazilian history," continues Pamela. "During the Covid-19 crisis and the Bolsonaro presidency, all of the major structures of governance fell apart. Health, education, sanitation, and even the postal system weren't working, yet somehow, in the midst of all this chaos, this beautiful project was happening, allowing people to connect with each other and proclaim: 'I exist. I matter. I am not alone.' "

Mask: the colorful terror © Flavia Neves and Daniel Nascimento

About *disability anthropology*

Disability anthropology examines how disability is perceived and represented in different cultures, how disability affects people's lives, and the interrelation between disability and identity. It is a subdiscipline of sociocultural anthropology which investigates human societies and cultures, focusing on how people live, think, interact and make meaning in their everyday lives.

The topics that sociocultural anthropologists study reflect the variety and diversity of individual humans and their communities. "When I started doing anthropology, there wasn't anything called disability anthropology – there was only medical anthropology, which I had never done," says Pamela. "I was a sociocultural anthropologist doing disability research and there wasn't really a place for me in the field at that time, but things have changed now."

Disability anthropologists use many research methods including participant observation, focus groups and interviews, ethnography, and creative participatory research. "In participatory research, the whole process – determining what's going to be asked, how it's going to be asked and what to do with the information – is all decided together with the community," says Pamela. "Sometimes, researchers have a hard time giving up that control, but I think it is the most ethical way of doing research." The creative aspect of participatory research means that the research outputs are not just academic papers that are published in scientific journals. "This kind of research involves something other than just writing words on a page, so the artwork and podcasts were all part of the results of our project," continues Pamela.

In addition to collaborating with groups, communities and other participants, anthropologists will often collaborate with experts from other fields including social and political sciences, linguistics, history, medicine, and media studies. This interdisciplinary way of working allows anthropology to explore human issues from multiple perspectives. "Anthropology can learn a lot from visual arts and digital technologies, especially in improving research tools and expanding the possibilities for social impact," says Nádia.

Pathway from school to *disability anthropology*

Study humanities and social sciences at school. History, psychology and geography can help you prepare for cultural anthropology and archaeology. Language and literature can provide a basis for linguistic anthropology, and health and biology can prepare you for medical or physical anthropology. Learning other languages may also prove to be useful in anthropological fieldwork.

Most universities offer courses in anthropology, and you can specialise as you progress through your studies. "Whatever interests you - from video games to insects - there is probably an anthropologist somewhere who has studied it," says Pamela. "So, search for anthropology projects or books about topics that interest you."

Look for opportunities to take part in research, fieldwork or community engagement, especially internships or opportunities which allow you to immerse yourself in unfamiliar cultures or experiences.

Meet *Pamela*

I was always interested in why there are power differences in society among different groups of people, and I followed that interest to study things like racial inequality, gender inequality and eventually disability inequality.

It's hard to choose just one thing I love about my job. I enjoy the research, but what I really enjoy is the opportunity to teach people something that's going to change their lives for the better, to help them figure out what they want to do with their lives. I like seeing that light bulb come on.

My persistence has enabled me to lead a successful career. In this life, there are always going to be people telling you that you don't belong or that you're not good enough. It can take some time and creativity to figure out how and where you fit within your chosen field. Find the people who uplift you and support you. It is also important to be flexible and open to moving to where the jobs are.

I have a sister who is autistic, and my mother was a special educational needs teacher. Over the years, I have been a disability activist, a researcher and a personal assistant to disabled people while I was at university. I had a mentor, the historian Lawrence Goodwyn, who once said, "Social knowledge is experiential," meaning that we are the most passionate about things that come from our own personal experience. For me, living life with a disabled sister and having some disability issues of my own (ADHD and anxiety) has been that spark.

To unwind, I enjoy spending time outdoors, walking or kayaking. I am part of an activist drumming group which I enjoy. I have a dog who I love spending time with, and I'm lucky to have children and a husband who are all excellent cooks, so I love to eat whatever they make (and I do the dishes!)

Pamela's *top tips*

Find a good mentor and keep learning as you go. Don't be afraid to make mistakes and don't be afraid to apologise for them. Have some humility and understand that even when you are advanced enough to become a teacher like me, you are still a learner, and you always will be.

Meet *Nádia*

My parents are descendants of German immigrants who settled in southern Brazil in the early 20th century. They were part of what we call 'whitening policies'. I was already aware of this racist legacy when I studied anthropology in Rio Grande do Sul, but migrating to Alagoas changed my perspective. It was here, while training other anthropologists, that I realized how limited my knowledge was, especially since my references were Eurocentric.

I like being able to contribute to building safe spaces in which women, Black, Indigenous and disabled people can access formal education and build a research career of their own. The most important thing is to use my white, able-bodied and cisgender privilege to discuss how racism, ableism and transphobia are interconnected with gender inequality.

Research in gender inequality, sexuality and disability is a huge opportunity to observe structural changes in culture and society. The social anthropology programme at the Federal University of Alagoas works with local organizations to support and encourage students to produce multimedia projects that increase the awareness of these changes.

One of the things that relaxes me the most is walking. I walk a lot on the sandy beach in Maceió, soaking my feet in the sea water and watching the waves move. I like walking in the forest, hiking and discovering new landscapes. I only consider myself to have truly visited a new city when I have walked around it on foot.

Nádia's *top tip*

Pay attention to how people around you react to difficult topics, especially when they avoid or resist them, and think about why they might react the way they do. It's not always easy to speak up, but even small actions or questions can make a difference.

Explore careers in *disability anthropology*

"Anthropologists work in many different fields," says Pamela. "All over the world, medical anthropologists collaborate with clinicians in research and teaching as well as in community health. Anthropologists work for nonprofit organisations, museums, government agencies and universities."

Explore the websites of the Canadian Anthropology Society (**cas-sca.ca**), the Associação Brasileira de Antropologia (**portal.abant.org.br**) or the American Anthropological Association (**americananthro.org**) to read about the latest research. You could even become a student member and attend events and conferences.

Discover more about the latest stories and findings from anthropology researchers all over the world by reading online magazines and journals such as *Sapiens* (**sapiens.org**), *Somatosphere* (**somatosphere.net**) or *Vibrant* (Virtual Brazilian Anthropology) (**vibrant.org.br**).

My self © Julia Arume and Mirely Cervieri

Ateliê Ambrosina

Ateliê Ambrosina is a feminist art collective and activist group founded by Bruna in Alagoas, Brazil. "In 2017, I was searching for a feminist group that I could collaborate with," says Bruna. "However, I realised that the main feminist movements in the city were linked to political parties led by men, which did not convince me. So, I gathered old and new friends and we founded Ateliê Ambrosina in 2018. We carry out activism, research projects, interventions and events led by LGBT women, white women, Black women, fat women, women with disabilities, and women of different social classes, education levels and ages."

Team members at Ateliê Ambrosina are 'artivists', meaning they use art for activism. "We use all kinds of art, including visual arts, audiovisual creations, music, theatre and podcasts," explains Bruna. "Anthropology has taught me to be a better activist through listening to others more attentively and with more patience."

Ateliê Ambrosina runs a community homeschool, called Casa Ambrosina, in Maceió, Bruna's hometown. "Casa Ambrosina supports the shelter and emancipation of girls and young women aged 12 to 21 in a state of social vulnerability," says Bruna. "We offer weekly courses in subjects such as photography, digital arts, theatre, percussion and futsal (a version of 5-a-side football)." Team members at Casa Ambrosina also offer support and guidance around combating poverty, child pregnancy and sexual abuse in adolescence, and they work to improve their students' options and access to freedom later in their lives.

