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ISSUE 38
June 2026

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WELCOME

ISSUE 38

Sharing a passion for STEM around the world

"Our aim is to bring science and scientists directly into classrooms to empower, inspire and motivate children and teenagers," says Dr Athanaisa (Nasia) Nikolaou, co-founder of Lecturers Without Borders (LeWiBo). Fellow co-founder, Dr Liubov Tupikina, continues, "Ultimately, I see LeWiBo as a platform for researchers to share what they are passionate about with the world." Nasia and Liubov tell us how they are connecting scientists travelling for work with local schools at their destinations, creating a bridge between the global research community and school classrooms (p 4).

"We believe in providing students with first-hand experiences of what science is and who scientists are," says Nasia. Here at Futurum, we share this belief. Which is why you'll find this issue packed with articles about real-world research projects being carried out by real people. And like us, these researchers are passionate about sharing research with students and teachers. So read on to feel empowered, inspired and motivated...

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Published by Sci-comm Consulting

Digital ISSN 2632-8399
A limited company registered in England.
Company No: 10791252

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CONTENTS

Research articles

44

Research articles

INTERVIEW

COVER STORY

Lecturers Without Borders

04

Sharing a passion for STEM around the world

Lecturers Without Borders (LeWiBo) is a non-profit organisation that bridges the gap between the global research community and school classrooms. The initiative encourages scientists who are already travelling for work to visit local schools, providing students with first-hand exposure to various STEM fields through interactive experiments. Founders **Dr Liubov Tupikina** and **Dr Athanasia Nikolaou** tell us more...

Why did you set up Lecturers Without Borders?

Liubov: The motivation came from a personal realisation following the defence of my PhD thesis. After all the hard work, I realised that no one was going to approach me to ask about my research; if I wanted to share my work with a wider audience, I had to be proactive. Establishing Lecturers Without Borders (LeWiBo) was my way of opening up this possibility, not just for myself, but for other researchers and professionals who found themselves in the same situation. Ultimately, I see LeWiBo as a platform for sharing what you are passionate about with the world.

What are LeWiBo's goals?

Athanasia (Nasia): Our overarching aim is to bring science and scientists directly into classrooms, both online and offline, to empower, inspire and motivate children and teenagers. We strive to provide a safe, inclusive environment for genuine dialogue between professional scientists, educators and students. On a broader level, we want to encourage a permanent relationship between the scientific community and the public. We believe in providing students with first-hand experiences of what science is and who scientists are, while giving a voice to minorities in STEM and ensuring science engagement opportunities for everyone.

How does LeWiBo engage with schools around the world?

N: Our main strategy revolves around the fact that researchers often travel for work. We leverage this by connecting scientists with schools in the regions they are visiting. We also facilitate connections through international conferences and partnerships with various organisations. Our vision for LeWiBo is to move beyond simple, one-off personal connections and toward long-term sustainable programmes. We want researchers to engage with schools to create lasting educational impact.

L: We are aware that teachers are under huge stress and often lack the time to organise extracurricular activities. Because of this, we try to make it as easy as possible for them to engage with us. They can subscribe through a form on lewibo.org, and we will then reach out to them when any scientists are travelling nearby.

Our goal is to facilitate participation that is low-effort for the educator but high-impact for the students. By building sustainable activities, we can attract more researchers to the network without adding to the administrative burden on schools.


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What does the LeWiBo network look like?

N: We have a main group of approximately 500 registered scientists. Because LeWiBo is a non-profit, all our lectures are provided free of charge, and we operate in a sustainable, self-operating manner. The number of scientists actively participating at any given moment fluctuates depending on the season, when people are travelling, or when major conferences are being held.

What is a typical LeWiBo experience for a student?

L: Although we do run webinars, offline and on-site events are an important part of what we do. For example, we have had researchers from France who travel to schools in Nepal to give lectures in person. Typically, a researcher arrives in the classroom and provides an overview of their work. But we also encourage them to focus on their 'passion subjects' – the topics they are most interested in explaining.

N: The main aim is to engage students. We don't just lecture on a requested curriculum topic; we bring something that sparks immediate curiosity, such as using metaphors to refer to exoplanets with exotic climates for elusive magma oceans (e.g., 'dragons in the sky') or setting up an ant colony experiment.

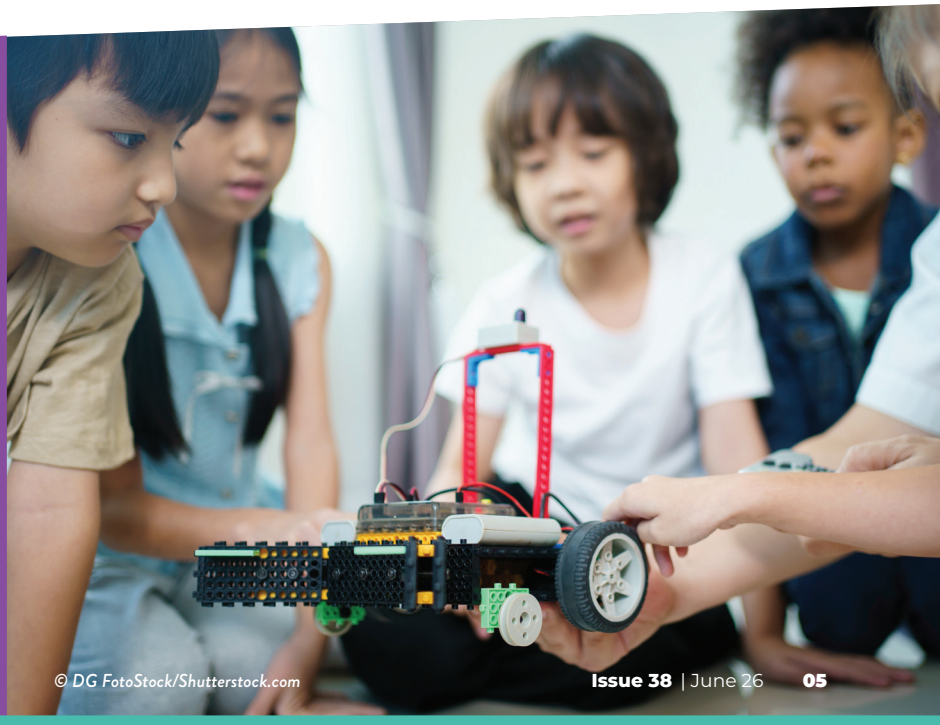
What student age groups do you work with?

N: We work with a very wide range of ages. Generally, we start with students around the age of 10, although we have organised events for children as young as seven. Our reach extends all the way up to the master's level in colleges and universities, meaning we work with students up to 30 years old.

What have been the challenges of making LeWiBo a success?

L: One of the most significant challenges is grabbing and maintaining students' attention, particularly with the older generation. Younger students are often easier to engage. When a scientist arrives from another country, their presence is already different and exciting.

> ***We strive to provide a safe, inclusive environment for genuine dialogue between professional scientists, educators and students.***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To ensure the lectures are successful – including for older students – we provide specific training for scientists and collaborate closely with teachers. This collaboration helps the scientist understand the specific audience and the cultural context of the school.

What impact has LeWiBo had?

N: We have an extensive network of schools. Before the COVID-19 pandemic, we were working with about 100 schools, but that jumped to almost 300 schools within a single year as we moved to webinars. While these numbers are impressive, we try to ensure that the quantity of schools is not our only metric. What truly matters to us is the number of participating researchers and engaged students. We attempt to collect feedback from schools to monitor this impact, though collecting data remains a difficult task.

L: We work all over the world, but we often find that schools in under-resourced areas or certain countries are easier to connect with because they are so open to welcoming scientists. However, we have had very interesting and successful experiences in many places, including Nepal, India, Germany and the UK. Schools have been very welcoming.

What has been a highlight for you during these school visits?

L: For me, and I think for many of our lecturers, a major highlight is the realisation that explaining your work to students changes your own relationship with the subject; it provides a fresh perspective on it. When you have to break down complex concepts for a young audience, you often start to understand aspects of your own work that you hadn't fully grasped before. It's a very important aspect of personal development that I try to pursue.

One specific moment that made me very happy was when I explained a mathematical problem – the kind usually reserved for PhD students – to a 5th grade class, and they provided original and insightful responses! This kind of outreach provides a sense of enjoyment and satisfaction that allows you to see your own subject in a completely new light.

How can teachers or scientists get involved?

N: We have made the process very simple for teachers because we want to be as accessible as possible. Apart from telling us your available time and the current curriculum topics you are working on, we don't require much else. We take the information about the students' ages and the topics and do the work of matching teachers with a scientist.

L: For scientists, the process is also straightforward – you simply need to register on our website. The 'tricky' part is that you must remember to tell us when you are travelling! So, we need to know you want to be part of the network and your travel schedule. We then provide hints on schools you can visit or teachers you can meet at your destination. Because we do not fund travel, we rely on researchers who are already going somewhere for work and want to make the most of their time there.

What's next for LeWiBo in the coming years?

N: Our next steps are focused more on depth than breadth. While we are always open to growing the number of scientists and schools, we want to connect more deeply with the people already in our network. We are planning 'meet and greet' sessions for our scientists and encouraging schools that have already participated to provide feedback and collaborate on creating sustained, long-term programmes.

L: LeWiBo is a collective effort, with many colleagues working to create new and valuable experiences for educational institutions, as well as for scientists. We'll keep building and sharing this experience together, as open and free education is precious in this fast-changing world.

LECTURERS WITHOUT BORDERS

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Meet *Liubov*

Dr Liubov Tupikina is a mathematician, working on stochastic processes and applications with research groups in France, Germany and Russia.

My interest in STEM was sparked by my school mathematics teachers, Alexander Ivanishcuk and Helen Bunina. If not for them, I would not be where I am now. They made me start to like physics first, and that led me to an interest in mathematics.

While many scientists might point to their PhD as their greatest achievement, I particularly enjoy working in interdisciplinary research problems, translating one language to another, as well as supervising and co-supervising students. Growing a network of young researchers around you is invaluable, and those connections and collaborations matter to me more than personal accolades. I am happy about the achievements of my students and collaborators with whom we are participating in research. And, of course, we are proud of Lecturers Without Borders!

Liubov's *top tip*

Love what you do, but don't stop there. You must also strive to deeply understand why you like it. Never stop questioning that motivation. If you maintain that constant inquiry, you can stay open to new ideas and ensure you never lose your path.

Meet *Nasia*

Dr Athanasia Nikolaou is a physicist and has been a member of the international science consortium of the ARIEL Space mission. She works as a contractor for the European Space Agency (ESA) in Italy.

My 'love at first sight' moment in science was receiving a kids' chemistry set when I was 10. I was very happy meticulously weighing substances and making colours change in solutions. At first, I was driven by beauty and was avoiding drilling into maths equations, but when I read an article about a Greek mathematician who was discovering equations that described irregular crystals, my imagination was captured! An equation that showed a pattern that isn't repetitive? I realised maths can be cool!

My father has always encouraged me to follow science, even when I was reluctant about my own skills in maths as a teenager. Luckily, he could see beyond the terror imposed by secondary education mathematics teachers at the time!

My career has been shaped by many experiences. At university, I had a professor of astrophysics whose door was always open for questions. A poster of a space mission that I got from him is still up in my room. Being accepted for a young graduate trainee position at the European Space Agency at the end of my master's degree and earning a place in the Advanced Concepts Team of the agency were pivotal. Since then, I discard no idea as too crazy or unfeasible, which has shaped my approach to science and teamwork.

I am proud of publishing my first paper in the journal *Climate Dynamics*. I highly respect the science published there. I am also proud that I was invited to NASA Goddard in the US to give a talk with other planetary scientists as an expert on magma oceans. The principle investigator of ESA's ARIEL mission, Professor Giovanna Tinetti, has trusted me and other scientists to write a chapter about rocky exoplanets and, thus, contribute to the red book of the mission. I feel honoured to have added a pebble in this giant effort of discovering worlds beyond ours.

Nasia's *top tip*

Ask about something but don't be reassured unless you have reproduced the proof yourself. As with almost in everything else in life, the devil is in the details that are silenced.

Where could atmospheric physics take you?

The Arctic is warming four times faster than the rest of the world, while in Texas, extreme weather events such as hailstorms are becoming more frequent and severe. **Dr Naruki Hiranuma** investigates what role atmospheric particles and clouds are playing in these changes. As an atmospheric physicist at the **University of Texas at El Paso** in the US, he hopes to improve our understanding of atmospheric ice and cloud formation and refine the physics theories that explain how clouds and precipitation form.

Dr Naruki Hiranuma

Department of Physics,
University of Texas at El Paso, USA

Field of research
Atmospheric physics

Research project
Investigating the properties of ice-nucleating particles in Texas and the Arctic

Funders
US National Science Foundation (NSF); US Department of Energy (DOE); The Utah Department of Natural Resources

doi: 10.33424/FUTURUM702

PROFILE

Talk like an ...

atmospheric physicist

Aerosol – a nanoscopic to microscopic solid particle or liquid droplet suspended in the air (e.g., dust, pollen, sea spray, vehicle emissions, bacteria)

Albedo – a measure of how much light a surface reflects

Arctic amplification – the phenomenon of the Arctic region warming faster than the rest of the world

Ice-nucleating particle (INP) – an aerosol that provides a nucleating surface for water molecules to freeze on

Metagenomic analysis – an analysis of DNA extracted from a sample to identify organisms in the sample

Nucleation – the process of molecules clustering around a 'nucleus' particle

The air is full of particles, known as aerosols, which play a crucial role in cloud formation. They provide a surface for water vapour to be deposited or condense on, forming cloud droplets. "Ice-nucleating particles (INPs) are a subset of aerosols that can cause cloud droplets to freeze," explains Dr Naruki Hiranuma, an atmospheric physicist at the University of Texas at El Paso.

Ice, clouds, precipitation and climate

"INPs play a major role in forming and dissipating clouds, and atmospheric ice formation is a crucial first step needed for precipitation to form," Naruki continues. This means INPs have a significant impact on weather and climate, affecting things like rainfall patterns and cloud albedo (how much sunlight a cloud reflects). "Even though INPs are small and rare, they have a big impact on how clouds form and how the climate behaves," says Jennifer Ofili, a student in Naruki's research team. Naruki and his team are studying INPs in various locations and environments, such as Texas and the Arctic, to find out how they are affecting cloud formation globally and how this is being impacted by agricultural activities and climate change.

Why Texas?

Texas often suffers from severe hailstorms. It is also a major contributor to US cattle production, accounting for 42% of the country's beef. Naruki and his team are examining the link between cattle ranches, INPs and extreme weather events. "I analysed samples of dust collected from cattle feeding stations to test whether the dust is a potential source of INPs," says student Yidi Hou. "We want to understand what physical, chemical and biological characteristics of the dust contribute to atmospheric ice formation, as this is key for cloud formation."


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Why the Arctic?

"The Arctic is warming four times faster than the rest of the world," says Naruki. "Arctic amplification is altering sea ice coverage, climate and ecosystems." Climate change is altering Arctic cloud formation, which in turn impacts the Arctic climate. In the world's northernmost settlement in Svalbard and the northernmost city in the US, Utqiaġvik, Naruki's team and their collaborators collect aerosols to see how they are impacting and being impacted by climate change. "To collect aerosols, ambient air is drawn into a sampling pump and aerosols are deposited on a membrane filter," explains Ava Sealy, a student who participated in field studies. "These filters are shipped back to Texas for laboratory analysis."

Analysing aerosols

"In the lab, we subject aerosol particle samples to different conditions to observe changes in their physical and chemical properties, such as shape, freezing temperature and colour," says student Nadia Reyna. The team's freezing experiments include cooling tiny water droplets containing INPs to record what temperature they freeze at and using the portable ice nucleation experiment (PINE) chamber (a cloud simulation chamber that mimics atmospheric cooling) to trigger cloud droplet and ice crystal formation under controlled, simulated atmospheric conditions. The team also analyses the size and chemical composition of aerosols and uses metagenomic analysis to identify organisms in biological aerosols.

> ***"We aim to improve existing physics theories about nucleation."***

How are Arctic INPs linked to climate change?

The team has found that, in the Arctic, INPs originate from two sources: the land (e.g., soil dust) and the ocean (e.g., sea spray). "The rapid warming of the Arctic is causing significant glacier retreat, exposing long-buried soils and increasing aerosol emissions," says Naruki. "These newly de-glaciated surfaces serve as emerging sources of INPs."

"We also found that INP concentrations in the Arctic are significantly lower than global averages," Naruki continues. "This means that even small increases in aerosol emissions (due to retreating sea ice leading to increased sea spray or retreating glaciers leading to increased terrestrial exposure) could have disproportionate effects on Arctic amplification."

Importantly, this means that as the Arctic continues to warm, and snow and ice cover retreats, there will be more sources contributing to INPs and, therefore, an increase of INPs in the region. "We identified that the most active Arctic INPs trigger precipitation which reduces surface albedo," explains Naruki. "This creates a positive feedback loop that further accelerates Arctic warming."

How are cattle ranches linked to Texan storms?

"Our analyses revealed that in the Texas Panhandle, the highest levels of INPs are associated with the highest-intensity storms," says Naruki. The team's results also suggest a link between livestock operations and atmospheric composition in the area. "Using a cloud simulation chamber, we determined that livestock dust produces more INPs than typical soil dust," says Naruki. However, while the team identified some biological aerosols as being bacteria from cows, none of the identified bacteria species are known to act as INPs. This suggests that the dust's physical properties and/or organic contents are more important than its biological properties. "Our study concludes that cattle feeding stations serve as a substantial source for atmospheric INPs, potentially influencing regional cloud formation and climate," says Naruki.

How is Naruki's research advancing cloud physics?

Overall, the team's results show that the impact of INPs is substantial in both regions: whether that is linked to a faster rate of Arctic amplification or an increased likelihood of severe weather events in Texas. The team's research aims to understand how the tiny surface features of aerosol particles, including their shape and chemical makeup, affect ice formation in cold clouds high in the atmosphere. "By providing a missing molecular-scale perspective, we aim to improve existing physics theories about nucleation and better explain how clouds and precipitation form," concludes Naruki.

The mountain-top field study in the northern Wasatch Range (Utah) in March 2026. © Naruki Hiranuma

About *atmospheric physics*

"Atmospheric scientists study atmospheric phenomena, interpret meteorological data, and report on and forecast the weather and climate," says Naruki. "If you are interested in science, want to apply your knowledge in real-world situations, and love the weather, then studying atmospheric physics would be an ideal career development opportunity!"

Naruki is keen to highlight the huge range of opportunities available to those with a background in atmospheric physics. For example, atmospheric physicists not only forecast the weather, they can also modify it! Cloud seeding is the process of artificially adding aerosols to the atmosphere to promote cloud formation and precipitation. It can be used to cause rainfall during droughts or suppress storms by ensuring precipitation falls before storm clouds become too large. Naruki has previously collaborated with a cloud-seeding company to study snowfall in skiing regions in Utah, and previous students have gone on to work in the weather modification industry: "My time researching physical atmospheric systems has directly informed my daily work improving a potential weather modification approach," says one of Naruki's previous students. "It enables me to translate theoretical concepts into practical experimental design for investigating water droplet interactions in clouds and fog under real-world conditions."

Studying atmospheric science will prepare you for careers in many industries, including weather broadcasting. Ava now works in a commercial agricultural lab, applying the skills she learnt as a student: "Research is the foundation for developing and validating lab methodologies, then scaling them to industrial levels," she says.

Naruki collaborated with engineers to design the PINE chamber that he uses for his cloud simulation experiments. By combining his physics expertise with the practical knowledge and skills of industry engineers, Naruki and the team created an innovative instrument that is now used by atmospheric research teams around the world.

Download the team's resources from **futurumcareers.com/where-could-atmospheric-physics-take-you**

Pathway from school to *atmospheric physics*

"Atmospheric physics is built on knowledge from diverse fundamental science disciplines, such as physics, mathematics, chemistry and biology, as well as social science," says Naruki.

At university, a degree in physics, meteorology or atmospheric/environmental science would prepare you for a career in atmospheric physics.

"Atmospheric physics research is all about discovery," says Naruki. "So don't be put off if you find math intimidating."

"Gain hands-on experience whenever possible," recommends Yidi. This could include participating in simple experiments, science clubs or research-related activities. "Early exposure to scientific thinking and problem-solving will prepare you for future studies in this field."

Explore careers in *atmospheric physics*

"Studying physics is a pathway to many different careers," highlights Naruki. "A unique value of studying physics is the critical thinking skills you will develop – skills that are becoming ever more essential in the job market. So studying physics is vital for workforce development."

Atmospheric physicists are in demand in the aviation, renewable energy and water industries, in organisations dealing with weather and climate forecasting, and in engineering firms. This includes roles with private companies as well as with state and federal agencies.