You can learn more about Ateliê Ambrosina's bold, beautiful and ground-breaking projects by visiting its website: **atelieambrosina.com.br**

Meet *Bruna*

As an independent activist, it has been amazing to work with academic activist women like Pamela and Nádia. We learned so much from each other! The secret to success in projects like these is ensuring that the relationships are honest, straightforward, direct and spontaneous. The desire to learn how to communicate with lots of different people, whether they are academics or residents in remote, isolated villages, has helped me massively.

There comes a time in projects when you need to stop theorising and start doing. I think one of my best traits is knowing exactly when that time comes and how to make it happen. I am also committed to publicly displaying the results of the projects I am involved in, because I believe that activist initiatives should be shared with as many people as possible. So, I think the courage to receive feedback is extremely important, both to improve in the future and to encourage the continuity of our ideas.

I have a master's degree in anthropology from the Federal University of Alagoas and am currently studying a PhD in visual arts at the University of Brasília. My research is now focused on my own bodily experience as a queer, plural-bodied person, without boundaries between the genders of lesbian woman and transmasculine person. What motivates my research is knowing that our queer points of view are still underrepresented within the visual arts in Brazil. Expanding the enjoyment of visual arts, from a queer point of view, excites me. My artistic practice oscillates between activist urgency and long-term investigative processes. You can see more of my work on my website: **brucateixeira.com.br**

As an artist and researcher, I had the privilege of meeting Nádia, an advisor who was passionate about the anthropology of disability, gender studies and sexuality. She really helped change my way of thinking about the world, and that is priceless.

I'm an independent artist, so the line between relaxing and working is a bit blurred! But when I'm not having fun working, I enjoy going to the beach and to art galleries, hiking, playing pool, eating well, meeting friends, laughing and having good conversations.

Bruna's *top tips*

1. Look for people who can guide you, but make sure that they approach your relationship as an exchange based on mutual respect and admiration.

2. Don't give up on your project. When you've found something that you completely fall in love with, never stop believing in it!

3. In terms of visual arts: practice, experiment, do.

Filús

Pamela has collaborated with Bruna and Ateliê Ambrosina on another creative participatory research project called Filús, in which they co-created a documentary film with, for and about the people living in this community. "The community of Filús is descended from a type of community in Brazil called a Quilombo, formed by enslaved people who escaped into the forests and mountains," says Pamela. Located in a remote area in northeastern Brazil, it can be hard for the people of Filús to access education, employment, healthcare and clean water, although recent developments include a small schoolhouse for younger children, a medical office and some access to the internet.

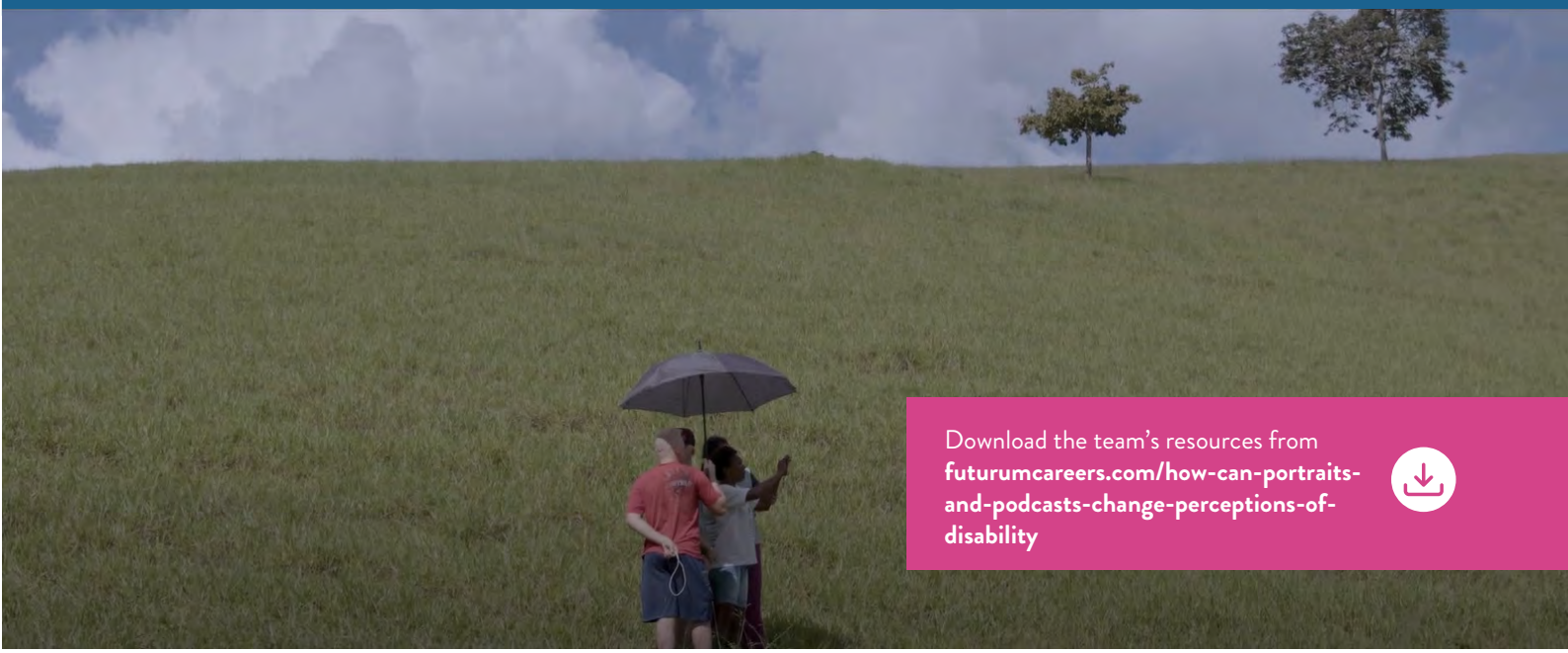
"In Filús, there is a larger concentration of people with albinism than almost anywhere else in the world," says Pamela. "In much of the world, albinism is seen as a disability, but I don't think that's how people in Filús look at it. They certainly see it as a disadvantage, as it impacts your vision and makes your skin vulnerable to cancer, but other than that, they don't see it as something strange or scary or negative. It's just part of who they are."

"Unfortunately, previous research projects in Filús have been primarily biomedical and extractive," continues Pamela. "Scientists came in to collect information and medical samples but, according to community members, gave very little back, despite the fact that they were receiving huge grants worth hundreds of thousands of dollars to conduct the research. None of this money ever trickled back into the community."

Pamela and Bruna wanted their research project to be different. "We wanted the community to be in control, and we wanted to share the resources that we received for the project," explains Pamela. As the community shared stories of their lives, the team from Ateliê Ambrosina shared their film-making expertise. Everything from the interviews and script writing to the final edits was done co-creatively. "It was very important that control of the project be with the community and that they approved anything that was done," says Pamela. "The Ateliê Ambrosina team has a great deal of experience doing this kind of participatory research and they were great at building a relationship of trust and mutual respect."

As well as sharing their technical expertise and training community members, the team from Ateliê Ambrosina paid participants and hired local people to work on the project with them. "However, the creative economy does not revolve only around the fair distribution of resources," says Bruna. "It also involves acknowledging co-authorship, so the entire local team is also credited with the research and production of the film."

"The story is best told in the film itself and by the people who live in Filús," says Pamela. You can watch the Filús documentary on YouTube: **https://www.youtube.com/watch?v=rlcdnkv-e2k&t=496s**



Download the team's resources from **futurumcareers.com/how-can-portraits-and-podcasts-change-perceptions-of-disability**

Bringing Indigenous rights, leadership and knowledge into archaeology

The impact of Canada's colonial history continues to be felt today through outdated practices that are not inclusive of Indigenous populations. This includes the field of archaeology, where the people whose history is being unearthed are often left out of the process. **The Institute of Prairie and Indigenous Archaeology** at the **University of Alberta** is changing archaeology through practice, policy and pedagogy, enabling education and research to benefit from Indigenous ways of knowing and being.

Dr Kisha Supernant, PhD

Director, Institute of Prairie and Indigenous Archaeology, College of Social Sciences and Humanities, Faculty of Arts, Department of Anthropology, University of Alberta, Canada

Field of research
Archaeology

Research project
Fostering Indigenous-engaged archaeology in Canada

Website
ualberta.ca/en/prairie-indigenous-archaeology

doi: 10.33424/FUTURUM608

PROFILE

INSTITUTE OF PRAIRIE AND INDIGENOUS ARCHAEOLOGY

Talk like an ...

Indigenous-engaged archaeologist

Archaeology — the study of human history and prehistory through the exploration of stories, perspectives, belongings and places

Indigenous Peoples — people whose ancestors have lived in an area since before colonialism and continue to maintain distinct cultural traits

Elders / Knowledge Holders — Indigenous People recognised by their community as custodians of cultural and traditional knowledge

Pedagogy — the method and practice of teaching

Canada's colonial era continues to haunt the nation through systemic inequalities that create differences in the opportunities, privileges and resources available to Indigenous and non-Indigenous people. This includes academia, where models of research and teaching continue to perpetuate injustices and disregard Indigenous knowledge. While these systemic inequalities may not be immediately obvious, their effects can be profound.

The Institute of Prairie and Indigenous Archaeology (IPIA) is aiming to change this for the field of archaeology. Using a holistic approach, the IPIA team, led by Director Dr Kisha Supernant, is ushering in a new comprehensive perspective on archaeology that puts Indigenous voices at the forefront. With many members of the IPIA team coming from Indigenous communities, the IPIA is Indigenous-led and embodies the values and ethos it aims to foster in the broader community and archaeological field.

Injustices in archaeology

The majority of archaeological remains on Canadian soil are from the Indigenous populations that lived there for thousands of years before European colonists arrived. "In Canada, archaeology has often been carried out by non-Indigenous researchers, without involving the people whose histories are being explored," says Kisha. "This has caused harm and left Indigenous voices out of important conversations. Indigenous People are still here today, and their knowledge, rights and authority must be respected."

Governmental policies on archaeology continue to be outdated, often not recognising the rights of Indigenous


© Stephanie Halmhofer

People to their own heritage. "At the moment, decisions about archaeological sites, artefacts and even sacred places are often made without proper involvement from Indigenous communities," explains Kisha. "This needs to change. Indigenous Nations need to have a say in what work is done on their lands, how it is carried out, and what happens to the artefacts discovered." Addressing these structural barriers involves concerted efforts from multiple directions – which is what the IPIA team is helping make happen.

Three interwoven braids

The IPIA team focuses on stimulating change in three connected areas: practice – how research is carried out; pedagogy – how archaeology is taught; and policy – how archaeology is governed. "Practice, pedagogy and policy are closely connected and all equally vital," says Kisha. "For example, even if we teach students differently, it won't make a lasting impact unless policies also support Indigenous leadership and rights." The IPIA's work is guided by heart-centred practice, a philosophy that recognises that collaborators bring their full selves to their work: body, mind, heart and spirit. "This creates a space where people care for each other, learn together and support each other," says Kisha.

Beyond equality, archaeology itself benefits hugely from including Indigenous perspectives. "Indigenous ways of knowing are based on deep relationships with the land and generations of community knowledge," explains Kisha. "History isn't locked in the past – it connects to the present and future." The patterns of thought taught by Western scientific education are not comprehensive; including Indigenous communities in education and research reveals new ideas and approaches that otherwise might not be considered. "This leads to research that is more meaningful, respectful and insightful," says Kisha. "Indigenous knowledge helps archaeology move beyond just collecting objects and towards understanding the deeper stories and relationships involved."

Supporting Indigenous-led research

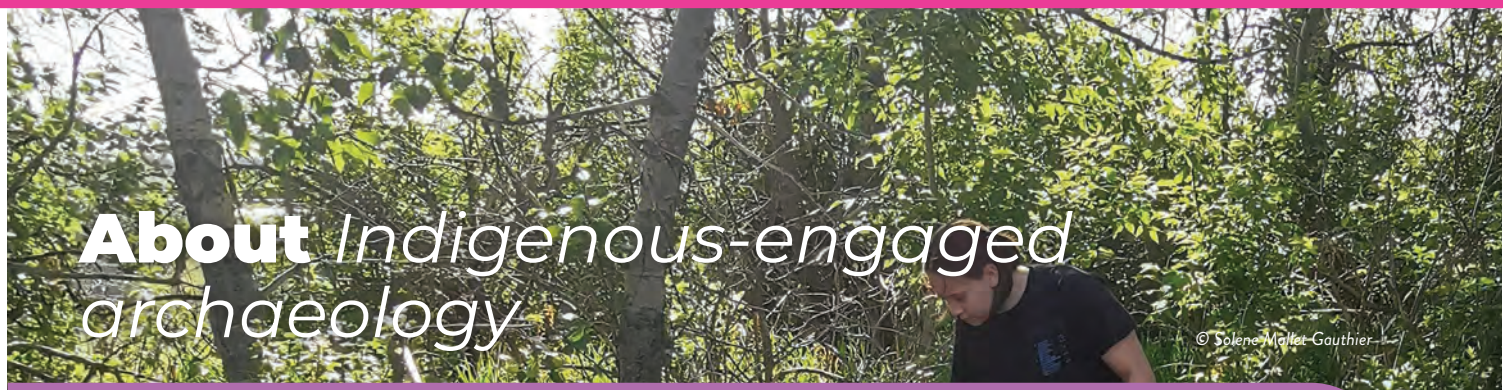
The IPIA prioritises building and maintaining strong relationships with Indigenous Nations. "We offer mentorship to researchers focusing on how to build relationships based on trust and mutual respect," says Kisha. "We also help design research projects where Indigenous communities set the goals and decide which questions matter the most." The IPIA also provides training and toolkits – for instance, on how to navigate regulatory systems and use digital archaeological programs. These empower Indigenous communities to lead or take part in archaeological work.

Moreover, the IPIA team is committed to teaching the next generation of archaeologists to appreciate the importance of Indigenous inclusion. "We are developing learning experiences where students do not just learn from books or lectures, but also directly from Indigenous communities," explains Kisha. "For example, in our archaeological field schools, community members and Elders teach our students about the land and its history from Indigenous perspectives." Students are also taught about the harms that archaeology has caused in the past and how these can be addressed through changed practices. Elders and Knowledge Holders are invited to speak to students to shape their understanding of Indigenous rights and relationships.

Changing the face of archaeology in Canada

The IPIA centres Indigenous communities and their needs in every aspect of its work. "We are proud to be pushing for change across the field – encouraging archaeologists to work in ways that support Indigenous goals and uphold the highest standards of research," says Kisha. "We are helping to set a new standard for what ethical, community-centred archaeology looks like." For instance, the IPIA team is involved in supporting Indigenous communities in finding the unmarked graves of children who died at Canada's Indian Residential Schools – a network of boarding schools designed to forcibly assimilate Indigenous children into colonial culture. This network was active for over 160 years, isolating children from their families and often subjecting them to abuse and neglect. Thousands died, and the search for human remains is ongoing. "This is sacred and emotional work, and we are grateful to be trusted with it," says Kisha.