The Bureau of Labor Statistics provides a wealth of information about careers in atmospheric science, including the qualifications you will need and the pay you can expect: **www.bls.gov/ooh/life-physical-and-social-science/atmospheric-scientists-including-meteorologists.htm**

Naruki has collaborated with Rainmaker, a cloud seeding company aiming to reduce water scarcity by enhancing rainfall and snowfall: **rainmaker.com**

Meet *Ava*

My elementary teacher inspired me to study environmental science. She was a phenomenal mentor who encouraged me to conduct research projects on biodegradable plastic, methane as a fuel source and the carbon cycle.

In high school, I joined Future Farmers of America where I realised how misunderstood Earth sciences were within agricultural communities. This motivated me to become an advocate for environmental science, particularly to rural communities where agricultural and environmental systems are closely connected.

My trip to Svalbard exposed me to different cultures, research approaches and perspectives. The challenges (like the fact that my luggage got lost on the journey, so I only had jeans and hoodie to wear during a snowstorm!) improved my self-confidence and taught me resilience, adaptability and independence.

Meet *Jennifer*

Growing up in Nigeria, I saw environmental problems up close. Water shortages and pollution were part of everyday life. I was inspired to pursue environmental science when I realised it isn't just about studying nature; it's about solving real problems that affect people's health, safety and daily lives.

Conducting research about INPs taught me so much beyond what I could have learnt in a classroom. I gained hands-on experience and learnt to communicate complex ideas in clear ways. One of my favourite parts was seeing atmospheric science, biology and data come together.

In the future, I want to find solutions for water security. I'm interested in how we can use science responsibly to improve rainfall patterns and reduce the risk of drought.

Meet *Yidi*

My grandmother is a senior engineer working in the environmental field. She inspired me to study environmental science because her stories about her research projects and expeditions sparked my curiosity about how we understand and protect the environment.

Participating in an undergraduate research project greatly enriched my academic training and personal development. It gave me experience in experimental design, sample collection and data analysis, and strengthened my problem-solving skills, independence, resilience and ability to communicate scientific findings clearly.

One of the highlights was seeing how real environmental samples could be transformed into meaningful scientific data, which was particularly rewarding. The experience has solidified my interest in pursuing atmospheric and environmental research as a future career.

Meet *Nadia*

Environmental science presented a new and exciting challenge for me. I already had a strong foundation in chemistry before becoming involved in the INP project, and I was eager to explore the physics behind environmental processes.

This research project was my first opportunity to work in a wet laboratory, where I gained hands-on experience with chemicals and lab techniques. Learning how to handle materials properly and record accurate data is essential in any scientific setting, and this experience strengthened those skills.

In the future, I hope to apply to medical school and pursue a career as a physician. Atmospheric physics research has helped prepare me for this path by strengthening my research skills and ability to work collaboratively in a diverse team.

Staying on track: geohazard monitoring for Canada's railways

Over 30,000 miles of train tracks are used to ferry goods across Canada's vast landscapes. Predicting, detecting and averting hazards such as landslides and forest fires is critical for mitigating their impact on this crucial rail network – but this is not easy, as many train lines run through extremely remote and inhospitable regions. At the **University of Alberta**, **Dr Renato Macciotta** is part of a unique partnership using remote sensing technologies to address this challenge, providing the rail network with the tools needed to stay on track.

Dr Renato Macciotta

Professor, David and Joan Lynch School of Engineering Safety and Risk Management, Department of Civil and Environmental Engineering, University of Alberta, Canada

Field of research
Geotechnical engineering

Research project
Using remote sensing technologies to provide the transportation industry and government agencies with practicable and cost-effective tools for geohazard monitoring and management

Funders
Canadian National Railway; Canadian Pacific Kansas City Railway; Transport Canada; Klohn Crippen Berger; Alberta Transportation; Natural Sciences and Engineering Research Council of Canada (NSERC)

doi: 10.33424/FUTURUM691

PROFILE

Talk like a ...

geotechnical engineer

Civil engineering – the professional discipline focused on the design, construction and maintenance of the built environment, including public works such as roads, bridges, dams and buildings

Geohazard/ground hazard – earth processes that pose risks to life, property and infrastructure, such as landslides, earthquakes and volcanic activity

Geotechnical engineering – a branch of civil engineering concerned with the engineering behaviour of earth materials (soil and rock)

Machine learning – computer systems that can learn and adapt without following specific instructions, drawing inferences from patterns in data

Laser scanning system – technology that uses laser light to accurately capture the 3D shape and geometry of physical objects or environments

Satellite-based radar – an active remote sensing technology located in orbit that emits pulses of energy to scan Earth's surface and detects the reflected signals

Canada is the world's second-largest country, and much of it is sparsely inhabited wilderness. To transport goods from one side of the nation to the other, there is only one viable option: rail. "Rail is the main mode of transport for Canada's goods and a critical part of its economy and sustainable development," says Dr Renato Macciotta at the University of Alberta. "Although many people live in Toronto, Montreal and Ottawa, which do have busy rail systems, this is a small section of the country. People in small towns have learned to live with the railway system, however they do not always appreciate that it is the backbone of Canadian life.

Canada's vastness and scattered population raise significant challenges for its rail network. "Hazards such as landslides can happen at points far from populated areas, making it challenging to address them – or even detect them in the first place," says Renato. "Particularly with the growing impact of climate change, we are seeing more frequent and more serious hazards happening." To tackle this, a multi-stakeholder research programme has been established to investigate the characteristics of these hazards, using its findings to develop

Students scanning Turtle Mountain in southern Alberta, Canada © Renato Macciotta

safety and prevention measures to avoid damage and danger to the railways and other transportation corridors like highways.

The Railway Ground Hazards Research Program

To keep railways safe, it is necessary to have systems in place to detect geohazards and, ideally, pre-empt them before they happen. "I'm involved with the Railway Ground Hazards Research Program, which is a collaboration between Canada's largest rail companies, the transport arm of federal government (Transport Canada), and a number of research and academic institutions," says Renato. "We are identifying techniques and technologies that can be deployed in the Canadian environment." The partners meet virtually every month, and in-person every year, to assess progress and work out next steps.

Due to its northern latitude, Canada sees some harsh and highly variable weather conditions, not to mention challenges related to the remoteness of some regions. Given these factors, remote technologies are proving especially handy, in combination with on-the-ground measurements when feasible. "So far, we're using technologies such as satellite-based radar, laser scanning systems and high-resolution photography that can be combined to build three-dimensional models of any area of interest," explains Renato. "And we've developed a range of algorithms, methodologies and workflows that enable us to process the information we get from these models."

For instance, high precipitation and rapid snowmelt may increase landslide risk, which the team can model. "Climate change is also affecting these characteristics, by leading to an increase in the frequency and volume of rockfalls, for example," says Renato. "This ties into our risk management framework that gives decision-makers the information they need." If a landslide falls onto a train track, the worst-case scenario is that it causes an accident, but the best-case scenario also involves closing the line for clearance and repair, which is damaging for businesses and consumers.

From analysis to action

"Always at the front of our minds is the question: what do we do with the data we collect?" says Renato. "For example, when we model landslide characteristics, we need to model how and when it is likely to damage the railway." Renato and the team are implementing machine learning techniques, which are proving effective in processing huge amounts of data and helping stakeholders make well-informed decisions. "For instance, our work helps decision makers decide how much to invest in stabilising a slope or protecting a section of the transportation corridor from rockfalls," says Renato.

These coordinated efforts have been in place for over two decades, but technological advancements have massively increased their usefulness in recent years. "When these technologies were in their infancy about twenty years ago, they were not developed enough for railways to rely on them," says Renato. "But today, it is a very different story." For instance, the team monitored a slope in northern British Columbia at high risk of landslides using laser scanning and other techniques that detect changes in a landscape to understand and predict its behaviour. "That enabled our partners to design stabilisation measures, which were then deployed in the field," explains Renato. "We also did some monitoring after the work and confirmed the success of the design." In another instance, laser-based technologies detected a slope at risk of landslides, leading to bespoke protection structures being put in place. "When the landslide occurred, there was very little damage to the protection structure and the track was unharmed," says Renato.

Future climate

Though the technologies Renato uses are improving exponentially, accelerating climate change is making mitigation and prevention efforts more challenging. "For instance, fifteen years ago I barely thought about forest fires at all when considering our field work schedule," says Renato. "Now, they are affecting safety not just for railways, but also for our teams that go out into the field to take measurements." While air quality was previously never a concern, wildfire smoke can impact the safety and health of people in the field, impeding their work significantly.

Due to the loss of vegetation making slopes more unstable, there are also links between forest fires and landslide risks. "One of the slopes that we are monitoring experienced a forest fire five years ago," explains Renato. "Since then, we have noticed substantial increases in the frequency of rockfalls there." Meeting these new challenges will involve increasingly detailed data, closer analysis and more coordination than ever before.

About *geotechnical engineering*

Geotechnical engineering is the branch of civil engineering that researches and models how earth materials, namely soil and rock, behave. Given that most infrastructure is built on soil and rock, understanding how they behave is critical to ensuring that structures are safe and stable. This expertise is also essential to industries such as mining. "Geotechnical engineering offers a fantastic balance between field and office life," says Renato. "If you like being out in nature and assessing real things, but also enjoy flexing your analytical, technical and imaginative skills in the office, then it could be for you." Research in this field always offers new and fulfilling rewards because every geotechnical project is unique – after all, the ground is different in every location.

Renato says that sustainable development is at the forefront of where research in the field is likely to go next. "We need to keep developing, but environmental health has to go alongside economic and safety concerns," he explains. "What's more, we need to know how climate change will impact our infrastructure, and plan accordingly." Artificial intelligence is proving critical in this regard given its ability to process huge quantities of data and find meaningful patterns. "But AI, even with proper expert guidance and review, can't do it all," says Renato. "We will continue to need engineers with a highly robust understanding of the ground, current and upcoming challenges, and how we can use new AI techniques most effectively."

Renato emphasises the importance of diversity in the field, both in terms of disciplines and sociocultural backgrounds. "If you only work with people like you, you don't have the opportunities to think outside the box and come up with novel solutions," he says. "Diversity impacts research positively. We need people of different backgrounds, genders and perspectives, all feeding into potential solutions."

Pathway from school to *geotechnical engineering*

Renato says that science and mathematics are highly useful in any field related to geotechnical engineering. "Even if your field isn't as technical as mine, these subjects will give you the skills to problem solve, which is critical across the board," he says.

At university, degrees or courses that lead most directly to a career in geotechnical engineering include civil engineering and geological engineering. Some may focus more on geology and Earth sciences, while others will focus more on structural or geotechnical engineering.

Download Renato's resources from **futurumcareers.com/geohazard-monitoring-for-canadas-railways**

Explore careers in *geotechnical engineering*

Renato says that the professors at the University of Alberta – and at other universities – are always happy to discuss their programmes and their specialisms. Find courses and staff details here: **ualberta.ca/en/engineering/civil-environmental-engineering/research/geotechnical-and-geoenvironmental.html**

The Canadian Geotechnical Society is a network of geotechnical engineers and professionals in related industries across the country that can help you build contacts and knowledge of the sector: **cgs.ca**

Meet *Renato*

At school, I liked both science and humanities. I got into civil engineering because I saw myself designing bridges: I loved the maths and procedures. I trained with a famous structural designer in Peru, but spent more time in front of a computer screen than I'd have liked. At university, a combination of studying, doing summer jobs and gaining a variety of other experiences helped me identify which stream of civil engineering I liked best, which is when I chose geotechnical engineering.

Then, I moved to construction to see the action! It was fun to deploy the skills I'd studied in the real world. In my early twenties, when I thought I had my next life chapter planned out, I got the opportunity to work for a Canadian-based consulting firm as a geotechnical engineer. Even though it wasn't on my radar beforehand, I jumped at the chance.

The department I teach in is known worldwide due to its legacy of pioneers in the field, particularly emeritus professor Dr Norbert R. Morgenstern - who is literally the living legend of this field - Dr Derek Martin and Dr David Cruden. If you had told me years ago that I would complete a PhD and then go on to teach here, I would never have believed you. Just the fact that I'm sitting here has exceeded all my expectations!

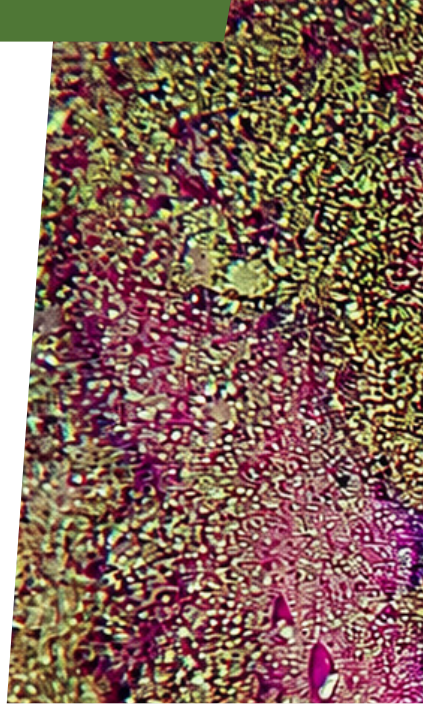
It's very fulfilling to interact with my graduate students. I love seeing how they grow in terms of their research and communication skills and go on to have meaningful careers in industry. We keep in contact – and now they're colleagues! Canada gave me an opportunity, and now I'm giving back by training highly qualified people. That makes me very proud.

Within the university, I want to sustain and develop this programme, so it keeps its excellent international reputation. As well as being passionate about my work, I'm family focused. I have a twenty-year-old daughter who's studying at the University of Alberta right now, and a two-year-old who keeps me busy at home!

Renato's *top tip*

Make a plan, but always be open to change and taking up exciting opportunities when they appear.

Stealing the slimelight: the fascinating world of slime moulds



Slime moulds are intriguing, fungus-like organisms that play a huge but hidden role in the environment. Historically, they have been understudied, but they are now starting to receive more attention. **Dr Chinyere Knight** from **Tuskegee University** in the US is a leader in slime mould research, studying and cataloguing specimens of slime moulds and fungi to document their diversity and characteristics. Through her research, she hopes to inspire and educate the next generation of mycologists.

Dr Chinyere Knight

Associate Professor, Department of Biology, Tuskegee University, Alabama, USA

PROFILE

Fields of research
Mycology; microbiology; science education

Research project
Studying and cataloguing slime moulds while training the next generation of mycologists via the EAGER project

Funder
US National Science Foundation (NSF)

doi: 10.33424/FUTURUM690

Talk like a ... mycologist

Fruiting body – the spore-producing structure of a fungus or slime mould, often seen as a mushroom

Fungi – one of the five kingdoms of life (along with animals, plants, protists and monera), containing mushrooms, yeasts and moulds

Mycology – the scientific study of fungi and related organisms

Protist – any organism with a nucleus that does not belong in the animal, plant or fungus kingdom, including algae, kelp, amoeba and slime moulds

Slime moulds – also known as myxomycetes, these are fungus-like protists that live in damp, shady habitats such as decaying wood and soil

Slime moulds are bizarre organisms that defy categorisation. Most are tiny, but some can grow surprising large; they may be single-celled or multicellular, depending on the stage of their life cycle; and they live in diverse environments, from the Arctic tundra to the hottest deserts. "Slime moulds, also called myxomycetes, were once classified as fungi, but are actually protists," explains Dr Chinyere Knight from Tuskegee University. "They play a huge role in regulating soil health and decomposing organic matter."

Despite their ecological importance, slime moulds have long been overlooked by research funding agencies in favour of organisms with higher economic impact, like pathogenic fungi that damage plant crops. But now, Chinyere believes it is their turn in the 'slimelight'.

Although mycologists usually study fungi, they also extend their expertise to slime moulds as the two categories share many attributes – even if they are not closely related. Both fungi and slime moulds play important roles in decomposition, reproduce using spores and favour dark, damp environments.

Studying slime moulds

Chinyere believes that if researchers give them the attention they deserve, slime moulds may hold the key to unlocking big societal advancements. "Studying the metabolic pathways of slime moulds and fungi may contribute to the development of new products and processes in medicine, agriculture and environmental science," says Chinyere. The next pharmaceutical breakthrough, a new biotechnology for managing soil health, or even new ways of cleaning up pollution may well be found within the cells of a slime mould.

Slime moulds can also help to educate the next generation of scientists. "Slime moulds are exceptional model organisms, and we can use them to demonstrate basic biological processes," says Chinyere. "They are also non-toxic and one species, *Physarum polycephalum*, has had its whole genome sequenced, which makes it hugely useful for genomic studies." Chinyere is drawing on


© Brogin Van Skoik, Tuskegee University

this organism's comprehensive genetic database to introduce her students to principles of evolution, cell biology, development and ecology.

The EAGER project

Chinyere wants to ensure that momentum for slime mould research is carried over to the next generation, which is why she is enlisting undergraduate and graduate students for the EAGER project. "This project supports exploratory work into untested but potentially transformative research ideas related to slime moulds," says Chinyere. The EAGER project has three main aims: 1) to create a reference database of certain gene sequences within myxomycetes, 2) to digitally curate the L. Frederick collection of slime moulds and 3) to train students in field collection and data science.

Over 40 years ago, Dr Lafeyette Frederick collected slime mould specimens from around the world, many of which are now housed in the L. Frederick collection at Tuskegee University. The EAGER project will extend his legacy by growing the collection, verifying identifications and transferring much of its information into a digital system to make it as accessible and long-lasting as possible. "Dr Frederick was a world-renowned mycologist, plant pathologist and botanist," says Chinyere. "He provided a model of distinction, diligence and humility that is essential for those who want to thrive in the world of science."

Foraging in the field

The diversity of slime moulds remains underexplored, despite the efforts of pioneering scientists like Dr Frederick. Chinyere is helping remedy this by collecting specimens from field sites, primarily in Macon County, Alabama, and training students to do the same. "I go out into the field in the warmer seasons after a good rain," she says. "When we find mature fruiting bodies, we put them into a small specimen box to preserve them for further morphological study."

> ***"I hope that this project will provide training and funds to support young mycologists and ecologists to pursue their dreams."***

Morphological identification – identifying the species based on its physical characteristics – is something of a dying art, as more and more scientists rely on genetic techniques. "Morphological identification remains critical to maintain and expand natural history collections," says Chinyere. "We train students in this skill to keep it alive."

Sometimes, specimens can be identified on location using field guides, but sometimes they need closer analysis than the human eye can provide. "Fruiting bodies may be found on tree bark and in the leaf litter," says Chinyere. "Some slime moulds are easy to spot and name, but smaller species require a dissecting microscope to view and identify. When we find a rare species, we take them to the lab and grow them in a moist chamber where we can monitor germination of spores." Chinyere and her team also makes sure to take duplicate samples so that some spores can be used for molecular studies in the future.

The next generation

The fieldwork and subsequent analysis by Chinyere and her students will bolster our slime mould knowledge and help address any sampling biases that exist in current slime mould catalogues. The EAGER project will create a more complete evidence base for understanding what slime moulds are and what they mean for the world and human society. "We've already done one survey of slime moulds in Camp Atkins Forest," says Chinyere. "Soon, we'll also collect samples from Tuskegee National Forest, to compare diversity and other characteristics between the two sites."

Two of Chinyere's graduate students, Brogin Van Skoik and Carmen Woods, are drawing on the project's findings to create digital teaching and learning resources. "It's important to share findings with the wider community," says Chinyere. "We want to create interest and increase awareness about these fascinating organisms." A new eight-week learning and research programme called Summer Learning Interactive Mycology Experience (SLIME), will further these goals. "I hope that this project will provide training and funds to support young mycologists and ecologists to pursue their dreams," says Chinyere.

© Brogin Van Skoik, Tuskegee University

About *mycology*

Mycology is the study of fungi and fungus-like organisms, such as protists. As they have a more subtle role in our environment than animals or plants, fungi and protists often go unnoticed and slip under the radar. That means they are likely to hold important knowledge just waiting to be found - offering huge opportunities for future researchers. "There is plenty of room for discovery in the field of mycology!" enthuses Chinyere.

Because fungi and slime moulds are not such 'glamorous' species, money for mycology research can be hard to find. "Finding funding can be a challenge," says Chinyere. "We tackle this by applying for funding from diverse sources and networking with other mycologists to work together and share opportunities." As mycologists discover more about the importance of fungi and slime moulds to life on Earth, this has the potential to unlock more funding.

Chinyere is passionate about ensuring that mycology, and science in general, is accessible to all – a passion developed through personal experience. As a high school student, she attended the American Chemical Society's Project SEED summer research programme, which was integral to her career. "For me, it was a critical turning point, allowing me to nurture my dreams and developing my desire to lead the next generation of young scientists," says Chinyere.

A phylogenetic tree showing the evolution of life on Earth. You can find slime moulds and fungi in the eukaryota section.
© Shutterstock.com/VectorMine

Download the team's resources from **futurumcareers.com/the-fascinating-world-of-slime-moulds**

Pathway from school to *mycology*

At school, useful subjects to take as preparation for a career in mycology include biology, chemistry, environmental science and mathematics. Other useful subjects include computer science and statistics.

Chinyere recommends taking university courses or modules in subjects such as ecology, microbiology and plant sciences (botany). Other areas of study that can lead to a career in mycology include anthropology and evolutionary or molecular biology.

Explore careers in *mycology*

Chinyere recommends seeking out local mycology communities or organisations to learn more and make connections with people working in the field. For instance, the Mid-Atlantic States Mycology Conference brings together students, researchers and citizen scientists to share ideas and connect with peers: **sites.duke.edu/masmc**

Tuskegee University offers a range of summer programmes for high schoolers and university students, including SLIME. Find out more here: **tuskegee.edu/Summer-Programs.html**

Meet *Brogin*

PhD Student, Tuskegee University, USA

Growing up, I was always curious about the natural world. I was especially drawn to biology and environmental science because they help to explain the living systems around us. That curiosity evolved into a deeper interest in organisms that are often ignored or misunderstood, like fungi or slime moulds.

I'm taking my PhD in the Integrative Biosciences programme with Dr Chinyere Knight. She is an outstanding mentor: supportive, gracious and genuinely invested in her students' success. She creates an environment where you feel trusted and encouraged to grow, while being challenged to think deeply and independently.

I aim to become an independent researcher and educator. I want to continue studying microbial biodiversity, while mentoring students from diverse backgrounds. My long-term goal is to build programmes that combine research, education and outreach, especially for students who may not initially see themselves in science.

Tuskegee University has a deep history and a strong mission of excellence, resilience and service. Being a part of that legacy aligns with my ideals of making meaningful change.

Slime moulds challenge how we define living organisms and how we classify life on Earth. They have complex life cycles and are highly diverse, the details of which I'm helping to uncover. There is still so much we don't understand about life, and this area of study helps expand what we know.

I've had challenges around access, resources and self-doubt. Graduate school can be demanding and it's easy to feel overwhelmed. I've overcome these challenges by staying persistent, asking for help, and surrounding myself with great peers and mentors like Dr Knight. Struggling doesn't mean you don't belong – growth often happens in uncomfortable moments.

Brogin's *top tips*

1. Stay curious, don't be afraid to ask questions and find mentors who genuinely care about your growth.
2. Don't compare your own journey to others'. Everyone's path is different, and that makes science stronger.

Meet *Carmen*

Undergraduate student researcher, Tuskegee University, USA

My love of STEM – 'Seeking the Truth about Earth's Mysteries' – began at an early age. I had many teachers who were enthusiastic about STEM, and I joined the Engaging Youth through Engineering club when I was young. It's important to have passionate, effective teachers.

I was granted the opportunity to participate in the SLIME internship programme. It was amazing to study alongside my peers and gain field and lab experience. We studied myxomycetes through sample collection, microscopy, taxonomy and DNA extraction.

I want to be a source of encouragement and guidance for students. After studying biology at graduate school, I plan to attend law school, focusing on educational policy and STEM development in southern states. I also want to collaborate with other changemakers to support communities in line with my faith.

I love the culture of hard work and scientific legacy at Tuskegee. Being a student here has grown my knowledge on the sciences, health and wellness, and public policy. It has ignited a new passion in me to carry the torch.

I believe that science is the study of God's creation. I am passionate about unlocking its mysteries to advance our lives and livelihoods. I am profoundly grateful to contribute to this collaborative, lifelong pursuit of knowledge.

Initially, I struggled with learning how to study. Research is not just discovery; it involves investigation, problem-solving and the ability to pivot quickly. Surrounding myself with people who want me to succeed is a big motivator to keep going and stay passionate. Curiosity and open-mindedness have helped me countless times. Every internship and learning opportunity has taught me resilience, delayed gratification and persistence. I choose to work hard, trying to maintain the right balance of organisational skills, creativity and motivation to keep on going.

Carmen's *top tips*

1. Seek lab placements, internships and conferences to figure out what you enjoy studying. Taking advantage of these moments will allow you to explore your passions and develop into a better scientist.
2. Make time to do the things that you enjoy outside of academia. Whether that is reading a book or painting a picture, do it!

How can smart buildings reduce greenhouse gas emissions and help us adapt to climate change?

Most of the buildings we spend time in are solid and unmoving, and manage their environmental conditions (such as temperature, lighting and air flow) using energy-hungry heating, ventilation and air conditioning (HVAC) systems. However, at **Bodeker Scientific** in New Zealand, **Dr Negin Imani** has taken inspiration from plants to design adaptive building façades that respond to environmental conditions to keep buildings well-lit, well-ventilated and at a comfortable temperature.

Dr Negin Imani

Senior Research Fellow, Bodeker Scientific;
Senior Lecturer, Open Polytechnic, New Zealand

PROFILE

Fields of research
Architecture; building science, technologies and systems

Research project
Designing biomimetic adaptive building façades

Funder
New Zealand Ministry of Business, Innovation and Employment Endeavour Fund Smart Ideas

Website
biomimeticbuildings.org.nz

doi: 10.33424/FUTURUM694

Talk like an ... architect

4D printing – creating materials that can transform their shape in response to changes in their environment

Adaptive façade – a façade that can change to maximise a building's energy efficiency and comfort of its occupants, for example by using shading systems

Biomimetic – designed and engineered to mimic a natural system

Façade – the exterior of a building

Shading system – a mechanical system that uses moving panels to cover a building's windows to prevent overheating and excessive brightness inside when it is sunny

Thermal equilibrium – a state where heat entering and leaving a system is balanced, so the temperature remains constant

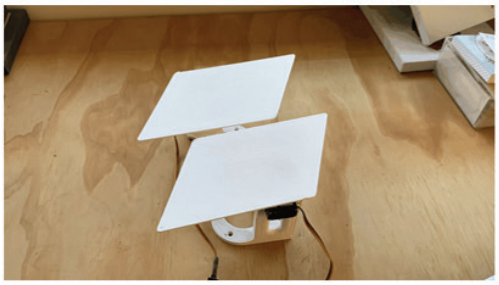
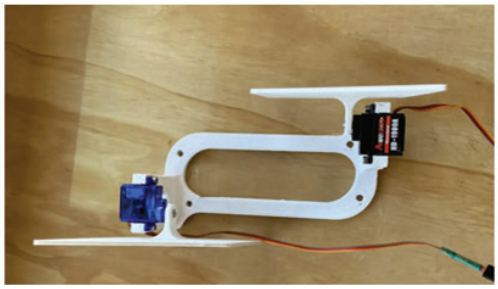
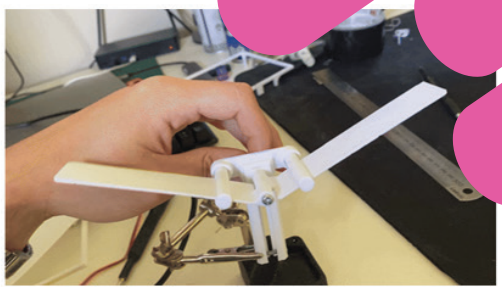
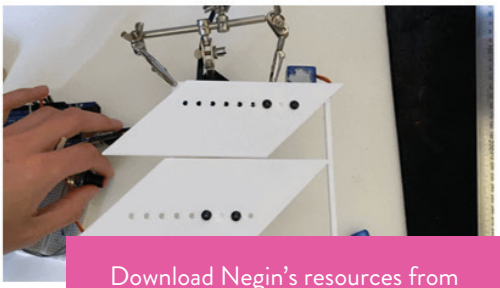
When the weather is cold, heating keeps our buildings warm. When the temperature outside rises, we use air conditioning to cool them down. However, these systems use huge amounts of energy (often provided by fossil fuels) and even then, we can still find ourselves sweating in summer or shivering our way through winter.

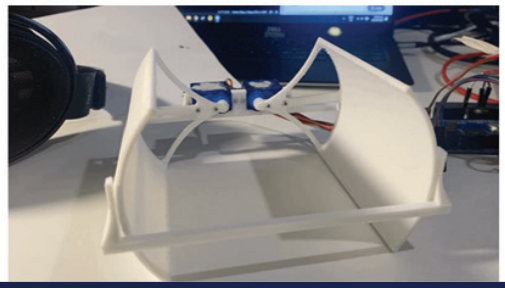
To make buildings more energy efficient and comfortable for their occupants, architecture researcher Dr Negin Imani from Bodeker Scientific is taking inspiration from nature. Since 2021, she has spearheaded nationally significant research on biomimetic adaptive building façades for energy efficiency, through two prestigious projects funded by the New Zealand Ministry of Business, Innovation and Employment. "An adaptive façade is a building 'skin' that can change depending on how much sun there is, or how hot or humid it is," she explains. "This reduces the need for heating, cooling and artificial lighting inside, making buildings more comfortable and efficient."

"We can learn from biological systems and apply natural ideas to buildings," Negin continues. "It's not about copying how something looks but understanding how it works and translating that logic into building design."

Learning from leaves

"The inspiration for our biomimetic adaptive façade came from how plants use stomata to regulate heat and moisture," says Negin. Plant leaves are covered in tiny holes called stomata which open and close to regulate heat, moisture and gas exchange. Their behaviour is governed



Download Negin's resources from **futurumcareers.com/how-can-smart-buildings-reduce-greenhouse-gas-emissions-and-help-us-adapt-to-climate-change**

Some examples of prototypes of Negin's shading systems. © Negin Imani

by changes in environmental conditions such as temperature and humidity. Stomata tend to open during the day to let in carbon dioxide for photosynthesis, then close at night to preserve water. However, during drought conditions, stomata close to reduce water loss and prevent dehydration. In more humid conditions, they remain open as the risk of water loss is reduced, allowing for continued gas exchange. Negin and her multidisciplinary, multi-institution team are designing biomimetic adaptive façades that respond to environmental conditions, inspired by plant stomata.

Buildings with balance

Negin has designed a shading system for an adaptive façade that includes both active and passive components. "Active systems depend on an external energy input (typically electricity) to move and use sensors, motors and control systems to respond dynamically to environmental conditions," she explains. "They are very precise and responsive but can be complex and require ongoing maintenance." In the motorised component of Negin's shading system, rotating panels are controlled by artificial intelligence (AI) to adjust the amount of sunlight hitting a building's windows, thereby altering the temperature and brightness inside to maintain maximum comfort and energy efficiency.

In contrast, passive systems do not need external energy input so are more energy efficient. They are made from materials that self-regulate by changing shape or properties in response to temperature, light levels or moisture in the atmosphere. "These materials can now be programmed through their composition, structure and fabrication process to behave in specific ways," says Negin. She uses 4D printing to create materials that react to moisture, and has incorporated these into her shading system so that it also automatically responds to changes in humidity.

Intelligent designs

By combining an active motorised system with a passive shape-changing material, Negin has designed a shading system for an adaptive façade that responds to environmental conditions. "The active system, especially when supported by AI, gives control, precision and the ability to adapt the façade in real time, while the passive system provides an energy-free response," she says. "Together, they create a smarter, more efficient and more responsive adaptive façade."

Both the active and passive parts of Negin's system are inspired by how plants maintain thermal equilibrium. "The active system is biomimetic at a system level, using controlled movement to regulate sunlight, similar to how stomata adjust their opening," Negin explains. "The passive system is biomimetic at a material level, behaving like plant tissue responding automatically to light and humidity."

Trial by sun and water

After designing prototypes of her shading system, the next step was to test whether they were up to the challenge of becoming part of an adaptive façade. "We tested how the 4D printed materials reacted to different conditions by spraying them with water," says Negin. "We then observed how they changed over time as they dried or were heated. By measuring how much they bent and how quickly they responded, we could understand how effective they were and how the design could be improved."

To test the effectiveness of the motorised component of the shading system, Negin looked at how effectively the different rotating panel designs could control or block sunlight. She also needed to check if her ideas worked on a practical level. "When we tested different designs, we looked at how simple and robust they were, and how easy they would be to install and maintain," she says. "Importantly, we also considered how they would look on a real building. It's not just about performance; an adaptive façade also needs to contribute positively to the overall architectural design."

Building on the work so far

One challenge for Negin and her team is making these designs simple, affordable and durable. "While there are several iconic buildings around the world that use adaptive façades, they are often very complex, expensive and difficult to maintain, so they're not widely used," says Negin. "We want to make these systems more practical, scalable and easier to apply in everyday buildings."

It takes an interdisciplinary group of highly skilled experts to design and test adaptive façade systems. Negin and her team hope to use their innovations to improve the process of applying adaptive façades in real buildings.

What should a delivery drone look like?

Imagine sitting in a park and ordering food, but instead of it arriving by car or bike, it is delivered by a drone. How would you feel? For his PhD at **Eindhoven University of Technology** in the Netherlands, **Dr Shiva Nischal Lingam** studied drone deliveries, with the goal of improving the experience for both recipients and bystanders in public places.

Dr Shiva Nischal Lingam

Previously: PhD Researcher, Department of Industrial Design, Eindhoven University of Technology, The Netherlands

Currently: Research and Development Engineer, Department of Aerospace Operations Safety and Human Performance, Royal Netherlands Aerospace Centre

Talk like a ...

research and development engineer

Defibrillator – a medical device used to restart a patient's heart

Drone – an aircraft or small flying device that does not have a pilot but is controlled remotely

User-centred design – an approach to designing technology in which the people who will use or be affected by the technology have a say in how it is designed

Field of research

Human-drone interactions

Research paper

Human interactions with delivery drones in public spaces: design recommendations from recipient and bystander perspectives.
Lingam, S.N. et al. (2025)
doi: 10.3389/frobt.2025.1580289

Funder

This research was supported by the Dutch Research Council (NWO) through the project 'Safety Solutions for Autonomous Vehicle Integration in Urban Mobility: Efficient and Reliable Acting in an Uncertain and Unreliable World' (NWA.1292.19.298). The research was part of a collaboration between Eindhoven University of Technology (TU/e) and Royal Netherlands Aerospace Centre (NLR). The contents are solely the responsibility of the authors and do not necessarily represent the official views of NWO, TU/e and NLR.

doi: 10.33424/FUTURUM704

PROFILE

Have you ever received a delivery from a drone? If not, it might not be long until you do, as drones are increasingly being used to deliver food and medical supplies. Manna Air Delivery, for example, has made over 250,000 flights in Ireland, Finland and the US since 2020, partnering with companies such as Deliveroo to deliver food, clothing and pharmaceuticals to customers. Zipline have also been delivering life-saving medicines and blood supplies to hospitals across Rwanda since 2018.

As a PhD researcher at Eindhoven University of Technology, Dr Shiva Nischal Lingam studied the challenges of using drones to make deliveries in public spaces. He hopes his work will help policymakers develop guidelines that will reduce the uncertainties about drone deliveries for people and the environment, and improve the process for everyone involved.

Why use drones for deliveries?

"Drones are already being used to deliver everyday items such as groceries, takeaway food and online shopping orders, as well as urgent supplies such as medicines and medical equipment," says Nischal. "They can be used to deliver items in emergency situations, such as defibrillators to heart attack patients or rescue equipment to hard-to-reach, disaster-affected areas."

Because they can fly directly to a location, drones are a fast and efficient way to deliver items. Drone deliveries can be much quicker for remote and rural areas that would take a while to reach via road. They are beneficial in cities because as well as being able to avoid traffic, they also reduce the number of delivery vehicles on roads and so reduce congestion and carbon emissions.

Despite these advantages, many people feel uncertain about drone

deliveries. Concerns often revolve around drone noise, the unpredictability of drone movements, and their environmental impact. To manage this, Nischal investigated how people interpret and react to drones in public spaces, and asked how they think drones should be designed to improve human-drone interactions.

Why did Nischal take a user-centred approach?

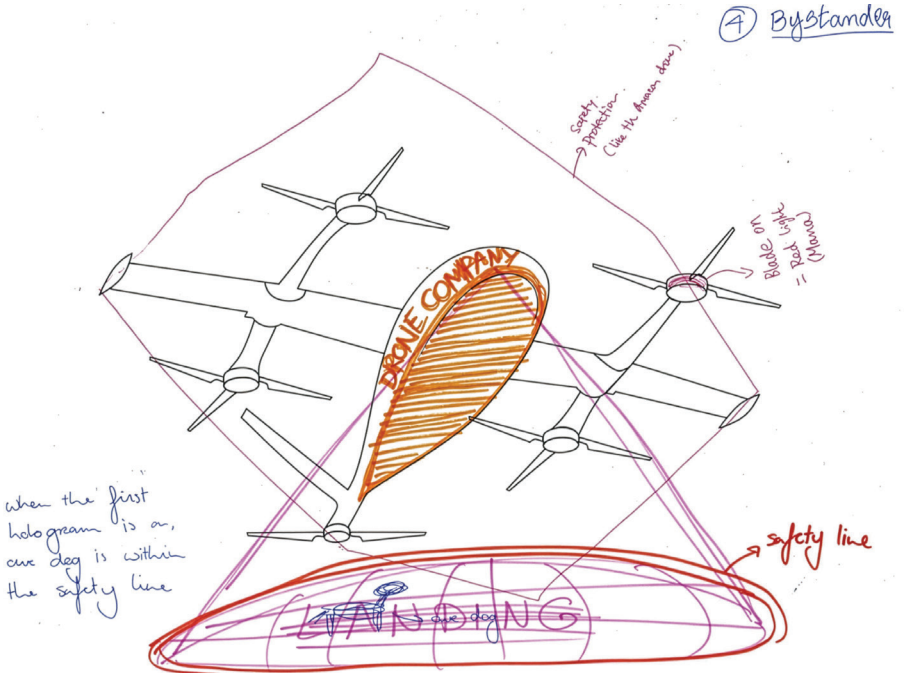
"User-centred design means understanding users' needs, behaviours and concerns first, then designing solutions to address them," says Nischal. "We chose to take this approach because if drones are only designed for performance or efficiency, they may still cause confusion, discomfort or safety concerns for people around them."

In Nischal's user-centred design project,he recruited participants to take part in focus groups. Participants were asked to imagine an interaction with a delivery drone in a public space, such as a park, either as the recipient of the delivery or as a bystander who is just watching. Nischal asked participants what their reaction to the drone would be, what factors might make them feel uncertain, and what information they would need to feel at ease. In their groups, participants drew storyboards to illustrate the scenes they expected during a human-drone interaction in a public space. They also drew sketches of drones to highlight design features they thought would help drones communicate with members of the public.

What did the study reveal?

A key finding from the focus groups was that both recipients and bystanders felt uncertain about the intentions of a drone, such as whether it was about to land, move closer, drop a package or leave. "Recipients felt uncertain about whether the drone was 'their' drone, while bystanders felt uncertain about the purpose of the drone," says Nischal. "Such feelings can lead to a lack of clarity, making people feel confused, cautious or even unsafe."

Bystander reactions were varied, ranging from curiosity and attempts to engage with the drone, to disengagement and moving away. "This can lead to unpredictable behaviours and safety concerns in public spaces such as parks," explains Nischal. Bystanders also raised concerns about privacy and the nuisance of propeller noises. "For some bystanders, the drone created a sense of being disturbed in what is normally a calm public space," says Nischal.



Nischal asked participants what delivery drones should look like and how recipients and bystanders would interact with them. © Shiva Nischal Lingam

As recipients had ordered the delivery, they were expecting a drone to arrive and so were less uncertain about its presence in a public park. However, they still felt uncertain about how to confirm that the drone was delivering to them and where they should stand while it made its delivery.

As both recipients and bystanders, participants expressed concerns over the environmental impact of drones and how to ensure they would interact safely with any wildlife in the area.

How could delivery drones be improved?

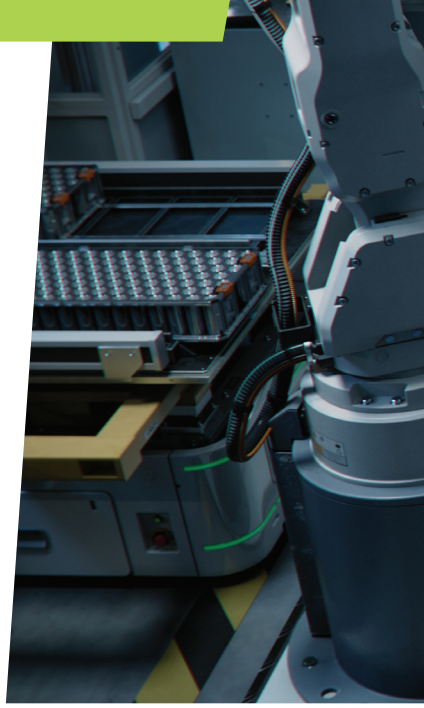
Nischal's study highlighted the current lack of clear communication from drones, which reduces trust and affects the comfort of everyone involved. To address this issue, participants suggested adding features such as audio and visual elements to drones. "For example, several participant sketches showed a light projecting from the drone onto the ground to indicate the delivery location when the drone descends to deliver a package," says Nischal. "They also suggested that blinking lights and audio warnings could indicate landing or take-off, as well as keeping bystanders at a safe distance."