Looking forward, the IPIA is focusing on forging new relationships and strengthening existing ones to broaden the impact of its efforts. "We want to expand our work in cultural policy and teaching, so that Indigenous communities have the tools and support they need to take the lead in archaeology," explains Kisha. "By continuing to braid together practice, policy and pedagogy, we aim to build a future for archaeology that is led by Indigenous knowledge and values."



About *Indigenous-engaged archaeology*

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Archaeology is the study of human history and prehistory through the physical things left behind. This means that most archaeological careers include time in the field, surveying and excavating sites, and analysing the artefacts discovered. Indigenous-engaged archaeology involves being fully conscious and inclusive of the role of Indigenous People in archaeological research – which is the focus of IPIA's approach. "One of the most rewarding parts of our work is collaborating with Indigenous communities on research that matters to them," says Kisha. "Working on questions from the community itself feels very meaningful, and how we approach these questions is significant. For example, it's important that the terms we use reflect our approach; we respectfully refer to 'belongings' rather than 'artefacts'."

The IPIA team's work on Métis archaeology in western Canada is informed by questions and priorities from the Métis community. The Métis are a mixed-race Indigenous People, holding both Indigenous and European ancestry. "Our work is changing the archaeological record and inspiring Métis communities to develop policies that protect their own heritage," says Kisha.

Kisha believes that the next generation of archaeologists will find a field increasingly shaped by Indigenous participation and leadership. "Whether a researcher is Indigenous or not, if they are working on Indigenous land, they first need to build respectful relationships with the community," says Kisha. "These relationships allow for research that is both innovative and respectful, grounded in Indigenous ways of knowing and committed to real-world impact."

Download the team's resources from **futurumcareers.com/bringing-indigenous-rights-leadership-and-knowledge-into-archaeology**

Pathway from school to *archaeology*

At school, history, geography, languages, biology and anthropology, if available, will help prepare you for a career in archaeology.

Kisha recommends seeking university courses in archaeology, anthropology, history and human geography. She notes that many universities offer Indigenous studies courses. If the university you are interested in does not offer these, online courses are a worthwhile alternative. Kisha also recommends seeking field schools or archaeological training programmes for hands-on experience.

The Archaeological Society of Alberta provides useful information, including education and outreach resources: **arkyalberta.com**

Explore careers in *archaeology*

Kisha recommends getting involved in archaeology as soon as you can – for instance, through volunteering with local archaeology groups, museums or community projects.

To understand more about what a career in archaeology entails, this webpage from the Archaeological Institute of America is a good read: **archaeological.org/programs/educators/introduction-to-archaeology/a-career-in-archaeology**

Read about the people who work at the IPIA, including students. Their profiles give you an insight into the type of research taking place in the field: **ualberta.ca/en/prairie-indigenous-archaeology/people/index.html**

Dawn Wambold photographs an excavation unit at the Chimney Coulee site in Southwestern Saskatchewan. The IPIA has been conducting fieldwork and research at this important Métis site since 2013, and it still has lots of stories to share! © Robert Wambold

Meet *Dawn*

Dawn Wambold, PhD candidate, Institute of Prairie and Indigenous Archaeology
Field of research: Historical and Indigenous archaeology
Funders: Social Sciences and Humanities Research Council (SSHRC) – Canada Graduate Scholarship
Province of Alberta – Alberta Graduate Excellent Scholarship (Indigenous)
University of Alberta – President's Doctoral Prize of Distinction

When I was a child, my parents had a subscription to *National Geographic* magazine; I would spend hours reading the articles about history and archaeology. My parents also had a large book called *The Adventure of Archaeology* that I read countless times.

I first studied engineering at university. This was followed by a technical career in oil and gas, but my fascination with archaeology persisted. The books I read mostly focused on faraway, out of reach places. Then I attended public lectures hosted by the Archaeological Society of Alberta, which changed my perspective – my home province had a fascinating archaeological story as well.

I grew up without grandparents so never heard their stories. Diaries from my Irish and English ancestors helped me connect to them in their own words, but I didn't have anything like that from my Métis side of the family. There was also a lack of Métis women's stories in the historical record. I realised that by pursuing archaeology, I could help shed some light on this.

For my PhD, I'm exploring my ancestors' connections to places in southern Alberta. My work emphasises the Métis concepts of keeoukaywin (the visiting way) and wâhkôhtowin (the state of being related with humans and non-humans, and the responsibilities and reciprocal obligations inherent within those relationships). This influences my attitude towards my work: I don't consider myself to be analysing sites or artefacts. Instead, I am visiting places and belongings that were important to my ancestors to learn their stories.

With the support of Kisha and the IPIA team, I'm able to explore my passion for history and archaeology. Everyone at the IPIA brings a unique set of skills and knowledge, and working with them has made me consider perspectives that make my own research more robust.

I'm proud to have published a book chapter. It appears in a collection of essays about Indigenous connections to the landscape. When I received my hard copy of the book, the first thing I did was to visit my parents to share my excitement with them!

Another career achievement is the positive feedback that I get from my Métis community, which reassures me I'm on the right path. Elders and others have told me how important my work is. They've shared so many family stories with me, and I'm proud that they see me as someone that they trust with the shared history of our ancestors.

I want to continue investigating places important to my Métis ancestors. This includes Chesterfield House, an eighteenth-century fur trade post. I am also the mother of a young archaeologist, so I aim to serve as a mentor to others, particularly Métis archaeologists seeking the stories of their ancestors.

Dawn's *top tip*

When seeking a supervisor or mentor, try to see if they will be a good fit for your style of learning. If you can, speak to students they supervise to learn more about their perspectives. Make sure you choose someone with whom you will have a rewarding working relationship.

Girls+Sports: using law and data to address gender inequality in school sports

Although laws in Canada forbid discrimination in schools, barriers to participation in school sports still exist – especially for girls. **Dr Jennifer Orange**, a human rights lawyer at **Toronto Metropolitan University**, is using data to investigate gender disparities in sports opportunities across Toronto schools. Through the Girls+Sports Project, her team aims to make these gaps visible and support efforts towards fairer and more equal access to sports for all students.

Dr Jennifer Orange

Assistant Professor, Lincoln Alexander School of Law, Toronto Metropolitan University, Canada

PROFILE

Field of research
Human rights law

Research project
Investigating and sharing information about gender disparities in sports participation across schools in Toronto

Funder
The Girls+Sports Project draws on research supported by the Social Sciences and Humanities Research Council of Canada (SSHRC)

Website
girlsplussports.ca

doi: 10.33424/FUTURUM615

Talk like a ... human rights lawyer

Equity — removing barriers to ensure that everyone has a chance to succeed and thrive, which often means providing different support systems and opportunities for different groups

Gender disparities — differences or inequalities between different genders in participation or opportunities

Intramural sports — sports activities organised within a school or community for students to compete informally

Human rights treaty — an international agreement between nation states that protects basic rights and freedoms for all people

Convention on the Rights of the Child — the most widely accepted international treaty that outlines children's rights, including education and non-discrimination

User experience (UX) design — the process of designing websites or apps so that they are accessible and enjoyable for people to use

The marathon has been an Olympic event since the first modern games were held in 1896. However, it wasn't until 1984, almost 90 years later, that women were allowed to compete in it. In 1921, the Football Association in the UK banned women's football, stating that, "The game of football is quite unsuitable for females and should not be encouraged." This ban remained in place for 50 years.

Unfortunately, these examples are part of the long and often unfair history of women's sport, which has been a constant fight for inclusion. Despite decades of progress, equal access to sport is still not guaranteed.

Today, countries around the world have made laws that promise equal opportunities. However, laws are only powerful if they are effective – and without clear evidence of how those laws are working in practice, inequalities can remain hidden. At Toronto Metropolitan University, Dr Jennifer Orange is collecting and analysing data to investigate whether girls in Canadian schools have the same access to sports as boys do. Her Girls+Sports Project is exploring gender disparities in school sports, helping to drive real change in policy and practice.

Why is equal access to sport important for young people?

"Canadian studies have shown that when young people participate in sports, they experience better physical and mental health and have a better chance of being employed," says Jennifer. According to the Convention on the Rights of the Child – the most widely accepted human rights treaty in the world – education must help every

child develop their personality, talents, and mental and physical abilities. It also states that education must be provided without discrimination of any kind. In other words, all young people should be able to take part in school sports, no matter their gender or background. Children's equal access to sport is a human right; however, not all students have the same opportunities to get involved.

What role do schools play in access to sport?

"Schools play a vital role in providing access to sport," says Jennifer. "For some children, school is the only place where they have the chance to play, and school sports tend to cost less than other sports opportunities."

According to research by Canadian Women and Sport, schools play a key role in providing access to sports and shaping young people's attitudes about sports. Its 2024 Rally Report shows that 90% of children between the ages of 6 and 12 take part in sports informally, through physical education classes and breaktime activities. However, when it comes to organised school sports, such as football or athletics, girls are 10% less likely to participate than boys. This disparity continues as students get older: only 40% of girls aged 13 to 18 are involved in intramural sports, compared to 50% of boys.

What is the Girls+Sports Project?

Jennifer created the Girls+Sports Project to explore whether girls and boys have the same opportunities to play sports in schools run by the Toronto District School Board (TDSB) – one of the largest school boards in Canada. "We want to educate students, parents, carers and teachers about disparities between girls and boys sports and teach them about children's rights," says Jennifer. "We hope that this project will lead to more opportunities for girls to play sports in the TDSB and promote gender equality in our communities."

To do this, Jennifer and her team collected official data from the TDSB, looking at the number of sports teams available for girls, boys and all-gender groups between 2021 and 2023. The data were then carefully analysed by filtering them according to details such as school level (elementary, junior or senior), sport and gender. The results are presented in easy-to-read charts on the Girls+Sports Project website, helping users see where differences in access still exist.

How is technology helping to share the team's findings?

To turn her research into something everyone can access and understand, Jennifer has teamed up with two computer science students who believe in the Girls+Sports Project. The raw data from the TDSB came in Excel files, which couldn't be easily displayed online, so the computer scientists converted them into a website-friendly format.

The Girls+Sports Project website was a collaborative effort between law and computer science students. Together, they worked on everything from writing the text and designing the user experience (UX), to building charts and graphs that make the data easy to explore. "We are just beginning to disseminate our findings," says Jennifer. "I am giving talks at conferences and working to publish academic papers, but most importantly, the Girls+Sports Project website is live and everyone can see it."

What's next for the Girls+Sports Project?

The Girls+Sports Project is just getting started. Jennifer and her team plan to continue working with the TDSB to collect new data and keep the website up to date. In the next phase of the project, Jennifer will interview teachers and staff involved in school sports to better understand the reasons behind the gender gap in participation.

Looking ahead, Jennifer hopes to expand the project beyond Toronto. She plans to apply for further funding to collect data from across Ontario and, eventually, all of Canada. She also wants to hear directly from students themselves – learning more about their experiences could reveal important insights into why some girls are less likely to take part in school sports.

"I hope that the Girls+Sports Project will make the differences between girls' and boys' participation in school sports visible, give people the tools they need to advocate for change, and demonstrate the power of interdisciplinary research teams," says Jennifer. "When legal researchers and computer scientists come together, they can do creative work that makes society better for us all."

About *human rights law*

Human rights law is a broad field that focuses on protecting the basic rights and freedoms of all people. It is grounded in legal systems around the world and supported by national and international agreements, such as the Canadian Charter of Rights and Freedoms, the Universal Declaration of Human Rights and the Convention on the Rights of the Child. These laws are designed to ensure that everyone is protected from discrimination and has access to fundamental rights, such as education, healthcare, housing and employment.

In Canada, one of the key institutions enforcing these protections is the Canadian Human Rights Tribunal. "The Tribunal hears complaints about discrimination in organisations governed by federal law," explains Jennifer. "Its mission is to 'resolve discrimination complaints and disputes about employment equity, pay equity and accessibility in a fair, independent and efficient way.' It is like a court, but less formal." Jennifer is a part-time member of the Tribunal. "I hear cases about discrimination and make decisions at the end of those cases," she says. "I also work as a mediator to try to resolve complaints before they go to a hearing."

Working in human rights law can be incredibly rewarding. "There are so many areas of law that relate to human rights, such as education, employment, health, housing, criminal law and immigration," says Jennifer. "I am always learning about different places and cultures, as well as about the ways that people want to live with dignity." For many legal professionals, the opportunity to make a real difference in people's lives by challenging injustice and advocating for fairness makes the field meaningful.

At the same time, the work can be emotionally and mentally demanding. "Our work to realise human rights for all will never be over," says Jennifer. "We see so many human rights abuses in the world, and that can be discouraging." The scale and complexity of global injustices – like poverty, climate change and conflict – can sometimes make the work feel overwhelming.

To stay resilient, it is important to focus on your physical and mental health. "When I have had a stressful day, I try to spend some time outdoors and do some physical activity like walking," says Jennifer. "If I am feeling anxious or low, I bring out my whole mental health toolkit — I see my friends and family, play with my dogs, exercise, meditate, eat healthy food (and chocolate — it works!) and focus on getting good sleep. These activities really help me feel better."

Pathway from school to *human rights law*

In high school, study subjects like social studies, history, law, English, civics, political science and philosophy. These subjects help develop critical thinking, communication skills and an understanding of social justice issues.

"There are many higher education courses that relate to human rights, such as law, social studies, political science and international relations," says Jennifer. "Courses on discrimination and issues like racism, ableism and gender equity can be helpful."

Students at Toronto Metropolitan University's Lincoln Alexander School of Law work with Law in Action Within Schools (LAWS) to host a technology conference for grade 11 students. LAWS is an education engagement and support programme for high school students, introducing participants to legal thinking and the justice system: **lawinaction.ca**

Take part in a Model United Nations to learn more about human rights and how they are protected around the world, hone your communication skills, and learn about global issues: **un.org/en/mun**

Explore careers in *human rights law*

To learn more about human rights law, explore websites such as the United Nations High Commissioner for Human Rights (**ohchr.org**), the University of Minnesota Human Rights Library (**hrlibrary.umn.edu**) and your country's human rights commission, which you can find via the Global Alliance of National Human Rights Institutions (**ganhri.org/membership**).

The National Film Board of Canada has a collection of free films about human rights: **nfb.ca/channels/human_right_site**.

"Working as a lawyer is a common career in human rights," says Jennifer. "But you can also work in international development, human resources, social work, research, advocacy, journalism, education, social media and communications, and, as the Girls+Sports Project shows, data and computer science."

@Rawpixel.com/Shutterstock.com

Download Jennifer's resources from **futurumcareers.com/using-law-and-data-to-address-gender-inequality-in-school-sports**

Meet *Jennifer*

I have always been interested in justice. As a young person, it really bothered me when people were treated unfairly. I was also interested in different cultures. I was involved in a Model United Nations in high school and majored in Asian and Middle Eastern Studies in university. Outside of my studies, I loved music and sports. I played on many school sports teams and was a competitive softball player.

My career has had many stages and side projects. Do not be discouraged if you don't find your dream job at first. Careers are built over time. Try to learn something from every experience and keep your eye on your goals.