To reduce uncertainty about the drone's intention, participants suggested that drone's appearance should be designed with logos and colours that people would recognise. For example, a food delivery drone from Uber Eats should be branded as such, while a medical drone delivering a defibrillator should have similar colours to an ambulance.

As drone delivery becomes more common across the world, Nischal hopes his work will help guide policymakers to develop regulations that make both recipients and bystanders feel comfortable, safe and at ease with drones operating in public spaces.

Download Nischal's resources from **futurumcareers.com/what-should-a-delivery-drone-look-like**

Building better batteries: how can computer simulations shorten development time while improving safety?



As the global shift to renewable energy accelerates, so does our need for batteries, both for personal use and in industry. Batteries need to store more energy than ever before, at lower costs, while also being sustainable and safe. At **RWTH Aachen University** in Germany, **Benedikt Späth** is using computer simulations to supercharge the process of developing new batteries.

Benedikt Späth

Head of Battery Development, Chair of Production Engineering of E-Mobility Components, RWTH Aachen University, Germany

PROFILE

Fields of research
Product development; production engineering

Research project
Using computer simulations to improve battery development processes

Funder
The Na.Ion.NRW Project (EFRE-20800353) is funded by North Rhine-Westphalia and the European Union

doi: 10.33424/FUTURUM701

Talk like a ... production engineer

Cell – the components in a battery that convert chemical energy into electrical energy

Computer simulation – a digital model that imitates how something works or behaves in real life, so it can be tested without building a physical prototype

Digital toolchain – a set of connected software tools that share data and are used in combination with each other to help design, build and test a product from start to finish

Iterative – a process of repeating a cycle of operations, such as designing and testing, to improve a product more and more each time

Model-based systems engineering (MBSE) – a methodology which uses models to represent and test how different parts of a system work together

Production engineering – the branch of engineering focused on designing and improving how products are manufactured efficiently and at large scale

Thermal runaway – a dangerous situation where a battery overheats uncontrollably because it keeps generating more heat than it can release

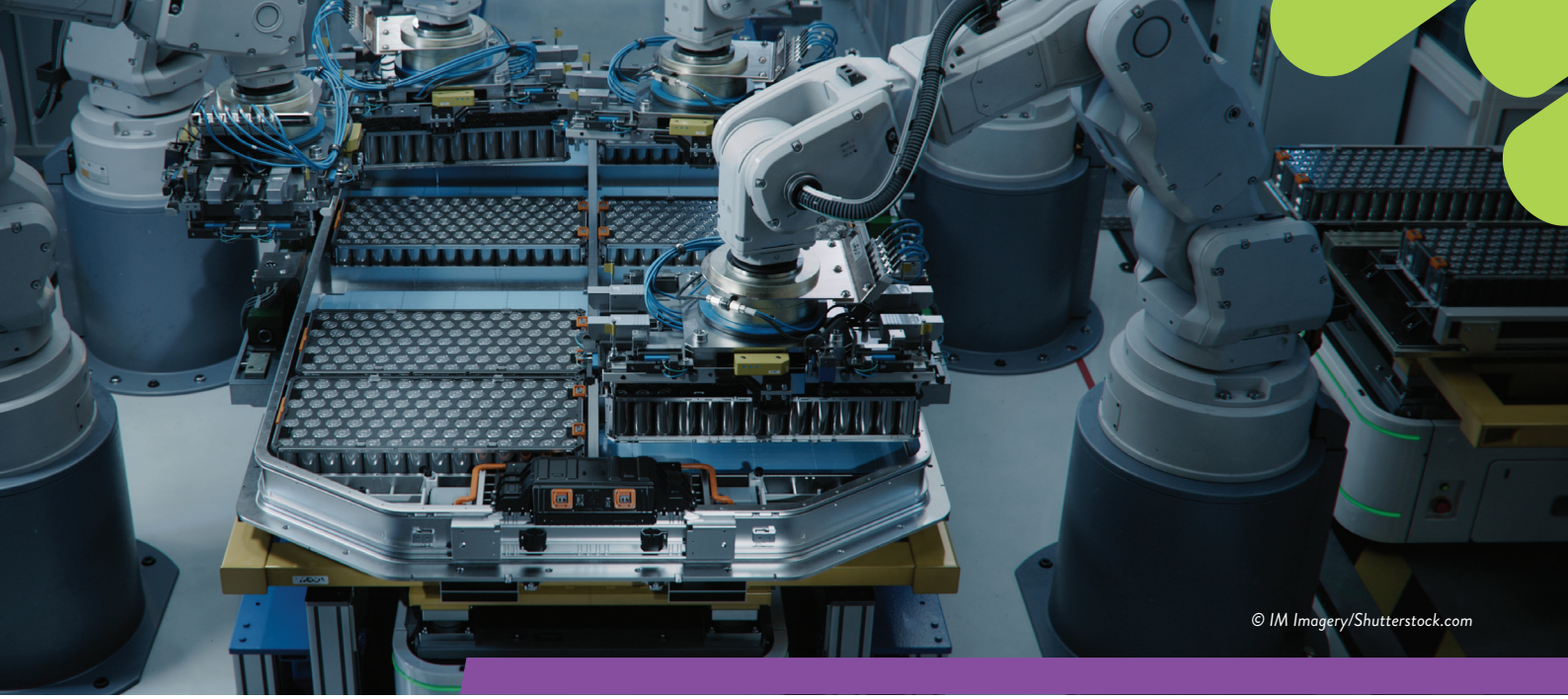
Since waking up this morning, you have probably used multiple products powered by batteries. These essential electrical powerhouses are found in mobile phones, laptops, cars and other everyday devices.

"Society's demand for batteries has grown significantly, driven by the global transition towards electrification and decarbonisation," says Benedikt Späth, a production engineer at RWTH Aachen University. "As we move away from fossil fuels and towards renewable energy and electric technologies, batteries have become a key enabling technology for storing and using energy efficiently."

Demand, design and development

Private use of batteries is soaring, as individuals move to using electric vehicles, solar panels and home energy storage systems. Renewable energy sources are increasingly used in industry, but solar and wind are weather-dependent and so rely on batteries to store energy when it is available and release it when it is needed.

This demand for long-lasting, large-scale and cost-effective batteries presents significant challenges for battery developers. "Improving one property often comes at the expense of another: for example, higher energy density can reduce safety," says Benedikt. "In addition, developers face challenges related to raw material availability, sustainability and recycling, while also scaling up production."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Battery development involves several stages, from initial design and material selection to testing and large-scale production, with simulations and experiments working together to improve performance and safety throughout. "Physical battery cells are built and tested, meaning simulations can be validated with real data," says Benedikt. "This is an iterative development cycle, where insights from testing continuously feed back into earlier design stages."

Powering forward with computer simulations

It can take many years to develop a new battery product, so Benedikt is using computer simulations to help to speed things up by moving test experiments into the digital world. "This means new battery technologies can reach the market more quickly, helping to reduce costs, improve sustainability and accelerate the transition to renewable electric systems," he says.

Benedikt uses digital toolchains which link design, testing and data analysis tools so information flows smoothly and automatically from design to production. "This increases transparency and reduces inefficiencies," he explains.

Using digital toolchains also avoids the time delays caused by treating product development and production separately and allows Benedikt to constantly link the two by running simulations of both, which feed off each other. "We analyse how design decisions affect production and vice versa," he says. "We can detect issues much earlier which reduces costly redesign loops. On the product side, we simulate the behaviour of battery cells to predict performance, lifetime and safety. On the production side, we simulate manufacturing steps to understand how process parameters influence the final cell properties." These simulations rely on a combination of physics-based and data-driven models, integrated into a digital workflow that evolves as more data becomes available.

Thermal runaway

One of the key concerns for battery safety is thermal runaway. "This is a self-reinforcing overheating process inside a battery," explains Benedikt. "Once it starts, the battery generates heat faster than it can dissipate it, causing the temperature to rise rapidly in an uncontrolled way."

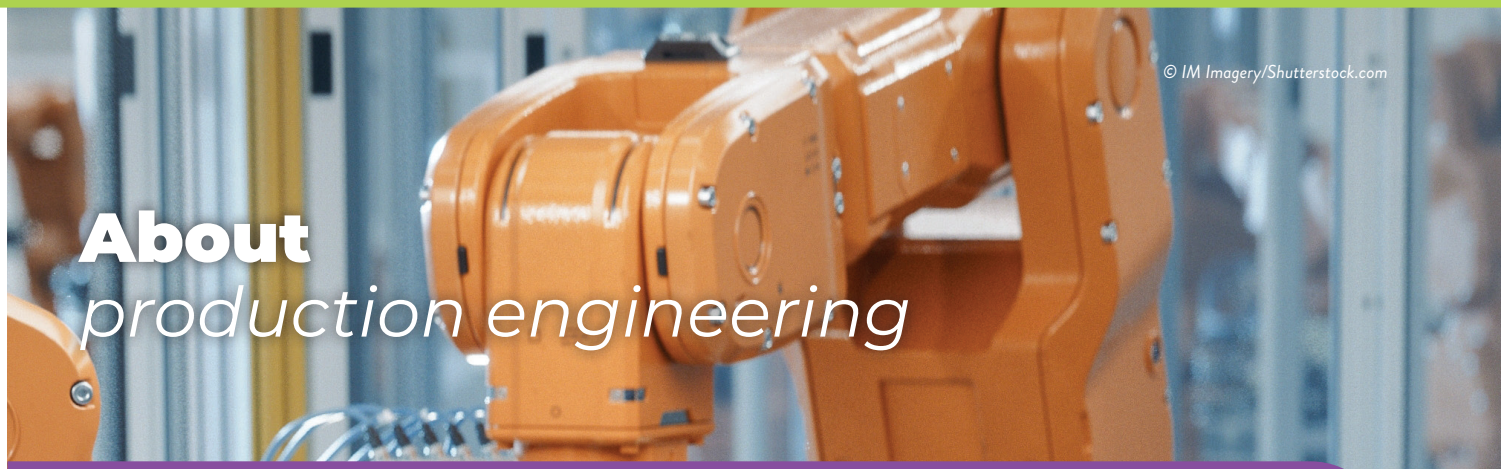
Thermal runaway can be caused by internal issues within the battery or by external issues such as damage or overheating, leading to explosions, fire and the release of toxic or flammable gases. Fortunately, incidents are few and far between, thanks to the inclusion of advanced safety features in today's batteries.

"We conduct thermal simulations which calculate how heat is generated and distributed inside a battery cell under different operating conditions, such as current, voltage, charging rates and material properties," says Benedikt. These models are part of a model-based systems engineering (MBSE) approach, linking thermal, electrical and mechanical behaviour to provide a complete picture. Early models are simple and fast while later models build complexity, and all models are validated with real data. "This allows us to evaluate safety-relevant scenarios early, reducing the risk of costly and dangerous failures."

The results are useful and practical. Benedikt's simulations reveal temperature patterns within the cell and battery system, identify hot spots and highlight cooling requirements. "We can understand where a battery might overheat and potentially enter dangerous states such as thermal runaway," says Benedikt. "We can identify critical conditions before they occur in reality." This helps product engineers make informed design choices about cell layout, cooling systems and safe operating limits early on in development.

Benedikt highlights that simulations do not replace real-world testing. Instead, the two approaches work together, each informing the other. "Simulations reduce the need for physical prototypes and enable faster and more efficient development, but in the end, simulations are always validated with real tests," he says. "For example, in thermal runaway investigations, we deliberately push batteries to their limits – through overcharging, heating or mechanical damage. In some cases, this can lead to severe failure events, including fire or explosions."

Computer simulations play a vital role in making the transition to renewable energy happen quickly, smoothly and safely, and the focus on safety is essential. "Batteries store a large amount of energy in a small space and are used in everyday applications such as electric vehicles and home energy storage systems," says Benedikt. "Reliable and safe batteries are therefore crucial for building trust in new technologies and enabling the transition to sustainable energy systems."



About *production engineering*

Would you like to work in an exciting and varied field, where you get to take innovative ideas and turn them into high-quality mass-produced products that solve some of the key problems of our time? If so, production engineering may be for you.

"Production engineers work at the intersection of engineering, data and business," says Benedikt. "They apply digital tools such as simulation, automation and artificial intelligence to improve production systems. Production engineering has a direct and visible impact on the real world. You are not only designing ideas – you are helping to turn them into products that people use every day."

Benedikt specialises in battery development. "Engineering in the battery field is particularly exciting because it is a highly dynamic and future-oriented field," he says. "Battery technologies and production methods are evolving rapidly, which means there are always new challenges to solve and opportunities to innovate."

Future production engineers will be at the forefront of providing vital solutions to global challenges, such as improving the sustainability of product design and production processes, producing new technologies at scale without compromising on quality or safety, and advancing the field alongside advances in data, technology and artificial intelligence. "Future production engineers will not only optimise factories but also help shape the transition to a more sustainable, electrified and digital society," says Benedikt. "Whether you're working on climate change, sustainable energy or electric mobility, many solutions depend on the ability to develop and manufacture new technologies efficiently and at scale."

Pathway from school to *production engineering*

"At school, subjects such as mathematics and physics are especially important, as they help develop analytical thinking and an understanding of how technical systems work," says Benedikt. "Computer science is also becoming increasingly valuable, as digital tools and data play a major role in modern engineering."

At college or university, typical study paths include mechanical engineering, industrial engineering or product design, which provide a broad understanding of both technical systems and production processes. During your studies, you can specialise in areas such as production engineering, manufacturing technologies or industrial digitalisation.

"In addition, skills in programming, data analysis and simulation are becoming more and more important, especially in fields like battery production, where digital tools are used to optimise both product design and manufacturing processes," says Benedikt.

Explore careers in *production engineering*

Everything that is manufactured requires production engineers to help develop the production process, so the career opportunities are endless!

Benedikt recommends exploring university websites and professional engineering organisations to learn about career paths, research and opportunities. For example, you can learn more about Benedikt's research in the Chair of Production Engineering of E-Mobility Components at RWTH Aachen University: **www.pem.rwth-aachen.de**

"My main advice is to stay curious and hands-on," says Benedikt. "Try to understand how things are made and don't be afraid to explore technical topics in practice by building things yourself or using tools like 3D printing."

Meet *Benedikt*

My grandfather sparked my fascination with technology. He was someone who could repair almost anything and had a deep practical understanding of how things work. He gave me my first computer, taught me how to use tools and encouraged me to explore technology on my own.

As a teenager, I enjoyed taking things apart, understanding their functionality and thinking about how they could be improved. I was also involved with the fire brigade and rescue services, where I experienced responsibility in real-world situations and gained early exposure to technical systems in practice.

I was motivated to pursue engineering by the idea of turning concepts into real products that have an impact. It is very satisfying to contribute to technologies, such as batteries, that play an important role in areas like electric mobility and renewable energy.

Batteries are everywhere in our daily lives. From smartphones and laptops to electric vehicles and renewable energy systems, we rely on batteries almost constantly, often without even noticing it. At the same time, each battery cell is a highly complex system where small changes can have a huge impact on performance, safety and lifetime.

In my free time, I enjoy spending time in nature, especially through activities like hiking, biking and diving. These help me stay active and provide a good balance to my daily work.

Benedikt's *top tip*

Don't be afraid of challenges. Engineering problems can be complex, but that is exactly what makes them interesting. Learning how to approach and solve problems step by step is more important than having immediate answers.

Download Benedikt's resources from **futurumcareers.com/building-better-batteries**

Meet *Achim*

Professor Achim Kampker is a mechanical engineer and the chair-holder of Production Engineering of E-Mobility Components at RWTH Aachen University.

As a teenager, I was very interested in agriculture and wanted to become a farmer. I was fascinated by working with nature, creating something tangible, and understanding systems that must function sustainably over long periods of time.

Becoming an engineer was not a childhood dream – it was more a process of elimination. Other options didn't feel like the right fit and engineering remained. Looking back, it turned out to be the right choice.

Being a mechanical engineer is rewarding because I can truly make an impact by creating technologies, systems and ideas that will change industries or improve society. However, it can be frustrating to deal with the slow pace of processes, especially when innovation could move much faster.

I find the efficiency and enormous potential of batteries fascinating. They are not just storage devices; they are key enablers for the energy transition, electrification, and entirely new mobility and industrial systems.

When I'm not working, I value spending time with my family which gives me balance, energy and perspective.

Achim's *top tip*

Be persistent, work hard and stay curious. Opportunities are often not obvious at first – you need to recognise them and be willing to take them when they appear.

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Noise complaints: how statistical innovations are cleaning up noisy data

Scientific data are rarely clean and clear. Often, they are blurred or distorted by 'noise' – random disturbances that get mixed in with real data and make them difficult to interpret. Thankfully, statisticians like **Dr Catia Scricciolo** from the **University of Verona** in Italy are developing methods to counteract the problem, drawing on mathematical optimisation and probability to remove this noise and reveal the signals it was hiding.

Dr Catia Scricciolo

Associate Professor, Department of Economics, University of Verona, Italy

PROFILE

Field of research
Statistics

Research paper
Adaptive minimax-optimal Wasserstein deconvolution with unknown error distributions. Scricciolo, C., (2026) doi: 110.1016/j.spl.2025.110589

doi: 10.33424/FUTURUM700

Talk like a ... statistician

Deconvolution – a mathematical method used to recover the original signal from data degraded by noise

Distribution – a function that describes the relative frequency of different outcomes in a dataset

Noise – in data analysis, the random fluctuations, measurement errors, or irrelevant information in a dataset that are not part of the underlying true signal and can obscure meaningful patterns

Optimisation – the process of finding the optimal solution to a mathematical problem

Regularisation term – a component in a model that prevents the model from trying to fit every fluctuation in the data

Wasserstein metric – a way to define the distance between two probability distributions

Imagine taking a photo with an unsteady hand. Your picture comes out blurry due to the shaking of the camera. "In theory, if you knew (or could guess) how the camera shook, you could digitally process the photo to remove the blur and get a sharp image," says Dr Catia Scricciolo, a statistician at the University of Verona. "The same principle applies to removing the 'blur' from data, via a process called deconvolution."

This is an important principle for virtually every scientific field. Blurry data can hide meaningful trends, which undermines scientific progress. So, statisticians have been working out how to counteract blurry data using the mathematical process of deconvolution. But doing so reliably, especially since randomness is involved, takes careful and innovative thought. Catia works on exactly this challenge, exploring how statistical methods can minimise the effects of noise and reveal the meaningful information within a dataset.

Blurry data

When scientists record data – whether astronomers are measuring stars, medical personnel are taking MRI scans, or physicists are measuring subatomic particles – their results are rarely squeaky clean. This makes it difficult to see the true signal through the blur. "In science, 'blur' comes from equipment limitations, physical effects or interference, as well as random noise," says Catia. "To counter this, scientists use deconvolution – a process that mathematically recovers the original clear signal from the blurred measurement."

When astronomers look up at the night sky using telescopes here on Earth, the atmosphere bends light randomly, which is why stars appear to twinkle.

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Download Catia's resources from **futurumcareers.com/how-statistical-innovations-are-cleaning-up-noisy-data**

When biologists look at cells under the microscope, all the parts of the three-dimensional cell that are not in the targeted two-dimensional plane show up as out-of-focus haze. "We can use deconvolution to turn blurry, hard-to-interpret data like these into sharper, more useful information," says Catia. "Mathematically speaking, this involves estimating the original signal by undoing the effects of an unknown or partially known blurring process."

Noise: the enemy of deconvolution

But deconvolution becomes trickier when the blurring is caused by random, unpredictable effects. "This type of unwanted, random disturbance is called noise," explains Catia. "Noise makes deconvolution much harder, and sometimes impossible." The more noise there is, the harder it is to decide what is signal and what is just random, limiting what can be recovered. Ideally, noise is minimised when the measurements are taken, but this is not always possible. "Because noise is random, you can never be completely sure which parts of your observation are the original signal and which are just noise," says Catia. "So, deconvolution can give you an estimate of the truth, but not the exact truth."

Thankfully, statisticians have some nifty tricks up their sleeves to help with deconvolution for noisy data. "The Wasserstein metric defines a distance between probability distributions," says Catia. "In plainer language, it's a way to focus on the overall shape of a distribution

> ***"All together, these methods turn messy, noisy data into a clean estimate of the original distribution."***

of data, rather than getting caught up in the 'bumps' caused by noise." Catia studies Wasserstein deconvolution through a mix of mathematics and probability. "I use mathematical optimisation to find the original distribution that best explains the noisy data," she says. "The Wasserstein metric then acts as a score that measures how far my guess is from the truth." Catia also adds in a regularisation term that forces a recovered distribution to smooth out any wiggles that are likely to be due to noise rather than actual quirks in the data. "All together, these methods turn messy, noisy data into a clean estimate of the original distribution," she says.