I have the opportunity to learn about all kinds of people and sometimes make a small difference in their lives. I love getting to hear what my students are thinking and watching them as they work through problems.

I want everyone to have the best opportunity possible to live, love, learn, work and play safely. It is up to all of us to notice when some people are being excluded. Taking a moment to invite someone into your group without judgment or welcome them to a team can make a big difference. You may not know them, but over time they could become a good friend.

My sheer determination has helped me be successful. I have had many setbacks in my career, but I just keep at it. Over time, my skills and accomplishments have added up.

I love to play and watch sports! Recently, I have become a big fan of the Toronto Sceptres in the Professional Women's Hockey League.

Jennifer's *top tip*

Volunteer for an organisation that supports human rights. It doesn't have to be in law. I have two personal rules for volunteering: (1) I go where I am needed and (2) I work in areas that I feel passionate about. While I have volunteered for human rights organisations, I have also volunteered washing dishes at a homeless shelter. I learned important lessons about human rights every time.

Rituals that build, break, include or exclude: the hidden dynamics of start-up life

Entrepreneurship involves navigating uncertainty, managing visibility and building trust. While these dynamics are widely acknowledged, the subtle interaction rituals that shape who receives support – and who gets left out – often go unnoticed. **Dr Rekha Krishnan** and **Dr Rajiv Krishnan Kozhikode**, from **Simon Fraser University** in Canada, study how interaction rituals influence cooperation, exclusion and inequality in start-up ecosystems, particularly during the formative early stages of a venture.

Dr Rekha Krishnan

Professor, International Business and Entrepreneurship, Finning Research Fellow

Dr Rajiv Krishnan Kozhikode

Associate Professor, International Business/ Management and Organization Studies

Beedie School of Business, Simon Fraser University, Canada

PROFILES

Field of research
Business

Research project
Investigating how interaction rituals shape cooperation, social order and inequality in entrepreneurial ecosystems

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

doi: 10.33424/FUTURUM613

Talk like a ...

business researcher

Accelerator — a business programme that supports start-ups, principally through mentorship and networking opportunities

Capital — the finances or financial assets that enable a business to run

Entrepreneur — a person who creates a business based on a new idea or product and who is willing to take professional risks to make their business a success

Ethnographic — related to the study of cultures

Gender bias — prejudice towards a particular gender

Interaction ritual — a focused, standardised form of social, interpersonal interaction

Pitch — a formal bid to gain a business contract, often in the form of a presentation or face-to-face meeting

Silicon Valley — an area in California, in the US, famous for its innovative technology businesses

Start-up — a newly-established business

Entrepreneurship is shaped not only by ideas and investment, but by everyday social interactions. Sister and brother research team Dr Rekha Krishnan and Dr Rajiv Krishnan Kozhikode, based at Simon Fraser University, study how interaction rituals – such as pitch sessions, peer feedback and informal bonding – shape trust, cooperation and exclusion in start-up ecosystems. Their work focuses on how social order emerges and evolves in these high-pressure environments, and how certain rituals can quietly include or exclude people. While Rekha and Rajiv's work is rooted in understanding how these rituals build or fragment entrepreneurial communities, it also sheds light on how gender norms and biases can be reinforced through routine interactions.

Start-up accelerators: where social order takes shape

Rekha and Rajiv collect their data from start-up accelerator intensive programmes where founders receive mentorship, pitch coaching and access to investor networks. But beyond these formal structures, accelerators function as dense social arenas, where everyday rituals, both structured and spontaneous, play a powerful role in shaping outcomes.

Download Rekha and Rajiv's resources from **futurumcareers.com/rituals-that-build-break-include-or-exclude-the-hidden-dynamics-of-start-up-life**

"Accelerators are saturated with emotionally charged interactions," says Rekha. "From coffee chats to peer feedback sessions, these rituals create subtle cues about who belongs, who gains legitimacy, and who is excluded." Some of these rituals foster bonding and solidarity, while others resemble high-stakes competitions. "Entrepreneurs aren't just building ventures," adds Rajiv. "They're also revealing who they are, who they want to become, and how they want to be seen."

In a year-long ethnographic study of a Silicon Valley accelerator, Rekha and Rajiv observed that support often emerged through rituals of giving without expectation of return – a surprising pattern in such competitive environments. "These were not random acts of generosity," Rekha explains. "They were sustained by early acts of giving that triggered a 'giving-gratitude' cycle." The findings, published in *Administrative Science Quarterly*, showed that rather than being fixed, expectations of reciprocity evolve through chains of social encounters – a key insight into how micro social order takes shape in entrepreneurial communities.

When rituals include — and when they exclude

Rekha and Rajiv's research highlights how interaction rituals can quietly sort and separate founders. Rituals like pitch sessions and social events may appear neutral, but they subtly shape who gains access to resources, emotional support and recognition. "Some rituals elevate certain founders, while leaving others feeling invisible," explains Rajiv. "This is why we treat these rituals not as background noise, but as active forces in the formation of social order."

Rekha and Rajiv group these rituals into two broad categories: 'bonding rituals', which foster trust and solidarity, and 'tournament rituals', which heighten competition and disintegrate networks. While their *Administrative Science Quarterly* study focused on ritual structure and emotional dynamics – not gender –, these same frameworks have helped them investigate how exclusion operates in various forms, including gender-based exclusion in other contexts.

Gendered dynamics: emerging insights

While not the starting point of their research, Rekha and Rajiv have increasingly explored how gender norms are reproduced or disrupted through interaction rituals. Their findings show that even in ecosystems designed for inclusivity, gendered expectations often resurface through informal social practices.

In an Indian accelerator Rekha and Rajiv are currently studying (in collaboration with Dr Muqbil Burhan), for example, male founders built rapport through shared participation in religious fasting rituals. Female founders, excluded from these bonding moments, experienced reduced access to peer networks and visibility. "In response, some women formed their own support circles," says Rekha. "But they expressed a clear desire to remain integrated, not siloed into women-only programmes but part of the same accelerator ecosystem as their male peers."

Similarly, in Indigenous product markets in India, the team's field experiments (in collaboration with their post-doctoral fellow, Dr Neethu Parvathy), revealed that ritual participation can reinforce deeply internalised gender norms, even among empowered women. "This study made it clear that interaction rituals, whether in Silicon Valley or in product markets in rural India, are key to understanding how inclusion and exclusion play out," says Rekha.

Looking ahead: from observation to impact

The team's mixed-methods approach, combining ethnographic fieldwork with field experiments, has allowed them to study rituals across diverse geographies: from high-tech hubs like Vancouver and Silicon Valley to conflict-affected accelerators in Jammu and Kashmir (with Dr Muqbil Burhan), refugee camps in Tanzania, and tribal villages in India. Across these settings, one insight holds: rituals do not simply reflect social order – they produce and disrupt it.

Looking ahead, Rekha and Rajiv hope their research can inform more inclusive accelerator design, helping programme leaders understand how subtle rituals shape outcomes. "We want to translate our findings into practice," says Rajiv. "If we can identify the kinds of rituals that foster trust and belonging, we can help create entrepreneurial environments where more people – not just the usual few – can thrive."

About *business research*

Business research is a broad field that can involve the study of any aspect of business. Rekha and Rajiv are especially interested in the social aspect of business: how societal norms and social interactions influence business success, and the reasons why these factors exist in the first place. By identifying and addressing inequities, their research is helping to make business a more equitable field.

While business is global, its nature is highly dependent on cultural and social context. "Our research examines how social order emerges and unravels in new entrepreneur communities, be they in high-tech business or rural marketplaces," explains Rekha. By examining entrepreneur experiences in dramatically different societal contexts, Rekha and Rajiv gain greater insights into the role of interaction rituals. "These rituals reveal that entrepreneurship is never just economic," explains Rajiv. "It's deeply social, context-dependent, and often a reflection of broader inequalities and aspirations."

The arrival of big data is opening new doors for business researchers, especially as the rise in digital business spaces massively increases the quantity of data that can be collected. "Virtual platforms like Discord, Slack, Zoom and WhatsApp are now key arenas for interaction rituals," says Rekha. "They're not just communication tools: they're social spaces thick with social norms, emotional cues and implicit power dynamics." Unpacking how these social factors affect business practices is a growing area of research, and Rekha and Rajiv believe it could tell us a lot about our interactions and how we can improve them.

Meet *Rekha*

When I was in high school, India was going through a transformative period of liberalisation. The Finance Minister, economist Manmohan Singh, introduced sweeping reforms, making India a promising investment destination. I was captivated by what Singh was doing for the country and was drawn to economics as an undergraduate major. Sometimes, it's a role model that sparks your path.

I then did a research-intensive master's programme at Cochin University of Science and Technology. The Applied Economics Department supported an annual exchange programme to the Netherlands for the top three students. I was fortunate to be selected. Until then, studying abroad wasn't even on my radar – I couldn't have afforded the application fees, let alone tuition or airfare, but this was a fully funded programme.

While at Tilburg University, in the Netherlands, I took courses in business, organisation theory and strategy. When a PhD position opened up, it felt like a natural next step – and one I embraced wholeheartedly. That unexpected semester in the Netherlands changed the course of my academic life.

My PhD dissertation won the Richard Farmer Best Dissertation Award and was a finalist for the Blackwell and Gunnar Hedlund awards, which was incredibly meaningful. My work examined the constraints placed by established social order, specifically the limits of inter-organisational trust. Through a series of studies on this topic, I contributed significantly to our understanding of the dark side of trust and trust violation. The recognition gave me confidence that pursuing the topics I'm passionate about can lead to something impactful.

I like to believe the best is yet to come, but looking back, one of my proudest achievements is the body of work I have developed on interaction rituals and social order among early-stage entrepreneurs. This study opened up a broader research programme for me – one that now spans the US, Canada, India and Africa.

Working with my brother has been indeed rewarding. There's no filter between us. We can share raw ideas or half-formed hunches without hesitation, knowing they'll be met with thoughtful feedback. In a profession where one can feel solitary, having a built-in ally and sounding board within your own family is a real gift.

The biggest challenge, though, is that our relationship is multiplex – we're not just collaborators, we're family, so personal challenges inevitably spill into our work. Our father passed away last year. The loss has affected both of us deeply, and because we were grieving together, it naturally impacted our ability to focus on research.

Moving forward, I'm excited to continue exploring the questions that have long driven me – how new social orders emerge and how they are reinforced through interaction rituals. I'm particularly drawn to understanding how women entrepreneurs navigate and sometimes resist the expectations placed upon them. Most of my work has had its greatest influence within academic circles, and I want to translate those insights for broader use.

An important goal for me is to mentor the next generation of scholars, particularly women and students from underrepresented or resource-constrained backgrounds. I had strong mentors and a supportive family, but not everyone does. I want to pay it forward by creating bridges for brilliant students who may not have access to elite institutions or networks, but who have the drive and talent to ask bold questions.

Rekha's *top tips*

1. With information now widely accessible, you don't need elite connections to discover global opportunities. What matters is preparing yourself and staying alert to what's out there.

2. Cultivate good mentors and embrace feedback.

Meet *Rajiv*

My academic journey began with a degree in botany, inspired by a deep passion for environmental conservation and a desire to combat deforestation where I grew up. But the curriculum I encountered felt disconnected from the urgent ecological issues I cared about, and I found myself disillusioned.

I pivoted to software and learned to code. While there was satisfaction in building tools to solve everyday problems, I couldn't see myself creating banking or accounting software for faceless multinationals. I craved work with purpose. That search took me to a Master of Business Administration (MBA) degree, initially for economic stability — but it turned out to be transformational.

During my MBA, I began to appreciate the interconnectedness of economic, political and social systems. I realised that no social problem exists in isolation from markets and institutions. After a few years working in banking — in roles spanning foreign exchange and wealth management — I found myself drawn back to the big questions that first inspired me, which led me to research.

My background in botany trained me to observe systems — to see how multiple elements interact in complex, sometimes unpredictable ways. That instinct has carried over into my work as a social scientist. Whether studying ecosystems or organisations, you need the patience to observe, the discipline to document, and the curiosity to ask why things behave the way they do. In both domains, the goal is not just to describe what's happening, but to understand underlying mechanisms.

My work now explores the ethical and political challenges faced by corporations, particularly in emerging markets. One of my papers — a study on the Indian banking industry — draws on my botany background and ecological metaphors to develop a theory of organisational dormancy — how organisations, like certain plants, enter periods of low activity as a survival strategy in hostile environments.

Science teaches humility. In both the natural and social worlds, certainty is rare, and outcomes often defy predictions. A good scientist learns to stay close to the data while remaining open to surprise — a mindset I carry into all my research.

Working and studying in different countries has taught me different things. India gave me a grounded understanding of social complexity and institutional diversity. The US trained me in theoretical depth and empirical precision. Canada offered a culture of openness and pluralism in both research and identity. The Netherlands exposed me to deeply reflective, interdisciplinary scholarship. And in Hong Kong, where I completed my PhD, I developed the two traits that continue to define my academic life: a relentless work ethic and a high aspiration for scholarly impact.

One of my proudest moments was being named a finalist for the Academy of Management Journal's Best Paper Award for my very first publication in that journal, which was also the first essay of my doctoral dissertation. That paper examined how organisations navigate the often-conflicting pressures they face from multiple political stakeholders. The recognition was incredibly meaningful, not just because it came early in my career, but because it affirmed the relevance of a topic I care deeply about. It also gave me the confidence to pursue a research agenda at the intersection of ethics, politics, and organisational life – one that doesn't shy away from complexity.

When I began my academic journey, Rekha was already a newly minted PhD and collaborating with her felt like working with a mid-career scholar. That dynamic created a productive tension. I was never shy about challenging her ideas, and she welcomed – even demanded – that kind of pushback. Our mutual respect makes our work stronger. That kind of partnership is rare, and I feel very fortunate to have it in my own family.

I see myself continuing as a curious scholar – someone driven to explore untapped issues and organisational dilemmas using novel and creative approaches. I also hope to bridge the gap between scholarship and practice – through advisory roles, public engagement, and practitioner-oriented writing.

Rajiv's *top tips*

1. There are no inherently 'good' or 'bad' choices — only different paths and different kinds of learning.

2. Stay grounded, but don't be afraid to change direction if something stops making sense to you. The world doesn't need 'perfect'.

Pathway from school to *business research*

Rekha and Rajiv recommend developing a strong foundation in social sciences, especially sociology, economics and psychology, which inform the social aspects that underpin business. Some high schools may also offer business studies.

Rekha and Rajiv also emphasise the importance of research skills and recommend pursuing courses in statistics, data science, and research design and methods.

At university, courses that can lead to a career in business research include sociology, business science, economics and psychology.