Helping out scientists

Catia's research is improving the reliability of Wasserstein deconvolution methods, which other scientists can then use to clean up their own datasets. "Scientists in other fields can apply my deconvolution method without needing to be experts in the mathematics behind it," she says. "For example, doctors can use it to sharpen MRI scans, helping them see tumours more clearly." Going back to astronomers, they can use Catia's method to clean up blurry images of distant galaxies, uncovering details that were previously hidden by the noise of the atmosphere. Space telescopes can also benefit – when the Hubble Telescope was first launched, there was an error in its mirror array which introduced blur into the data it recorded. Using deconvolution, astronomers recovered stunning images of space from the blurry data.

Catia hopes that her research can help accelerate scientific discovery by taking the burden off scientists to develop their own data cleaning methods. "Instead of struggling to invent their own mathematical solutions, they can use the Wasserstein deconvolution techniques I helped develop," she says. "In short, my work removes a barrier so other scientists can focus on their own research – whether that is curing a disease, discovering a new planet or understanding human behaviour."

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How are computer scientists combatting food fraud?

Food fraud is a growing concern, with low-quality products deliberately mislabelled and fraudulently sold as high-quality products. In Italy, a team of computer scientists, including **Professor Remo Pareschi** from the **University of Molise**, has developed a digital platform to provide traceability in food supply chains, helping to combat food fraud and improve food safety.

Professor Remo Pareschi

Stake Lab, University of Molise, Italy

PROFILE

Field of research
Computer science

Research project
Developing a digital platform to provide traceability in food supply chains

Institutions
ENEA; National Metrology Institute of Italy; Universities of Bari, Naples Federico II, Parma, Rome Sapienza, Siena and Molise

Funder
Italian National Recovery and Resilience Plan supported by the European Union

Website
metrofood.it

doi: 10.33424/FUTURUM698

Talk like a ...

computer scientist

Black box – a system in which an observer cannot tell how outputs from a model were derived from inputs

Blockchain – a method to ensure that digital data cannot be altered

Cryptographic fingerprint – a digital code that uniquely identifies a piece of data

Extra virgin olive oil – pure juice from pressed olives that has not been chemically treated or mixed with other batches of oil

Provenance – place of origin

If you buy a bottle of Italian extra virgin olive oil, there is a significant risk that the liquid inside is not what it claims to be on the label. "Extra virgin olive oil is one of the most counterfeited food products in the world," says Professor Remo Pareschi, a computer scientist at the University of Molise.

You might wonder why, as a computer scientist, Remo is interested in mislabelled olive oil. Well, he and his colleagues are using their computer science skills to develop a digital platform that provides traceability in food supply chains, helping to combat food fraud and improve food safety.

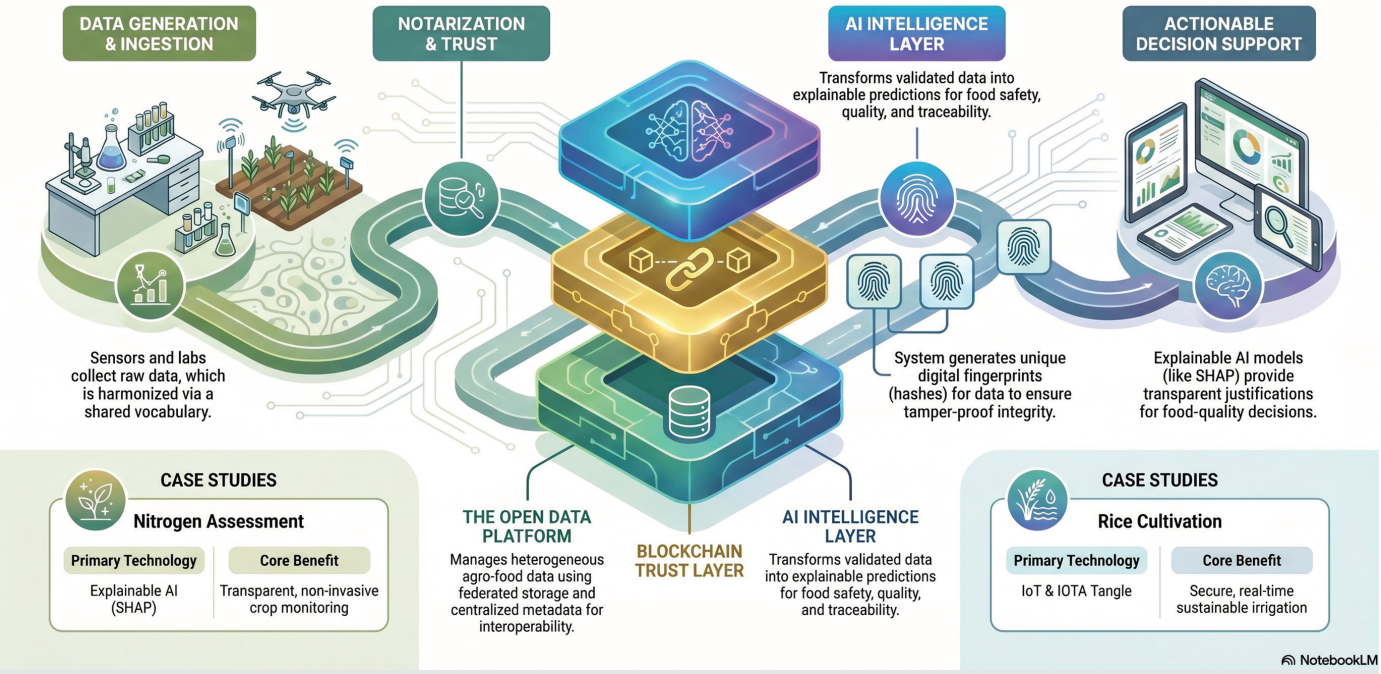
Why do we need traceability in food supply chains?

"Think about what happens between a farm and your plate," says Remo. "Food is grown by a farmer, analysed by a laboratory, packaged by a company, checked by a certification body, shipped by a distributor and finally sold by a supermarket." Each stage in this process produces information, such as soil measurements, chemical analyses of food samples and quality control certificates.

Historically, this information is stored in separate systems that do not interact with each other, making it hard to trace individual items through the supply chain. If there is a contamination outbreak, for example, it is difficult to reconstruct what happened. And consumers cannot check whether the product they are buying is really what it says on the label. Is the olive oil really Italian extra virgin? Are the eggs really free range?

Developing a traceability platform

To address this, a network of Italian institutions has developed METROFOOD-IT. This project brings together universities, research centres and laboratories across Italy, combining physical research facilities (where food samples are analysed) with the platform that Remo and his colleagues have built. "METROFOOD-IT tackles information fragmentation by



A diagram of the METROFOOD-IT platform. © Remo Pareschi

building a single digital infrastructure that connects laboratories, producers, certification bodies and consumers, so that data generated at any point in the food supply chain can be stored, verified and analysed in a coordinated way," says Remo.

METROFOOD-IT consists of three components – an open data platform, a blockchain layer and an AI layer – that work together as a single pipeline. The open data platform stores all data generated throughout the food supply chain, from soil moisture measurements and satellite images of crop health on farms, to food nutrient levels and bacterial analyses in processing plants, to certification documents stating exactly where and when an item moved through the production line.

Verifying data with blockchain

A blockchain is a digital ledger stored across many computers in a network. Once data is written into a blockchain, no one can change or erase it. The blockchain layer in METROFOOD-IT ensures that data on the platform is authentic and has not been tampered with.

"In METROFOOD-IT, we use blockchain in a clever way," says Remo. "We don't put the full datasets on the blockchain as that would be too expensive and slow. Instead, we register a cryptographic 'fingerprint' of each data file that is calculated from the file's content. If someone altered even a single comma in the original data file, it would produce a completely different fingerprint."

The blockchain layer means that if someone wants to verify that a lab report or provenance certificate has not been tampered with, they can recompute the data's cryptographic fingerprint and compare it to the one stored on the blockchain. If they match, the data is authentic. "This is important because food safety depends on trust," says Remo. "And trust depends on the ability to prove that data hasn't been altered along the way."

Analysing data with AI

Once data has been stored in the METROFOOD-IT open data platform, it is verified through the blockchain layer. After this, the AI layer generates useful insights from the data. Some advanced AI models use a 'black box' process – they give answers without explaining how or why they have reached those conclusions. "That's not good enough for food safety regulations, because a certifier or policymaker needs to understand why the model is making a particular decision," says Remo. So in METROFOOD-IT, the AI layer uses techniques that open the black box to show which parts of the data most influence each prediction. "The outputs of the platform aren't just numbers," says Remo. "They're explained recommendations that producers, certifiers and regulators can trust and rely on."

Tracing olive oil production

With so many cases of low-quality olive oil being fraudulently sold as extra virgin, olive oil production is a great example of how METROFOOD-IT works. The open data platform stores information from every step of the process, including soil analyses from the olive grove, the date and conditions of the harvest, chemical analyses performed at the oil press, and bottling and packaging records. Each piece of data gets its own cryptographic fingerprint registered on the blockchain, so no one can later alter a certificate or swap in cheaper oil and claim it is the original. The AI layer combines the data to confirm the oil's provenance and detect potential fraud. "Everyone in the chain benefits," says Remo. "Producers can prove the authenticity of their product, sellers gain confidence in what they're distributing, and consumers can scan a QR code on the bottle to check that the oil they're about to buy is what the label claims it to be."

Thanks to the work of the computer scientists behind METROFOOD-IT, food supply chains are becoming safer and more trustworthy – and the next generation of computer scientists will help take this work further.

Download Remo's resources from **futurumcareers.com/how-are-computer-scientists-combatting-food-fraud**

Building better AI: how are computer scientists improving AI systems?

As artificial intelligence (AI) plays an ever-greater role in our lives, computer scientists are constantly improving AI systems. At the **University of Molise** in Italy, **Professor Remo Pareschi** has developed a more effective AI framework that allows humans and AI agents to work together to solve complex problems.

Professor Remo Pareschi

Stake Lab, University of Molise, Italy

PROFILE

Fields of research
Artificial intelligence (AI); computer science

Research project
Developing a new and more effective AI framework

Funders
This research was developed within the broader context of the METROFOOD-IT project and the Vitality project, both funded through the Italian National Recovery and Resilience Plan (PNRR).

doi: 10.33424/FUTURUM699

Talk like a ...

computer scientist

AI agent – a software system that can perform a task on its own, such as analysing data or making decisions

AI framework – the underlying structure that determines how AI agents are organised and work together

Artificial intelligence (AI) – a computer system that mimics human intelligence in its ability to understand information and make reasoned decisions

Large language model (LLM) – a type of AI trained on large amounts of text that can understand and generate human language

Semantic processing – understanding the meaning of information

Topic space – a structured channel through which AI agents communicate about a particular topic, separated from other topics

Today, we rely on artificial intelligence (AI) to perform a huge range of tasks. With its ability to analyse data and make decisions, AI can do everything from acting as a virtual personal assistant to helping doctors diagnose diseases. However, traditional AI frameworks face several challenges that limit their ability to complete tasks effectively. So Professor Remo Pareschi, a computer scientist at the University of Molise, has developed a new AI framework that is more organised and effective.

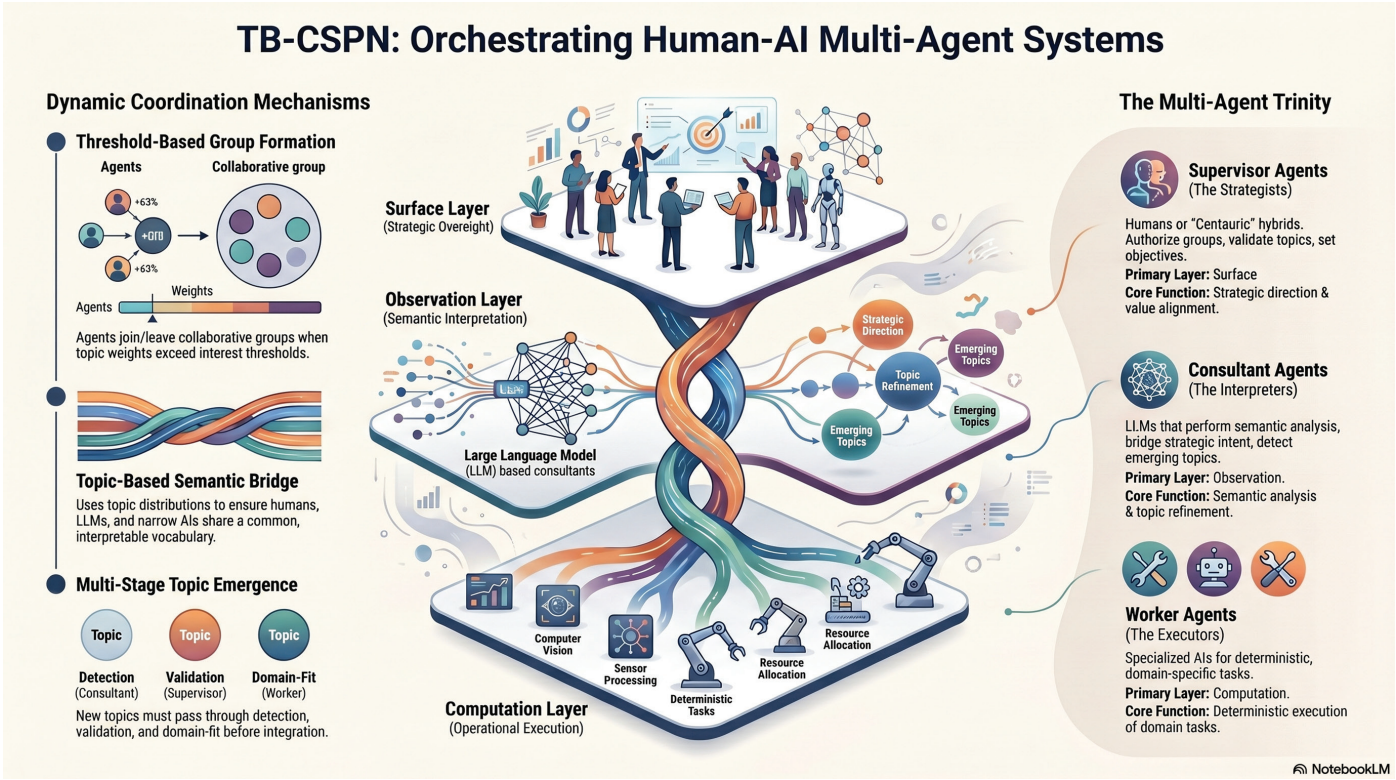
What are the problems with traditional AI frameworks?

In traditional AI frameworks, AI agents communicate through a large language model (LLM) that sits at the centre of the system. The LLM acts as the controller, interpreting messages from each agent (known as semantic processing) and coordinating how agents interact. "This approach works well for many tasks, especially those involving language," says Remo. "However, the reliance on LLMs as the central model can slow things down and it can become difficult to manage as the number of agents and interactions grows."

Imagine asking a classmate to pass a note to your friend. This method of communication works well when two of you are passing notes back and forth through your classmate. But imagine if the rest of the class joins in the written conversation. There are now 30 people trying to communicate with each other, and every message must be passed on by that one original classmate. This will cause a bottleneck in communication because the classmate at the centre of the system will not be able to process and respond to all the information fast enough. Additionally, as the classmate at the centre is doing two completely different jobs at once (understanding what each note says and deciding who should get it next), neither job gets done as well as it could.

What is Remo's new framework?

To address these challenges, Remo and his colleagues, Professor Paolo Bottoni and



A diagram of Remo's TB-CSPN AI framework. © Remo Pareschi

Professor Uwe Borghoff, developed a Topic-Based Communication Space Petri Net (TB-CSPN) AI framework. "The TB-CSPN framework organises AI agents differently," Remo explains. "Instead of sending messages directly to each other through the LLM, agents communicate through shared topic spaces." Agents interact with each other within structured spaces, where information is grouped by topic. LLMs are still used to understand and generate meaning, but other AI components control and coordinate the system.

The key innovation in the team's TB-CSPN framework is that roles are separated, rather than all being performed by a central LLM. "In TB-CSPN, some components focus on semantic processing while others focus on coordination (organising who does what and when)," Remo explains. "Because these roles are separated, each part of the system can work more effectively. In simple terms, it turns a chaotic conversation into a well-organised collaboration."

To overcome the limitations of traditional AI frameworks, Remo and his colleagues had to ensure that their new TB-CSPN framework was effective, transparent and scalable. "One of the main challenges was designing a system where multiple agents can cooperate effectively without becoming too complex," he says. "Another challenge was ensuring that the system remained clear and interpretable, so that humans can understand how decisions are made." The structure Remo's team has developed – where agent communication occurs through topic spaces and semantic processing is separated from coordination – allows the TB-CSPN framework to achieve this. Without the LLM bottleneck at the centre of the AI system, TB-CSPN speeds up decision-making and enables easier tracking of how decisions have been made. In addition, new agents can be added without disrupting the system.

How could TB-CSPN help solve real-world problems?

"TB-CSPN can be used in many real-world situations where multiple types of information must be combined," says Remo. "Examples include managing emergency responses (e.g., floods or wildfires) and supporting sustainable agriculture. In each case, different AI agents in the system analyse distinct aspects of the problem and collaborate to support human decision-making."

In an AI system designed to help with emergency management, separate AI agents would specialise in weather, transport and safety, each communicating through dedicated topic spaces. Humans would hold authority over the structure of the system itself, such as what each agent is permitted to do and under what conditions actions can be taken. This means humans do not have to monitor every step, but they remain in control of the overall process. Information produced by the AI system would then be shared with humans, who would use it to make decisions about the appropriate emergency response.

"In this vision, AI is not meant to replace humans, but to work alongside them as part of a coordinated system," explains Remo. "Human experts remain involved in key decisions, especially in complex or sensitive situations such as emergency management or environmental planning." TB-CSPN is a practical way to implement this vision as it provides a structure in which both AI agents and humans can contribute to shared information spaces, with each bringing their own strengths to the process: "AI systems can analyse large amounts of data quickly, while humans can provide judgment, experience and ethical reasoning."

"More broadly, this research explores how to design AI systems that behave less like isolated tools and more like organised communities, where humans and AI agents cooperate to solve complex problems together," continues Remo. "Understanding how to build these collaborative systems may be one of the most important challenges for the future of artificial intelligence."

About *computer science*

Our increasing reliance on computer systems in everyday life provides a wealth of opportunities and challenges for computer scientists. "I look at computing not just as a matter of writing code efficiently, but as a way of shaping how different kinds of agents – people, software, robots, sensor networks, AI models – interact with each other and the infrastructures they inhabit," says Remo. "The challenge for the next generation of computer scientists will be to figure out how to make these hybrid systems work well together safely and intelligibly."

Yet it is precisely these challenges that make the work so rewarding. "There is something deeply satisfying about starting from a formal idea and then watching it come to life as part of a working system that real people rely on," says Remo. "Computer science's most valuable contributions to society are going to come from designing systems that balance the theoretical side with human context."

What skills do computer scientists need?

"A computer scientist who has technical depth, conceptual breadth and the ability to connect with people and organisations will be extraordinarily well-equipped for the decades ahead," says Remo. He divides the skills required by computer scientists into three categories: technical fluency, foundational reasoning and soft skills. "Technical fluency means having solid programming skills, a good grasp of data structures and algorithms, and familiarity with platforms such as the cloud and AI frameworks," he explains. "Foundational reasoning means being able to logically and analytically design systems and evaluate what AI is producing. Finally, it is important to be able to work well in a team, communicate clearly and understand the human context in which your computer systems will operate."

Pathway from school to *computer science*

Develop your coding skills by learning a computer language such as Python or R and exploring software repositories such as GitHub. "There is no better way to understand how real systems work than to explore them," advises Remo.

While coding is an essential skill for computer scientists, Remo highlights that, as AI increasingly takes on the routine task of writing code, computer scientists will need a broader intellectual foundation. "Study mathematics and philosophy, which will teach you to reason about abstract structures and spot hidden assumptions," he says. "Logic is where mathematics and philosophy meet, and it underlies how computers reason. Study cognitive science because understanding how people think is crucial for designing systems that work with people. And don't underestimate the value of being able to communicate clearly."

At university, study a degree in computer science, information technology or computer engineering.

Explore careers in *computer science*

In today's digital world, career opportunities for computer scientists are endless.

"To be a computer scientist today is to have the opportunity to be at the centre of things as they are now and as they are still to come," enthuses Remo. "We are moving into a world where the digital, physical and social increasingly overlap. And through artificial intelligence, we are watching something genuinely unprecedented take shape."