Explore careers in *business research*

Simon Fraser University's Charles Chang Institute for Entrepreneurship offers opportunities for students to access workshops, mentorships and 'incubator' programmes to foster entrepreneurial thinking: **sfu.ca/chang-institute/home**

Venture for Canada offers internships that pair students with start-ups to build their business knowledge and entrepreneurial skills: **ventureforcanada.ca/programs/internship-program**

Attention teachers! Scientix®: a platform packed with science-focused services

Scientix® is an invaluable meeting point where educators can access a wide range of relevant services for free. These include innovative community-building programmes, engaging global campaign initiatives, inspiring teaching materials and news items, and much more. We spoke with **Dr Agueda Gras-Velazquez**, Science Programme Manager and Head of the Science Education Department at **European Schoolnet®** (EUN), to discuss the achievements and latest developments of the Scientix® community.

What is Scientix®?

Over the past 14 years, Scientix® has evolved from a small online platform into a dynamic, thriving community for science education in Europe, with thousands of members, resources and evermore opportunities to connect with science education projects and STEM education educators, researchers, policy makers and industry representatives.

The **core values** remain the same as we continue to work on science education in many different ways: we bring new topics and pedagogies in the classroom, support teachers with courses and resources, and enable collaboration between key education stakeholders to transform STEM education for the 21st century.

For this reason, we work with the **Ministries of Education STEM Representatives Working Group** to define our priorities and shape education policy, with STEM Industry partners through the **STEM Alliance by Scientix®** to bring real-world and employment perspectives, and of course, with our Scientix® Ambassadors, teachers and academic experts to improve practice in the classroom.

How does Scientix® help teachers stay up to date?

Scientix® is an essential platform for teachers to explore the constantly evolving landscape of pedagogies and topics at the heart of European education. One such evolution is the European Commission's **STEM Education Strategic Plan**, presented as part of the **Union of Skills**, which highlights the value of **Integrated STEM education**, a pedagogy that has long been at the heart of Scientix®.

Integrated STEM teaching and learning, also known as STE(A)M, breaks down the barriers of subject-based education by focusing on transversal and problem-based classroom experiences. The 'A' stands for integrating science, technology, engineering and mathematics with all other topics in the curriculum, from arts to physical education, to help students connect with science and make learning more contextual and relevant.

Such pedagogies go beyond addressing the gaps in what we teach and seek to improve how we teach, and present challenges for educators who need training, support and tools. This is why it is important for Scientix® to continue collaborating with EU-funded projects, like the **STE(A)M Education European Roadmap**, which bring together all education stakeholders for the long-term inclusion of STE(A)M in European curricula. Scientix® is also focused on introducing STE(A)M education

at an early age, and we are thrilled to be expanding our activities in Early Childhood Education and Care (ECEC) and to propose STE(A)M-based resources for teachers, in addition to inspiring STEM role models for younger students in projects like **OUTSTE(A)M**.

Another major development in European science education is the increasing space allocated to developing environmental knowledge, empathy and competences in formal education. As the European Comission's GreenComp framework becomes more central to achieve the ambitions of the EU Green Deal, Scientix® collaborates on initiatives like **BUSTIC EDU**, which will help educators navigate and develop green competences, and will centralise GreenComp resources in the upcoming Scientix® Collections, developed in partnership with **CISCO**.

I couldn't talk about Scientix® without mentioning our annual Scientix® **STEM Discovery Campaign**, which has become a flagship event for science education in Europe.

The Scientix® STEM Discovery Campaign is a global effort inviting educators and organisations to celebrate STEM careers and studies. Taking place from February to April, participants share activities on its **interactive world map**.

The **2025 edition** wrapped up in April, and it was a great success, with over 6,500 STEM activities shared by educators, engaging more than 800,000 participants across the world, including over 600,000 students.

Every year, we also organise the **Scientix® Awards**, which celebrate the outstanding achievements of science teachers in various fields and subjects. For the 2025 edition, we awarded **more than 50 educators from around the world**, many of whom were invited to join a workshop in the **Future Classroom Lab** in Brussels, discovering resources, projects, and new technologies to enhance their practice. Of course, they also sampled Belgian waffles, fries and chocolates!

> ***"Scientix® is an essential platform for teachers to explore the constantly evolving landscape of pedagogies and topics at the heart of European education"***

> ***Another major development in European science education is the increasing space allocated to developing environmental knowledge, empathy and competences in formal education.***


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This year, the Scientix® portal unveiled a brand new design. What has changed?

The redesign of the portal makes it easier to use, giving all users a better experience. But this is more than just a new look: it also includes brand new content.

One of the new features is the **Scientix® Community Tool**, a mobile app designed to help educators and Scientix® Ambassadors work together and share knowledge. The tool is available in 37 languages and allows users all over the world to connect with each other using an interactive map, provide their views through regular polls and access opportunities.

There are also the **Scientix® Interest Groups**, comprising online and in-person communities where members exchange ideas and best practices to improve STEM education in Europe. These groups, recognised by Scientix® for their quality and integrity, show what committed individuals can achieve when they cooperate.

What resources can teachers find in the Scientix® portal?

Our improved Resources page is another highlight of the redesign of the Scientix® portal. The new layout organises the page into three categories: Knowledge, Networking and Professional Development.

The **Knowledge section** provides useful materials on STEM topics, job profiles, research reports and background on Scientix® initiatives. Futurum resources are also featured here, in the **Teaching materials** category.

The **Networking Resources section** provides support for content oriented towards community building. Here, users will have access to the **Scientix® Blog** and to the **Scientix® Interest Groups** that I mentioned earlier, for professional exchange and collaboration.

Finally, the **Professional Development section** brings together all of the learning opportunities offered by Scientix®, including **MOOCs** (created in collaboration with the **European Schoolnet Academy**), **webinars and workshops**. It also allows school leaders to explore the STEM School development framework and find out more about the **STEM School Label** support for school STEM strategies.

This new structure makes it easier than ever to explore and grow within the Scientix® resources ecosystem.

What inspires your passion for the Scientix® mission to integrate science education and connect STEM subjects with the world around us?

I always say the same thing, and it's because I firmly believe it: science shapes every aspect of our daily lives, from the food we eat to the technology we use. It opens up a world of infinite possibilities for everyone.

At Scientix®, we promote science education to inspire future scientists and ensure that all students recognise the important role that science plays in society, regardless of their chosen career path. Through fostering curiosity, supporting relevant policies and encouraging public

engagement, our goal is to create a world where science continues to enrich lives and address the challenges of tomorrow.

And working with European teachers is a daily source of inspiration. Their commitment and passion never cease to amaze me, and it is rewarding to see the Scientix® community growing and helping them learn and connect with each other. So check our **news section** and subscribe to our **newsletters** to ensure you don't miss out!

About *Dr Agueda Gras-Velazquez*

"As Head of the Science Education Department at European Schoolnet® (EUN), I oversee the coordination of all STEM projects in which EUN is involved. Additionally, I oversee the day-to-day management of Scientix® (the leading science education community in Europe) and coordinate EUN's Ministries of Education STEM Representatives Working Group."

Connect with Scientix®

SCIENTIX®
The community for science education in Europe

Scientix® is the leading science education community, bringing together everyone involved to create a world in which STEM is seamlessly integrated into everyday life. As a platform for connection and guidance, Scientix® enables all key stakeholders to participate in shaping a future where science education plays a central role in our society. Scientix® is coordinated by European Schoolnet®, the network of 30 plus ministries of education.

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Inspiring the next generation

SCIENTIX®
The community for science education in Europe

Where Science Education Comes Together

Scientix® is the leading European community for science education, connecting teachers, researchers, policymakers, and industry to transform STEM learning for the 21st century.

- Access free, high-quality STEM teaching resources.
- Explore training, webinars, and online courses designed for teachers.
- Connect with peers across Europe through dedicated interest groups.
- Stay up to date with the latest science education trends.
- Discover projects, news, events, communities, and tools on the Scientix® portal.

www.scientix.eu

Scientix® is an initiative of European Schoolnet®