Prospects provides information about what you can do with a degree in computer science: **prospects.ac.uk/careers-advice/what-can-i-do-with-my-degree/computer-science/**

© Andrey_Popov/Shutterstock.com

Download Remo's resources from **futurumcareers.com/building-better-ai-how-are-computer-scientists-improving-ai-systems**

Meet *Remo*

When I was young, I was curious about everything. I had a set of encyclopaedias – a row of heavy volumes on a shelf – that I would pull down, flip open and lose myself in for an hour. I read them constantly, wandering from one topic to the next. It was nothing like what is available today, with Wikipedia and AI assistants to answer almost any question you can think of.

I attended a 'classical' Italian high school where I spent years studying Latin, Ancient Greek, literature and philosophy, before going to university to study computer science at a time when the digital world was beginning to take shape. My background in classical studies shows there is no incompatibility between the humanities and sciences – the two worlds speak to each other far more than people tend to assume.

I spent several years leading research and innovation teams at the European Computer-Industry Research Centre and Xerox, where I guided technology projects from early-stage ideas through to real products and services. My industry experience was a real asset when I became an academic computer scientist – understanding how a business works and how technology is brought to market gives me a different perspective from my colleagues. And this perspective has allowed me to create spin-off companies from the results of my research.

I enjoy reading in my free time, from Wikipedia articles about the evolution of life to science fiction to classic British humour. Reading widely across genres teaches you to move between different registers of thought, which is extremely useful when you work, as I do, at the intersection of formal ideas and real-world systems. I also think that anyone thinking about artificial intelligence should spend time wondering how the natural kind ever came about in the first place.

Remo's *top tip*

Don't hesitate to take side paths. I've done it many times – from classical studies to computer science, from academia to industry and back again, and from research into spin-off companies. Side paths are where original ideas, unexpected connections and the most interesting work tend to appear. A perfectly straight career is rarely the most creative one.

Can eye-tracking uncover the secrets of social media advertising?

The rise of social media has provided advertisers with new ways to connect with potential customers, by designing adverts that blend in with other social media content. At **Hochschule Ruhr West University of Applied Sciences** in Germany, behavioural scientists **Dr Maike Hübner** and **Professor Julia Thalmann** are using eye-tracking technology to examine how users engage with these 'native ads'.

Dr Maike Hübner

Research Associate

Fields of research
Behavioural science; advertising

Professor Julia Thalmann

Professor of Retail Management and E-Commerce

Fields of research
Retail marketing; consumer behaviour; user experience (UX)

Hochschule Ruhr West University of Applied Sciences, Germany

Research project
Using eye-tracking to investigate native ad engagement

Funders
Hochschule Ruhr West University of Applied Sciences; Fundação para a Ciência e a Tecnologia

doi: 10.33424/FUTURUM687

PROFILES

Talk like a ...

behavioural scientist

Consumer literacy – the ability to make informed decisions as a consumer

Disclosure – a label to show that a social media post is sponsored content or advertising

Eye-tracking – the process of measuring, recording and analysing how a person looks at something (where, for how long and in what order)

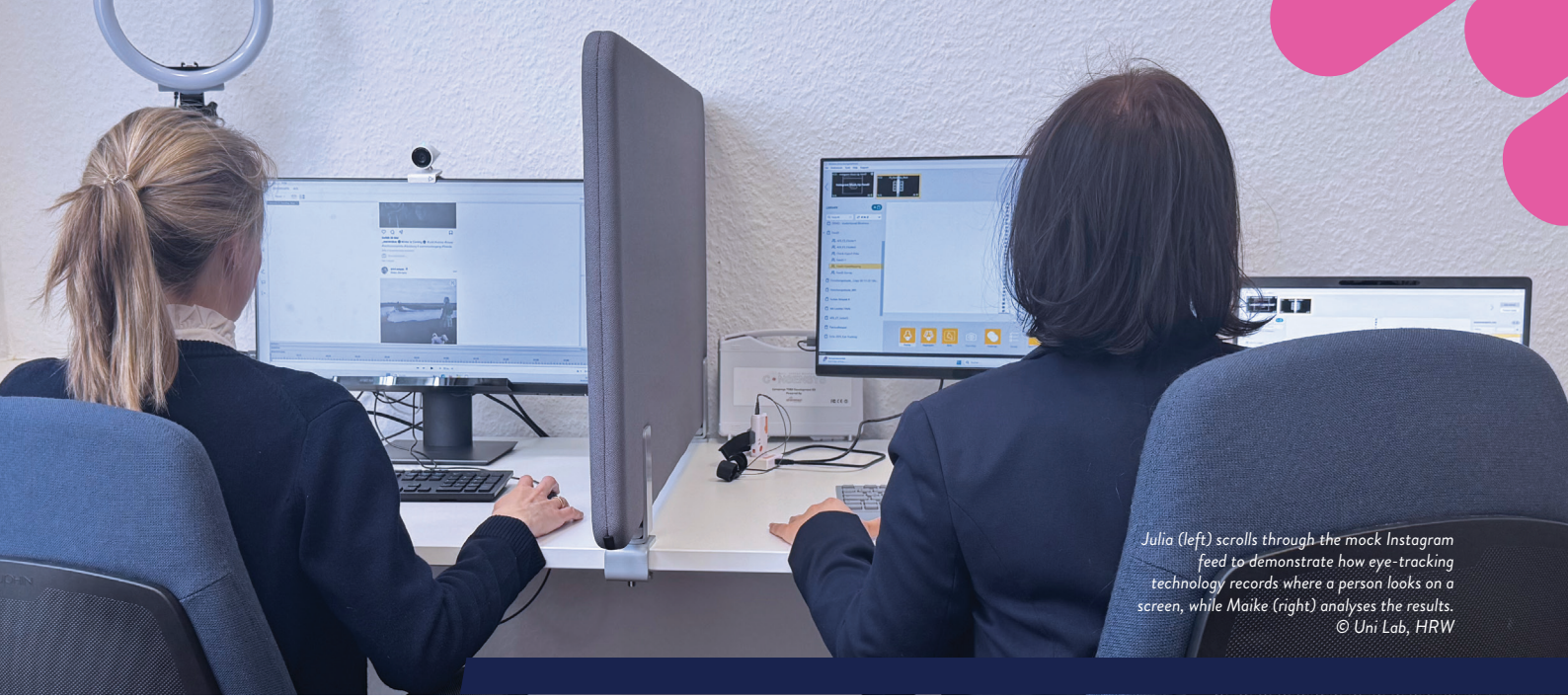
Native ad – an advertisement designed to match the look and feel of surrounding content

Organic content – non-paid social media posts, such as content shared by users or brands without paying the social media platform or influencers

Sponsored content – social media posts that brands pay a social media platform or influencer to share, such as adverts

Adverts are always evolving in response to societal changes, as advertisers create new ways to attract people's attention and encourage them to buy products. In recent years, social media has become a dominant influence in many people's lives. "Originally, when social media sites were viewed on computer screens, ads were often placed in banners at the top or side of the screen," says Dr Maike Hübner, a behavioural scientist at Hochschule Ruhr West University of Applied Sciences. "However, viewers learnt to ignore these areas – a behaviour called 'banner blindness'." And today, most people use social media on their phone, where screen space is much more limited.

These developments and behaviours made banner ads less effective, so advertisers needed new ways of getting users' attention – and 'native ads' were born. "A native ad is an advertisement that looks like normal platform content," says Maike. "Instead of appearing as a separate commercial, it is placed directly into a social media feed, so it blends in with posts from friends or influencers."



Julia (left) scrolls through the mock Instagram feed to demonstrate how eye-tracking technology records where a person looks on a screen, while Maike (right) analyses the results. © Uni Lab, HRW

Going native

Most people disengage from a social media post when they recognise it as advertising, which is why native ads try to blend in. "Brands have approximately 1.7 seconds to capture users' attention before they scroll on," says Maike. "Because native ads are designed to look similar to regular posts, they can be harder to recognise quickly, potentially allowing them to be processed more like regular content."

However, native ads are not allowed to go fully in disguise. "If you cannot tell that something has commercial intent behind it, you cannot judge it critically," explains Professor Julia Thalmann. "Clear labelling of sponsored content helps users make informed decisions." This is why most countries have laws about advertising transparency which require native ads to include a disclosure – a label such as 'sponsored' or 'ad'.

This creates what researchers refer to as the 'disclosure dilemma' – it is important that adverts are transparent so viewers know they are being advertised to, but when they realise they are being advertised to, they will often disengage. Maike and Julia wanted to disentangle the dynamics of the disclosure dilemma in native advertising.

Making an Insta-sham

Maike and Julia conducted an experiment to observe how viewers engaged with native ads. First, they created a mock Instagram feed containing 29 posts about common Instagram themes (e.g., travel, fashion, lifestyle). Eight of these posts were real native ads published by brands, and the remaining 21 were real organic posts.

Then, participants were asked to scroll through the mock feed and interact with the posts naturally, as though this was their personal Instagram feed, while Maike and Julia recorded their gaze using eye-tracking technology. "Eye-tracking technology uses infrared light to track where a person is looking on a screen by detecting reflections from the eyes," explains Julia.

Maike and Julia defined 'areas of interest' within Instagram posts, such as image, profile information, and 'like' and 'share' icons, plus advertising-specific elements such as disclosures and call-to-action buttons like 'shop now'. "Using eye-tracking metrics, we could assess attention allocation on each area of interest, revealing which post elements attract users' gaze, in which order, and for how long," says Julia.

Maike interviewed the participants after they had scrolled through the mock Instagram feed and asked them to explain what they were thinking while they looked at each post and why they engaged with it or scrolled past. "Someone might skip a post because they recognise it as an ad, because it is not relevant to their interests, or simply because they are scrolling quickly," says Maike. "Combining eye-tracking data with these interviews helped us understand both *what* people did and *why* they did it."

Are you being influenced?

This combination of data led to some interesting findings. "People spent less time looking at sponsored posts than organic ones," says Maike. "When they noticed a 'sponsored' label or call-to-action button, they usually stopped engaging with the post." However, if they did not notice these cues, many people interacted with native ads in the same way as organic content. "In the interviews, several participants said they scroll so quickly that they rarely pay attention to disclosures," says Maike. "This suggests that advertising can influence people even when they are not aware of it."

This raises questions about whether current disclosure rules are sufficiently robust to help consumers easily recognise sponsored content. To design digital spaces that are both engaging and transparent, it is important to understand how viewers interact with native ads. "Our research shows that transparency and engagement are closely linked," says Julia. "Advertisers can benefit from our findings by making adverts visually clear and honest rather than trying to blend in unnoticed, as transparency builds trust."

Maike finishes with advice to help you develop your own consumer literacy: "Recognising ads is not just about spotting disclosures or call-to-action buttons, it's also about asking questions," she says. "Ask yourself, what is the intent behind this post? Is someone trying to sell me something, promote an idea or influence how I feel? And why do I like or want this? Is it genuinely useful, or am I just afraid of missing out? Consumer literacy is about staying curious and reflective. Taking a moment to question what you see and why you respond to it will give you more control over your decisions."

About *behavioural science*

Behavioural science is the scientific study of human behaviour, combining insights from fields such as psychology, sociology, neuroscience and economics. "Behavioural science helps us understand how people make decisions in real life," says Maike. "It is important that businesses understand consumer behaviour, because they often assume people make rational choices, but in reality, many decisions are made quickly and are based on habits or emotions."

Common lines of behavioural science research involve investigating how attention, perception and decision-making work – areas that are of high interest to advertising companies working out how to sell products. "Behavioural science is also important for consumer protection," says Maike. "It helps us identify when people may be misled or overwhelmed by information and how to support better decision-making."

Behavioural science is always evolving because the factors that affect our behaviour are always changing, especially technology. "Things like voice assistants, social robots and AI tools are being designed to seem more human," says Julia. "Behavioural scientists will study how people interact with these human-like technologies." Additionally, virtual reality is blurring the lines between physical and virtual interaction and opening the door for new forms of advertising, such as adverts being displayed within the virtual environments of computer games. These topics are all highly interesting and important to behavioural scientists as they help us navigate this new world.

Download Maike and Julia's resources from **futurumcareers.com/can-eye-tracking-uncover-the-secrets-of-social-media-advertising**

Pathway from school to *behavioural science*

"Behavioural science connects many fields, so combining different perspectives will help you understand how people behave and how systems, products and markets work," says Julia.

Subjects such as psychology and sociology will teach you about how people think, feel and behave, while business and marketing will teach you how organisations make decisions and how behaviour is studied in real-world settings.

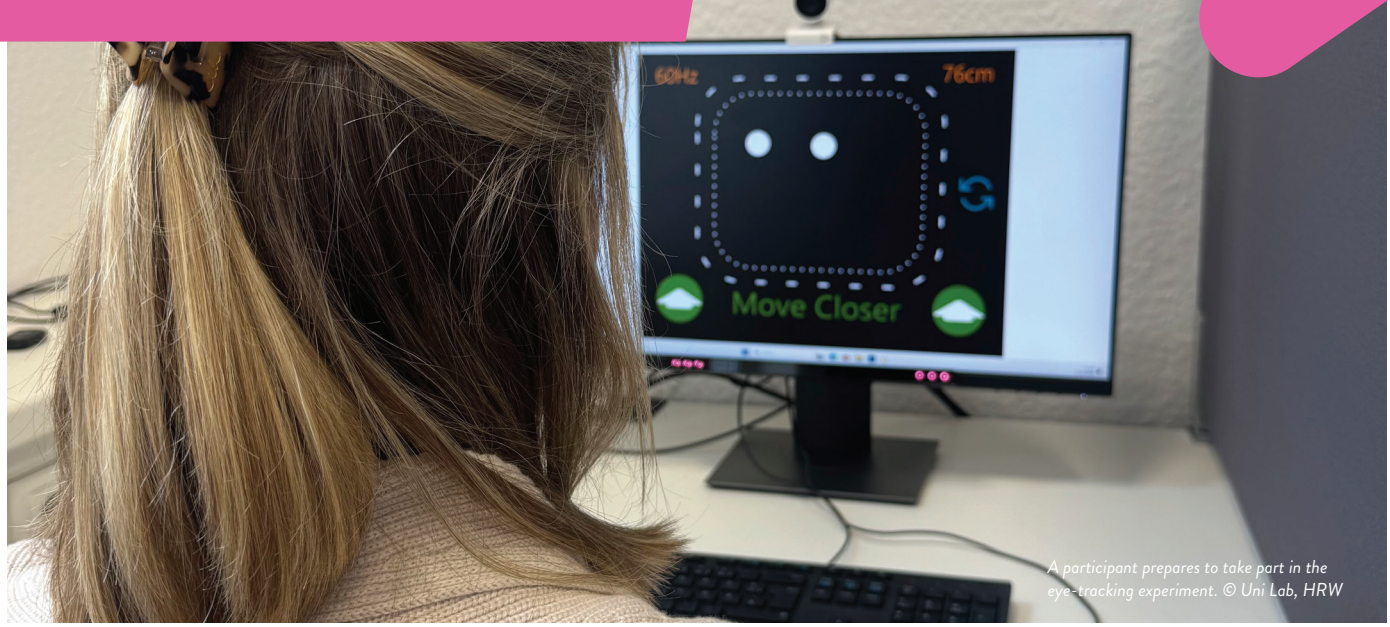
Learn statistics and data analysis skills as these are very important for analysing research data.

"Stay curious about how people think and behave," advises Maike. "And develop creativity and communication skills. Behavioural scientists work in teams across different disciplines, so being open-minded and collaborative is important."

Explore careers in *behavioural science*

Behavioural scientists understand human behaviour and decision-making, so are sought after in many different fields and industries. For example, you could work in advertising or marketing to persuade people to buy products, for a tech company to ensure that new technological innovations are user-friendly, for a political organisation to understand why people support different political parties, or for a healthcare organisation to encourage people to adopt healthier lifestyles.

This article introduces you to different career paths in behavioural science: **thedecisionlab.com/insights/hr/a-guide-to-career-paths-in-behavioral-science**



A participant prepares to take part in the eye-tracking experiment. © Uni Lab, HRW

Meet *Maike*

I've always been curious about why people do what they do. When I was at school, I also enjoyed creative subjects, and anything that let me question things and start a good debate.

Over time, I realised I was always the person asking "Why?" Why do people follow trends? Why do we trust certain messages? Why do people change their behaviour? When I discovered that the field of behavioural science is dedicated to studying exactly that, it felt like a natural fit.

I was motivated to study native ad engagement when I started noticing how often people around me referred to social media when talking about their decisions. Friends and family would say things like, "Someone I follow recommended this," or "This influencer uses that, so I tried it too." I found it fascinating and a bit strange how much trust people place in someone they have never met. I wanted to understand how this influence works and if these people fully realise they are being persuaded.

I spend much of my free time in my garden. I enjoy planting, harvesting and cooking with what grows there. I also love meeting friends to play board games and card games. And I will never say no to visiting a petting zoo and booping animal noses!

Meet *Julia*

As a teenager, I was fascinated by branding and retail advertising, and I was curious about how businesses work behind-the-scenes. At the same time, I wanted to explore the world and experience new cultures.

I spent several years working in the marketing industry. At the manufacturing company Henkel, I worked in sales, brand management and marketing, and later at the pharmaceutical company Johnson & Johnson, I managed retail accounts and commercial planning. These roles gave me a strong understanding of how consumer psychology, retail structures and strategic decision-making interact.

I actively use social media across various platforms, both professionally and personally. I am mindful about the content I consume and the time I spend online. Given my academic focus, I am very aware of how algorithms, recommendation systems and profiling mechanisms operate.

I recharge the most when spending time with family and close friends. I enjoy exploring new things – from trying out new recipes to travelling somewhere unfamiliar. Being active outdoors, especially hiking, skiing or running, gives me energy and perspective.

Maike's *top tips*

1. Embrace being the person who asks questions, especially when others might hesitate.
2. If something feels strange, unclear, or overly persuasive, take a step back and try to understand the underlying reasons.
3. Remember that it's okay to be different, to challenge ideas, and to question the status quo.

Julia's *top tips*

1. Never stop learning. AI, digital platforms and consumer research are evolving rapidly, so continuous learning is essential.
2. Go international because living and working abroad builds perspectives and adaptability that last a lifetime.
3. Take responsibility. Leadership grows through experience, so step into projects that challenge you.

Caught in the algorithm: exploring smartphone use in young people

Many of us spend more time on our phones than we would like. The compulsion to check social media, watch a new reel, or keep on scrolling is hard to resist, and there is growing evidence that this is having negative effects on our health. Young people, whose brains are still developing, are potentially especially at risk. At the **Université du Québec à Trois-Rivières** in Canada, **Dr Roseane de Fátima Guimarães** is examining the relationships between young people and their phones, and how we can make them healthier.

Dr Roseane de Fátima Guimarães, PhD

Research Chair on Youth Lifestyle Habits and Health, Department of Physical Activity Sciences, Université du Québec à Trois-Rivières, Canada

PROFILE

Field of research
Health and physical education

Research project
Exploring determinants and factors associated with problematic smartphone use among youth

Funders
Social Sciences and Humanities Research Council of Canada (SSHRC); Research Network on Cardiometabolic Health, Diabetes and Obesity; Ministère de l'Éducation du Loisir et du Sport in Québec; Fondation de l'Université du Québec

doi: 10.33424/FUTURUM689

Talk like a ...

health and physical education researcher

Biostatistician – someone who performs statistical analyses on data collected from medical and biological studies

Dopamine – a chemical messenger made in the brain that gives feelings of pleasure and satisfaction, among many other roles

Prefrontal cortex – the front part of the brain that helps manage thinking, emotions and behaviour

Problematic smartphone use (PSU) – the compulsive use of smartphones that disrupts an individual's daily life, work and relationships

Socio-demographic characteristics – attributes that can be used to segment populations in different ways, such as age, gender, education level and income

Many people spend hours a day on their smartphones – but where is the line drawn between healthy and problematic levels of use? "Problematic smartphone use, or PSU, is broadly defined as a compulsive pattern of smartphone use that interferes with daily functioning, work or academic performance, and social relationships," says Dr Roseane de Fátima Guimarães of the Université du Québec à Trois-Rivières. "Specifically, this might include difficulty concentrating on other tasks, using a device longer or more frequently than intended, or physical signs of overuse, such as wrist or neck pain."

PSU appears to be on the rise, and many people are worried about its effect on society, especially the negative impact it is having on young people. Roseane is spearheading a landmark study to investigate PSU in young people, drawing on a wide range of data to understand the factors that might make youngsters vulnerable to PSU, as well as the effects of PSU on their well-being. Her research could lead to strong, evidence-based recommendations for addressing PSU at every level, from individual decisions to public policy.

Teenage troubles

Children and teenagers are potentially particularly vulnerable to the temptations that smartphones offer – and the long-term effects on health and development. "At these ages, the brain is still developing and is highly

plastic," says Roseane. "The adolescent brain has a strong desire for rewards, limited behavioural control and a high sensitivity to experiences." In particular, the prefrontal cortex, responsible for behavioural control and decision-making, is still maturing.

"The younger brain is particularly sensitive to dopamine," says Roseane. "As a result, smartphone and social media use may feel especially appealing." This means that teenagers may find it especially challenging to regulate smartphone use, given it provides a readily accessible dopamine fix. "It's not surprising that adolescents may use their smartphones excessively, even when they are aware that it may negatively affect their health," says Roseane.

SMARTKids Québec

To learn more about PSU and how to address it, Roseane has been piloting the SMARTKids Québec study, which explores the factors associated with PSU in young people. "The study includes presenting 250 students from primary and secondary schools in Québec with a wide-ranging questionnaire," she explains. "Questions cover areas such as socio-demographic characteristics, smartphone habits, physical activity, sleep duration, depression and anxiety, self-esteem and academic performance."

Once they have collected the data, Roseane and her team analyse them with the help of a biostatistician. "The team organises and prepares the databases and develops a detailed analysis plan for each research question," explains Roseane. "The biostatistician ensures that the data structure is high-quality and that the statistical methods we use are appropriate." The study takes advantage of a pivotal policy moment: since the 2025 academic year, Québec has banned smartphones in schools – creating unique 'before and after' scenarios that can capture how the ban affects PSU.

The chicken and the egg

Roseane and her team have uncovered many interconnected factors that appear associated with PSU. "Psychological vulnerabilities such as depression or anxiety can lead adolescents to use smartphones as a coping mechanism," says Roseane. "Sleep problems often reinforce excessive use, while developmental factors make adolescents more vulnerable due to their still-developing self-control." There are plenty of other factors too: families with poor communication, parental conflict, or family members with heavy smartphone use all increase the risk of PSU, while supportive relationships reduce it. "Lifestyle habits like low physical activity, high recreational screen time and sedentary behaviour all further contribute, as does gender, with screen time higher amongst boys than girls," says Roseane. "Overall, it's clear that PSU arises from the interaction of many psychological, social and behavioural factors, rather than a single cause."

The team is also drawing conclusions about how PSU affects participants' quality of life. "Impacts affect both physical and mental health, as well as academic performance," says Roseane. "Impaired concentration, memory and attention are all common." It also appears that PSU may lead to sleep problems and sedentary behaviour – which raises the 'chicken-and-egg' question. "It's difficult to determine cause and effect," says Roseane. "PSU may worsen these issues, or it may be that youth already experiencing these issues are more likely to engage in PSU."

Tackling PSU

Addressing this dilemma is one key focus for the next stage of the team's work. Québec's smartphone ban in schools may help tease out these relationships, given that smartphone use is expected to drop overall, and is something that team member and PhD student Robin Chaverot is investigating for his thesis. "We will focus on the factors most closely associated with PSU, such as disrupted sleep, academic performance and mental health symptoms," explains Robin. "This will help us identify both risk and protective factors to guide evidence-based recommendations." The team is also well-aware of newer technologies that are changing how teenagers interact with the world. "We anticipate expanding our scope to include AI chatbots," says Robin. "These are increasingly relevant for public health and likely to soon come under regulation."

In the meantime, Roseane has some advice for young people who are worried about their smartphone use. "Try setting limits on social media use and prioritising real-world activities like physical exercise, outdoor walks and meeting friends in person," she says. "Build your self-regulation skills, develop healthy routines and nurture supportive family or peer environments."

About *health and physical education*

Health and physical education is a broad field, focusing on educating different groups of people – from the general public through to policymakers – about how to look after their health and physical fitness.

Interdisciplinarity is critical and is becoming ever-more ingrained in the field. "Combining exercise science, nutrition and psychology, for example, creates opportunities to develop innovative programmes and interventions that can have a real impact on communities," says Roseane.

The world is always changing, both in terms of technology and societal priorities. "Wearable devices and AI tools allow us to collect and analyse data in ways and scales that were never before possible," says Roseane. "There is also growing emphasis on mental health and social determinants of health, which opens up new avenues for research." New tools and knowledge are creating a rich arena for future research opportunities in the field.

Educating others is what motivates Roseane and her research. "The moment of knowledge transfer, when our findings change into something meaningful for people, is incredibly fulfilling," she says. "On a more personal level, seeing a student graduate is also deeply rewarding, because it shows the impact of mentorship and education alongside research."

Download Roseane's resources from **futurumcareers.com/caught-in-the-algorithm-exploring-smartphone-use-in-young-people**

Pathway from school to *health and physical education research*

Roseane recommends building a strong foundation in biology, chemistry and physical education at school.

At college, courses such as exercise science, anatomy, physiology, psychology, nutrition and research techniques can all build appropriate knowledge.

Roseane highlights gaining a university degree in physical education, kinesiology or health sciences as a useful pathway. Other subjects such as motor learning, public health and epidemiology can provide valuable expertise in the field too.

Explore careers in *health and physical education research*

Roseane recommends seeking practical experience via internships, volunteer programmes or community health projects.

Connecting with professional organisations can provide rich resources, networks and opportunities. For instance, PHE Canada provides a huge range of physical and health education learning activities: **phecanada.ca**

ParticipACTION is a Canadian charity that promotes physical activity. Its website provides a wide range of resources to help you understand the underlying science and connect with professionals: **participaction.com**

Meet *Roseane*

As a child, I enjoyed playing piano and bass. I also loved swimming and spending time outdoors. My secondary school biology teacher, who was also passionate about sports, greatly influenced me through nurturing my interest in human physiology and how the body works. That inspired me to pursue a career in physical education.

I worked as a physical education teacher in schools in Brazil. This experience shaped my career; I saw first-hand how many children, especially adolescents, were not active enough. This inspired me to pursue a master's degree on how physical activity and sedentary behaviour impact children's and teenagers' cardiometabolic health.

My master's research revealed a need for intervention. Adolescents consistently had the poorest profiles across many age groups. This became the foundation of my PhD project: a school-based programme designed to improve health indicators and promote healthier lifestyles among adolescents.

To pursue my postdoctoral training, I moved to Canada. In the final year of my postdoc, I secured a professor position – a proud career moment. I am also proud of building a strong research team and obtaining funding so we can conduct high-quality research.

I aim to provide high-quality training for my students to prepare them for their careers. I want to continue building strong, applicable research and develop recommendations to promote healthy lifestyles in children and youth. I want to help people improve their well-being and overall balance in daily life.

I try to maintain an active lifestyle myself. It keeps me fit and helps me disconnect and recharge. I also value spending time with family, which helps me maintain balance.

Roseane's *top tips*

1. Stay curious and step out of your comfort zone.
2. Seek opportunities for exchange experiences – they are incredibly enriching.
3. Networking, collaborating and meeting new people can open new perspectives and help shape your career.

Meet *Robin*

Robin Chaverot, PhD student, Interdisciplinary Doctoral Program in Health and Society, Université du Québec à Trois-Rivières

During high school, I studied marketing. I discovered strategies to influence the brain, with the objective of encouraging users to consume – known as neuromarketing. These days, I am studying closely related fields.

I entered university in the field of sport sciences. I quickly developed a passion for physical education and health. After a few years working in education and knowledge sharing about good sporting practices and healthy lifestyle habits, I decided to pursue research.

I have always been interested in the mechanisms behind the addictive power of technologies. Research into the effects of television on neurological and psychological indicators of health fascinates me. As digital tools have become ever-more prevalent, my interest in their relationship with our health and how they are regulated has only grown.

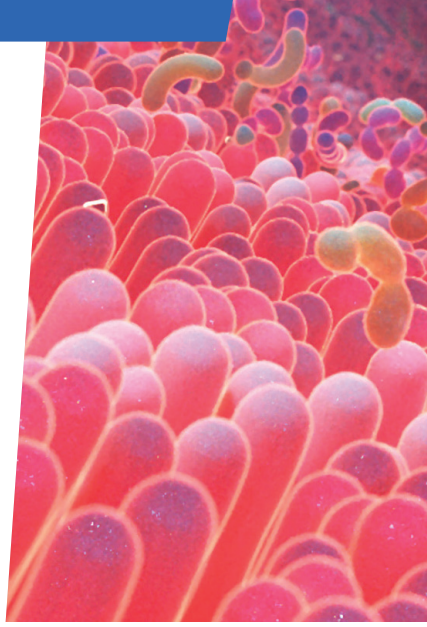
It's important to be passionate about one's research. Research is a long-term commitment; it requires close collaboration, organisation, leadership and motivation. Key to success is continuing to learn. A doctoral student must master research methodology, statistics, scientific writing and dissemination of knowledge, among many other skills.

Undertaking my PhD allowed me to migrate to Canada. Here, I discovered a new university, a new research laboratory and a very different way of working. This doctoral programme has allowed me to collaborate with people from diverse backgrounds – a hugely formative experience, both professionally and personally. Meeting new people at conferences and various scientific events is highly enriching for an academic career.

After my PhD, I want to become a teacher-researcher in academia. My goal is to continue to conduct research projects while teaching students. Above all, I hope to keep contributing to the expansion of scientific knowledge on screen use, and to help build recommendations for public health authorities.

Robin's *top tips*

1. Trust yourself.
2. Do not give up when you encounter obstacles.



Can microbes in a baby's gut prevent food allergies?

Food allergies are becoming increasingly common in children, yet scientists still do not fully understand why some infants develop allergies while others do not. At the **University of Rochester** in the US, **Professor Kirsi Järvinen-Seppo** and **Dr Erin Davis** are investigating how an infant's gut microbiome influences their risk of developing food allergies.

Professor Kirsi Järvinen-Seppo

Chief of Pediatric Allergy and Immunology

Dr Erin Davis

Postdoctoral Fellow

Department of Pediatric Allergy and Immunology, University of Rochester, USA

Fields of research

Paediatric allergy; immunology

Research project

Investigating how the infant gut microbiome and early-life exposures influence immune development and the risk of food allergies

Funders

US National Institutes of Health (NIH); National Institute of Allergy and Infectious Diseases (NIAID); US Department of Agriculture (USDA); Janssen R&D

doi: 10.33424/FUTURUM696

PROFILES

Talk like an ... immunologist

Allergen – a substance, such as a protein in food, that can trigger an allergic reaction in some people

Antibody – a specialised protein made by the immune system that recognises and helps neutralise harmful substances such as bacteria or pathogens

Gut barrier – the protective lining of the intestines that controls what substances enter the bloodstream

Gut microbiome – the community of microorganisms, including bacteria, viruses, fungi and archaea, that live in the digestive tract

Perinatal antibiotics – antibiotics given to a mother or infant shortly before, during or after birth

Sensitisation – the process by which the immune system becomes increasingly reactive to a substance after initial exposure

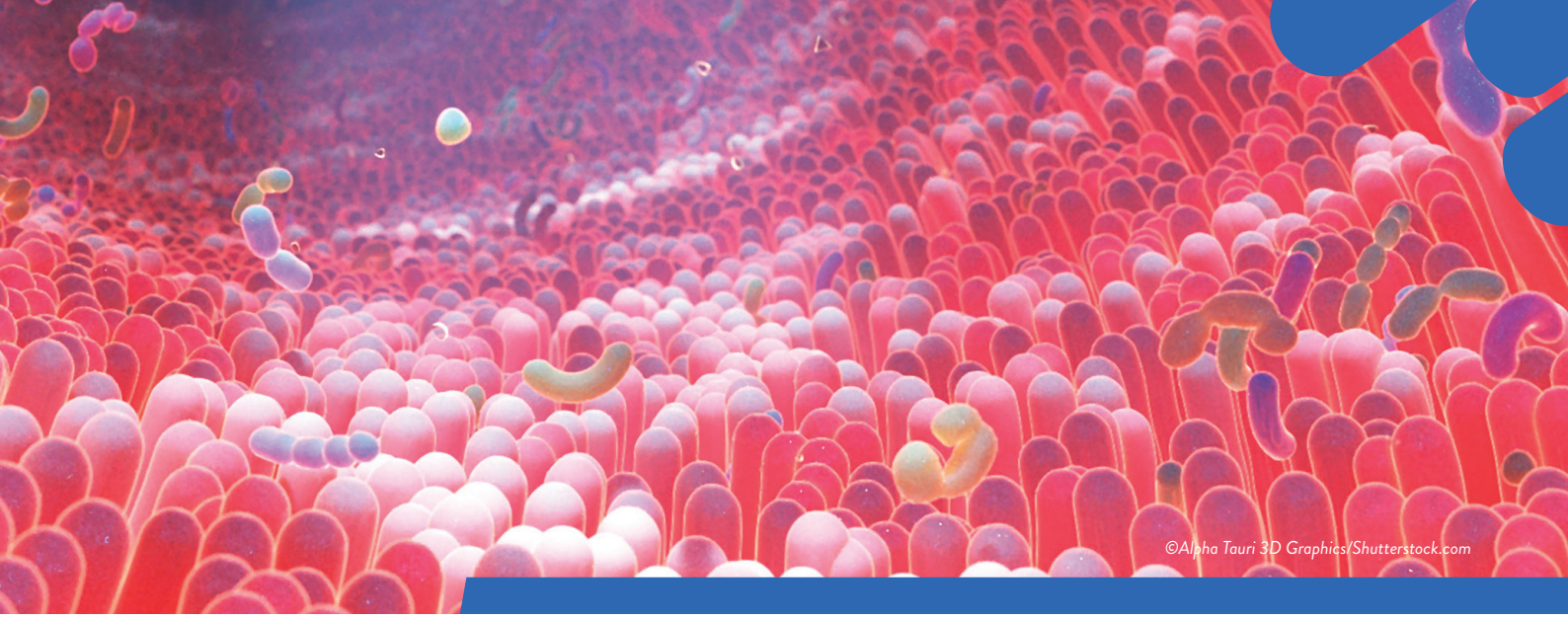
Tolerance – the immune system's ability to recognise a substance as harmless and avoid reacting to it

Around 1 in 13 children experience food allergies, making them one of the most common chronic health conditions affecting young people. They occur when the immune system reacts to certain foods as if they were harmful, even though they are usually safe to eat. For example, some of the most common food allergies are caused by proteins found in cow's milk, eggs, peanuts, wheat and fish.

Some allergic reactions happen quickly and can cause symptoms such as vomiting, coughing or wheezing. Other reactions develop more slowly and may involve stomach pain, diarrhoea or bloody stools. "Genetic predisposition to allergic disease plays a big role in the development of food allergies," says Professor Kirsi Järvinen-Seppo at the University of Rochester. "However, exposure to perinatal antibiotics, the make-up of the infant gut microbiome and the timing of exposure to specific food allergens have also been shown to have a significant effect."

Why does the immune system sometimes mistake food for a threat?

The immune system is designed to protect the body from harmful invaders such as bacteria and viruses. However,



in people with food allergies, this system reacts to harmless food proteins as if they were dangerous. One important factor influencing this process is how the body first encounters a food. "For example, skin exposure to food allergens is more likely to lead to a child developing an allergic reaction, whereas oral exposure is more likely to lead to them developing tolerance," explains Kirsi.

What is the gut microbiome and how could it influence food allergies?

"The gut microbiome is the collection of microorganisms that live in our gastrointestinal tracts," explains Dr Erin Davis, a postdoctoral fellow in Kirsi's laboratory. Although some microorganisms are present in everyone's gut microbiome, the specific amounts and types of bacteria in each of our guts is unique and changes as we grow. For example, a child's gut microbiome is often less diverse but more dynamic than an adult's, with the diversity increasing as they are exposed to more environmental and dietary factors. A child's gut microbiome begins to stabilise at around two years old, but will continue to change throughout their adolescence.

"Our gut microbiomes play a vital role in digesting nutrients such as fibre, protecting us from harmful pathogens, synthesising vitamins, influencing the nervous system and shaping our immune responses," says Erin. Because of these important functions, scientists have linked gut microbiome composition to several health conditions, including allergic diseases. Studies have shown that infants who develop food allergies often have different levels of certain gut bacteria compared to those who do not. However, researchers are still working to understand exactly how these microbes – and the molecules they produce – interact with the immune system to either protect against allergies or increase the risk of developing them.

How do allergy rates differ between farming and urban communities?

Scientists have noticed that children raised in rural farming communities often have lower rates of allergic diseases and asthma than those growing up in cities. Kirsi's lab studied infants from a traditional farming community known as the Old Order Mennonites in Western New York and compared them with infants living in urban environments.

"We found that by 12 months of age, only 3% of infants in the Old Order Mennonite farming community had atopic eczema, an inherited skin condition, and none had food allergies," says Kirsi. "In contrast, among urban infants at high risk of allergic disease, 25% had atopic eczema and 11% had food allergies."

Although the reasons for these differences are not yet fully understood, the team has found that immune cells and antibodies vary between farming and urban infants. They believe that differences in the gut microbiome and early-life exposure to certain foods, including breast milk, may help explain these patterns.

How does breast milk influence food allergy development?

Breast milk plays an important role in shaping an infant's gut microbiome, which is essential for healthy immune development. "It contains oligosaccharides, a type of carbohydrate, that are not digestible by the infant but can be broken down by certain bacteria," says Erin. "In breaking down breast milk oligosaccharides, bacteria can produce metabolites that may reinforce the infant's gut barrier and potentially increase their tolerance to certain foods, protecting against food allergies."

Breast milk can also contain antibodies that recognise food proteins, which may help protect infants from developing allergies. A mother's diet can influence the composition of her milk – for example, eating certain foods may increase the levels of related antibodies or nutrients, such as fatty acids. Kirsi's lab found that women living in traditional farming communities produce breast milk with different levels of antibodies, fatty acids and oligosaccharides compared to women living in urban environments, which may contribute to differences in allergy risk.

How could the team's research help prevent food allergies in the future?

"Our programme is focusing on the prevention of food allergies," says Kirsi. By identifying early-life exposures, like the healthy infant microbiome, that help the immune system develop tolerance to foods, her team hopes to design new strategies that reduce the risk of allergies in infants. At the same time, they are working to identify biomarkers – measurable signs that show whether a child is developing tolerance or sensitisation to certain foods – which could help doctors monitor prevention strategies and identify infants at higher risk.

About *paediatric allergy and immunology*

The intersection of paediatric allergy and immunology involves investigating how the immune system develops and reacts to allergens in children. Over the past few decades, the field has advanced rapidly. "When I started practising food allergy, we had no therapies available except strict avoidance of trigger foods and preparation to treat reactions," says Kirsi. Today, several treatments exist to manage food allergies, and promising prevention strategies are being developed.

Working in this area comes with unique challenges. Accessing the human tissues involved in allergic reactions, such as the intestinal tract, is complicated, making it difficult to study the underlying mechanisms. Researchers are developing innovative laboratory models, such as artificial guts, to simulate these tissues and test potential treatments. Scientific research also requires persistence, as experiments or analyses do not always go as planned. "Getting experience in a research laboratory and getting used to working through and learning from setbacks will be invaluable," says Erin. "Surrounding yourself with supportive colleagues will make working through any challenge far easier."

A typical day studying paediatric allergy and immunology involves a mix of lab work and data analysis. "Much of my day is currently spent performing statistical analyses on data we have generated in the lab, creating scientific figures, discussing results with colleagues, presenting findings at meetings or conferences, and writing papers to hopefully get those data published," says Erin. "Earlier in my career, I also spent time preparing samples, performing experiments and mentoring students in the lab."

Download Krisi and Erin's resources from **futurumcareers.com/can-microbes-in-a-babys-gut-prevent-food-allergies**

Pathway from school to *paediatric allergy and immunology*

Study science subjects at school, such as biology and chemistry, to prepare for further study at college or university.

Conducting research in a laboratory as a high school or undergraduate student, or participating in a summer research programme, can also be valuable, whether you are aiming for a clinical or research-focused career.

Explore careers in *paediatric allergy and immunology*

Organisations such as the American Academy of Allergy, Asthma and Immunology (**aaaai.org**), the European Academy of Allergy and Clinical Immunology (**eaaci.org**) and the American Association of Immunologists (**aai.org**) provide useful information for students interested in paediatric allergy and immunology.

"There are numerous careers in paediatric allergy and immunology, including those that treat patients in a clinical setting, such as a physician, nurse or dietitian," says Erin. "You could also work as a scientist, either conducting research at an academic institution or working at a company developing therapeutics to prevent allergic disease."

"My tip is to get as much exposure as possible," says Erin. "Reach out to a paediatric allergist or immunologist in your local community or university and see if you can shadow them in clinic or work in their lab if they are conducting research."

Meet *Kirsi*

I grew up in Finland and was interested in being a good student so that I could make it into medical school. I had no idea about biomedical research and only discovered that pathway later.

I love learning from my patients and understanding what they and their families need. Then I can try to answer their questions with the help of my research team and hopefully get some solutions back to the clinic. I enjoy that every day is different, and that I can move the field forward with my persistence.

> ***Curiosity, courage, integrity, persistence and kindness have allowed me to lead a successful career.***

The possibility to advance medical knowledge and make a big impact in the lives of children with allergies is motivating for me. I love being able to do translational research in my laboratory where we work on clinically important questions.

Curiosity, courage, integrity, persistence and kindness have allowed me to lead a successful career. Being trained by excellent scientists and clinicians, and engaging in professional opportunities, such as presenting at conferences, reviewing grant applications and networking, have also been key.

To unwind from work, I exercise, listen to music, do gardening, travel, and spend time with family and friends.

Kirsi's *top tip*

Look for a role model who can train you.

Meet *Erin*

For as long as I can remember, I have been interested in paediatric chronic disease prevention. This is probably because I grew up watching my parents, both paediatric healthcare professionals, take care of chronically ill children. I wanted to understand how to stop diseases before they started, or at least decrease associated symptoms. It wasn't until I started doing clinical nutrition research in college that I realised that I wanted to engage in the field from a nutrition perspective. I became particularly interested in infant nutrition and the microbiome because nutrition is the principal driver of infant microbiome composition, which is associated with short- and long-term health and susceptibility to multiple diseases, including allergies.

I love working as a team with my colleagues to discover something new – information that inches us just a little closer solving the puzzle that is early allergic disease development. The long, spontaneous conversations in the lab about a new piece of data or hypothesis that has us buzzing are some of my favourites.

I am motivated by the potential to develop strategies to prevent the onset of these allergic diseases, allowing children to lead healthy lives and enjoy all activities, experiences and foods without worrying about or feeling the daily burden of their disease.

I'm a nutrition scientist by training, so I had a steep learning curve when joining an immunology lab for my postdoctoral research. My curiosity and communication skills continue to help me engage effectively with my colleagues, ask a lot of questions, gather and learn new information quickly, and collaborate effectively. Supportive environments, colleagues and mentors have also been exceptionally important in the success I have had so far.

I'm a foodie. When I'm not working, you can often find me at a new or well-loved local restaurant, watching cooking videos, or cooking in my own kitchen with a nice vinyl record on in the background.

Erin's *top tip*

Reach out to clinicians or researchers. They can connect you with other trainees in the field and refer you to relevant, credible sources of information and research for you to explore.

What are the links between childhood stroke and epilepsy?

Strokes are most often associated with older adults, but they can happen to babies, children and teenagers too. Although they are rare, childhood strokes can have serious long-term effects, with one in three children going on to develop seizures and epilepsy. At the **University of California, San Francisco** and **Benioff Children's Hospital** in the US, **Dr Christine Fox** is exploring how the brain heals itself after a childhood stroke and uncovering how this can lead to epilepsy.

Dr Christine Fox

Professor, Department of Neurology, University of California, San Francisco (UCSF)
Director, Pediatric Stroke and Cerebrovascular Disease Center, Benioff Children's Hospital, California, USA

Field of research
Paediatric vascular neurology

Research project
Investigating how childhood stroke leads to epilepsy through the Seizures and Children's Outcomes after Stroke (SCOUTS) Study

Funders
US National Institutes of Health (NIH); American Heart Association; Pediatric Epilepsy Research Foundation

This work is supported by the NIH-NINDS under award number R01NS119896. The contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH.

Website
pediatricstroke.ucsf.edu

doi: 10.33424/FUTURUM703

PROFILE

Talk like a ... paediatric vascular neurologist

Cognitive – relating to mental processes including thinking, learning, memory and understanding

Epilepsy – a neurological condition where a person has repeated, unprovoked seizures

Haemorrhagic – caused by bleeding, especially from a ruptured blood vessel

Ischemic – caused by a blockage that reduces or stops blood flow

Neurology – the field of medicine that studies, diagnoses and treats disorders of the nervous system, which includes the brain, spinal cord and nerves

Paediatric – the treatment and medical care of children

Stroke – a medical emergency where blood flow to part of the brain is suddenly interrupted or reduced

Seizure – a sudden burst of abnormal electrical activity in the brain that can affect movement, behaviour or awareness

Around one in four adults will have a stroke in their lifetime, and the risk of having a stroke increases with age. But children can experience strokes too. "Although strokes occur more commonly in adults, a stroke can affect people of any age, including babies, children and teenagers," says Dr Christine Fox from the University of California, San Francisco. "Childhood strokes are rare, but can lead to later complications, with roughly one in three patients developing epilepsy."

What is stroke?

There are two main types of stroke: ischemic stroke and haemorrhagic stroke. While ischemic strokes are caused by a blocked blood vessel, haemorrhagic strokes are caused by bleeding in the brain. "Strokes in children often have different causes than those in adults," says Christine. "Some children have a stroke because of conditions such as heart defects, blood-clotting disorders or a blood vessel malformation in the brain. Sometimes, a stroke will happen in someone who is healthy but gets an infection or injury that damages blood vessels in the head or neck."

The common signs of a stroke for adults – face drooping, arm weakness, slurred speech, dizziness, headaches – may differ for babies and children. "Childhood strokes are

Christine is studying the links between childhood stroke and epilepsy. © UCSF

often misdiagnosed at first because most people don't expect them," says Christine. "Younger children can't describe what they're feeling, so symptoms may seem vague and are easily mistaken for other, more common conditions like migraines." These misdiagnoses can delay treatment.

"Identifying a childhood stroke as quickly as possible is crucial because the brain is extremely sensitive to losing blood flow, and every minute of delay can lead to more damage," says Christine. Fast diagnosis allows doctors to begin treatments that restore blood flow, improve recovery and give the brain a better chance to heal.

Once the initial emergency is over, doctors focus on protecting the patient's brain from further complications and diagnosing the cause to prevent more strokes from happening. Longer term, the priority shifts to rehabilitation. "This can include physical therapy, speech-language therapy and occupational therapy to help with movement and daily tasks," says Christine. "Children's brains are still developing, which affects how they respond to injury and how quickly they recover. The good news is that a child's brain has a strong ability to adapt. With early treatment, rehabilitation and support, many young people can regain skills and continue to lead active, fulfilling lives."

What are the VIPS studies?

The international research projects VIPS I and VIPS II (Vascular Effects of Infection in Pediatric Stroke) took place between 2010-2014 and 2016-2022 and explored whether common colds or viruses could contribute to ischemic childhood stroke.

"The VIPS studies provided strong evidence that minor infections can trigger stroke in children," says Chrisine. "There is nothing unusual about the infections themselves, so further analyses are underway to uncover whether there is something unusual about how the body responds to infection that leads to stroke."

What are the links between childhood strokes and epilepsy?

About one in three children who have strokes will go on to develop epilepsy, which is far higher than in adults who have strokes. Epilepsy can be caused by brain injuries and people with epilepsy experience repeated seizures. "Injured brain tissue is more likely to produce abnormal electrical signals, even after it heals," says Christine. "Epilepsy can start weeks, months or even years after a stroke."

It is hard to know when a seizure will happen, which can make living with epilepsy tough. "Some children worry that a seizure might happen in public, which can make it harder to concentrate or feel confident in new situations," says Christine. "Seizures and the fear of having them can influence daily life, school, friendships and confidence." Some seizures may lead to injuries caused by falling, and anti-seizure medications can cause tiredness, mood swings and cognitive difficulties.

The SCOUTS study

Christine is leading the SCOUTS (Seizures and Children's Outcomes after Stroke) study, which is trying to understand how the brain recovers after a childhood stroke. She is exploring whether inflammation, which occurs when the brain is healing, might impact the likelihood of epilepsy. "From studies in animals, we know that certain inflammatory responses in the brain after a stroke can influence the chance of developing epilepsy," says Christine. The SCOUTS study is also identifying which connections in the brain, known as neural networks, are more likely to trigger seizures after a stroke.

"In this study, we are analysing brain images and information about inflammatory markers that were collected from children at the time that they were enrolled in the VIPS studies," says Christine. "We are collecting new data from those same children, years later, about whether they have developed epilepsy as well as asking about other physical, cognitive and emotional outcomes."

What are the next steps?

Christine is exploring the differences in the brains of children who develop epilepsy after a stroke compared to those who do not. "The SCOUTS study will help us find ways to predict who is most likely to develop epilepsy after a stroke based on the neural networks that are injured or the inflammatory responses measured in their blood," she says. "In the long-term, we want to learn how to prevent post-stroke epilepsy. We hope to find treatments, like a medicine that targets a specific inflammatory response, that we can give to children who are at higher risk of epilepsy after a stroke."

About *paediatric vascular neurology*

"Paediatric vascular neurology is an exciting field because doctors and researchers are still discovering why strokes happen in children and how to treat them more effectively," says Christine. Childhood strokes are rare, so there is still a lot of research to be done, and working in the field provides the opportunity to carry out meaningful studies and shape future treatments.

For Christine, each day is varied as she splits her time between working with patients, conducting research and teaching students. "In my clinical practice, I am often faced with medical mysteries and challenged to think creatively," she says. "Working with medical students and neurology residents at different levels of training is rewarding, and as a researcher I get to collaborate with scientists around the world and contribute to research that can genuinely help children. My day-to-day work is highly collaborative, working with many other subspecialists like neurosurgeons, radiologists, intensive care specialists and therapists to name a few. Every day is a little bit different and offers a chance to learn something new."

Working with a rare disease presents practical problems, such as finding research funding, but the main challenges are on a human level. "Working in an intense hospital setting with children who have serious neurological injuries can be stressful, and, some days, the work is emotionally heavy," says Christine. "Part of my job is to have hard conversations with parents or kids who are scared, overwhelmed or grieving. While these aspects of my work are challenging, those challenges are also what make the work meaningful. I hope that I can give critical medical care, provide valuable information for families to understand and make medical decisions, and offer human comfort."

Pathway from school to *paediatric vascular neurology*

At school, subjects like biology, chemistry and physics can help you build a solid foundation. Developing communication and teamwork skills will also be beneficial.

At university, studying medicine and taking courses in neurology, paediatrics and research methods will build on these foundations.

Christine recommends developing traits such as curiosity, persistence and empathy. "It's also important to take care of yourself along the way, because medical training is long and can be demanding," she says. "Developing good study habits, time management skills and coping strategies for stress will serve you throughout your career."

"Get exposure to healthcare settings by volunteering at hospitals or shadowing doctors to help you understand what it's like to work with patients and families," suggests Christine. "Look for opportunities to get involved in research. This will help you build critical thinking skills and find out if you like the day-to-day work of a scientist."

Explore careers in *paediatric vascular neurology*

The UCSF Science & Health Education Partnership runs an eight-week summer internship programme for high school seniors in San Francisco (**sep.ucsf.edu/programs/high-school-students/intern-program**) and the UCSF Center for Science, Education and Outreach offers an eight-week summer enrichment programme for high school students (**cseo.ucsf.edu/cure-internship**). "Many other universities may have opportunities for high school students who are looking for exposure to careers in health or science," says Christine.

Explore the websites of the World Stroke Organization (**world-stroke.org**), the American Academy of Neurology (**aan.com**), the International Child Neurology Association (**icnapedia.org**) and the International Pediatric Stroke Organization (**community.internationalpediatricstroke.org**) for useful information, resources, career advice, and opportunities to volunteer and meet professionals in the field. You could even consider attending events or conferences to discover more.

Download Christine's resources from **futurumcareers.com/what-are-the-links-between-childhood-stroke-and-epilepsy**

Meet *Christine*

As a teenager, I loved to read and to play sports – volleyball, basketball, track and rugby. Playing sports and being physically active has always been helpful for me as a social outlet and to balance other interests with school and work. I would have experienced a lot more burnout if I did not have these fun outlets!

I love working with people. Some of my patients are healthy but have a stroke risk factor, and I teach them how to stay healthy. Some of my patients have had a stroke, and I am involved in their medical treatment during their recovery. It is a privilege to be able to support children and their families during a vulnerable time, to develop long-standing relationships, and to see kids grow and change.

I love working with my colleagues at UCSF and with research collaborators around the world. It's exciting to be able to travel for work and engage with other people who are interested in similar areas of science and medicine. My schedule is a little different each day and each week, which makes the work interesting and keeps me on my toes.

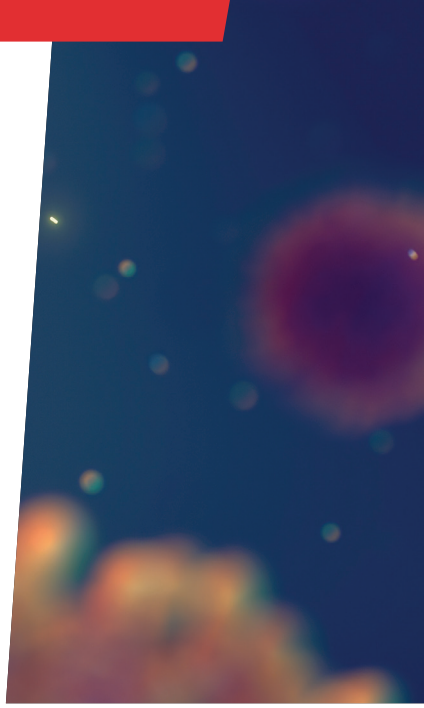
I love to be physically active. I bike to work almost every day, and enjoy mountain biking, road cycling, snowboarding and running with friends. I have three kids, so our household is pretty busy. I like to cook with my husband and eat family dinner together when we can make it work with everyone's crazy schedules!

Christine's *top tips*

1. Find a sub-discipline that you enjoy. This will help you persevere when the training becomes tiring.
2. Build strong relationships with supportive peers and mentors.
3. Maintain a balance in life with friends, family and your other interests. This is key to satisfaction in whatever career you pursue.

How do researchers make sure new vaccines are safe?

Clinical trials are a rigorous and time-consuming part of medical research, with new drugs or vaccines sometimes taking ten to fifteen years to complete. At the **University of Alberta** in Canada, **Dr Vanessa Meier-Stephenson** is trialling a new vaccine for hepatitis C, using several specialist techniques, such as a 'double-blinded' approach, to make sure the vaccine is safe and reliable.



Dr Vanessa Meier-Stephenson

Assistant Professor, Faculty of Medicine & Dentistry, Medicine Department, University of Alberta, Canada

PROFILE

Field of research
Infectious diseases

Research project
Running a double-blinded clinical trial of a hepatitis C vaccine

Funders
Li Ka Shing Applied Virology Institute; Canadian Institutes of Health Research (CIHR)

doi: 10.33424/FUTURUM695

Talk like a ...

medical researcher

Adjuvant – an ingredient in vaccines and medicines that strengthens the body's immune response

Antiviral – a medicine that treats viral infections or viral diseases

Double-blinded – a type of clinical trial where the participants and researchers are unaware of who has received the vaccine and who has received a placebo

E1 and E2 – the surface proteins of the hepatitis C virus that allow it to bind to a cell

Efficacy – the ability of something to produce the intended result

Hepatitis C – a virus which can result in serious liver damage and liver cancer

Phlebotomy – the process of making a puncture in a vein, usually for the purpose of taking blood

Placebo – a treatment that does not contain the active therapy and should therefore produce no physiological effect

Stability testing – testing a product over time to see if it remains stable

T-cell – a type of immune cell that helps the body recognise and fight diseases

Hepatitis C is a virus that infects the liver and is potentially life-threatening if left untreated. According to the World Health Organization, over 240,000 people died from hepatitis C in 2022. Despite decades of research into the field, there is currently still no vaccine for the disease.

At the University of Alberta, Dr Vanessa Meier-Stephenson is a doctor and researcher who is testing a vaccine for hepatitis C. "The University of Alberta is an incredible place for this kind of work," she says. "Dr Lorne Tyrrell, who developed the first antiviral for hepatitis B, and Sir Michael Houghton, the Nobel Prize winner for the co-discovery of hepatitis C, both work just down the hall from me!"

What is in the new vaccine?

Vaccines are made up of carefully chosen ingredients which all work together to produce the desired effect of fighting the infection. Often, these ingredients include strands of genetic information, adjuvants or specific proteins.

The hepatitis C vaccine that Vanessa is trialling is the next generation of a vaccine developed by Sir Michael Houghton and his team. "Their first-generation vaccine, which was mixed with a different adjuvant, was tested in chimpanzees and showed positive effects," explains Vanessa. "In 2010, a variation was given to humans in a trial in the US which tested three different doses of the E1 and E2 proteins. They found the lowest dose worked just as well as the higher doses."

This time, the E1 and E2 proteins inside the vaccine have been produced a little differently. The proteins have also been paired with a stronger adjuvant, in the hope that this will stimulate T-cells more effectively.

Testing time

Once a new vaccine has been developed, the product goes through rigorous pre-clinical testing (which involves animal testing), toxicity screening and stability testing. It then goes through a clinical trial to ensure it is safe and effective for human use. Even though a version of the vaccine that Vanessa is studying has previously been tested in humans, the product must still go through this full process, as the combination of the new adjuvant with the E1 and E2 proteins might cause a different reaction.

One of the final checkboxes for the vaccine is its stability, as Health Canada (the regulatory agency) needs to know that the vaccine components do not fluctuate over time. "We have to prove that the vaccine is biochemically and biologically exactly the same today as it was six months ago," explains Vanessa. "This involves challenging the product with different temperatures and other environmental factors to ensure its consistency and safety over time."

While the quality control team completes the stability testing, Vanessa and other members of her team – such as her study coordinator Kelly Kim – can start planning the structure of the clinical trial. "Kelly handles all aspects of the trial, including setting up the protocols, organising the regulatory paperwork, recruiting and screening participants, visit coordination, phlebotomy, follow-up checks, documentation, and on and on!" says Vanessa.

How is the trial structured?

The clinical trial of this hepatitis C vaccine will involve 27 participants, with three taking part in the first stage, and 24 taking part in the second. "The first stage involves staggered dosing and extreme scrutiny," says Vanessa. The team will monitor the three participants closely for any signs of a negative reaction and make sure there are no unexpected side effects to the vaccine. "In a clinical trial, every little detail is pertinent," emphasises Vanessa. Once the team is satisfied with the initial safety stage, the trial will move into the second stage with the remaining 24 participants.

"In the randomised controlled trial stage, half of the participants will receive the actual vaccine product, while the other half will receive a placebo," explains Vanessa. This stage of the trial will also take a 'double-blinded' approach, where both the participants and the clinical team are 'blind' to which patients have taken the placebo vaccine. Instead, the vaccine will be administrated by a nurse who is not involved in the data collection, and the syringe will also be covered in tape so the participants cannot guess which mixture they are receiving.

"It's important to do this sort of blinding to ensure we're capturing every little detail," says Vanessa. "For example, if you thought you'd been given the placebo, you might not report the upset stomach you had later that day, or if we saw an abnormality on a test, we might interpret it less significantly if we knew it was a placebo case." This part of the trial also demands an extremely high level of scrutiny. "Even minor abnormalities in blood tests that I might normally dismiss as a clinician will get documented," says Vanessa.

What next for the team?

Vanessa and the team have planned out their clinical trial and are confirming stability testing to ensure that their vaccine is safe and stable enough for the rest of the work to start. "We are right at the starting line of the next stage," says Vanessa. "We have the required approvals from Health Canada, animal studies are complete, and we have our recruitment materials ready to go."

Through teamwork and collaborative efforts, the team will soon know if the E1 and E2 proteins, alongside the stronger adjuvant, in the new vaccine will create the desired immune response. It is an exciting point in the journey for the research team.

About *medical research*

Medical research is an exciting area of healthcare where scientists work together on pioneering studies to improve patient care and patient experience. "Medical research is always evolving," says Vanessa. "It is common for clinical trials to explore drugs, such as medicines, vaccines and natural health products, or the development of devices, such as diagnostic tests, implantable devices and wearable devices."

Science conducted in the laboratory can provide discoveries that have practical, 'real world' medical applications for patients, a research process termed 'bench to bedside'. But it is not only scientists who work in medical research. "Doctors, nurses and coordinators working directly with patients can work in research," says Vanessa. "Their involvement also provides discoveries that go into clinical trials."

The introduction of artificial intelligence (AI) to the field is leading to a wide range of possibilities for the next generation of researchers. "What role does AI play in human research, and how will it impact medicine? Can it be integrated into or enhance certain areas in research?" asks Vanessa. "I would argue that it's less a case of 'AI will take over' or 'AI will take our jobs' and more about trying to understand how, with the support of AI, we can increase our efficiencies to achieve the many goals of medical research."

Pathway from school to *medical research*

Working in medical research requires a mix of scientific knowledge and interpersonal skills. "It is helpful to know basic sciences (i.e., biology, chemistry) to understand the science behind the research, but we mustn't forget that social sciences are equally important because most medical research relies on human interactions," says Vanessa.

At university, study a bachelor's degree in biology, biochemistry, pharmacy or a similar field. Take extra courses in communication or volunteer in a customer service environment to develop your interpersonal skills. "I would recommend students take whichever courses/subjects interest them most at the time," adds Vanessa.

To work in research, you will typically need at least a bachelor's degree. Many researchers complete a topic-focused master's degree or develop a high-level of expertise with a PhD.

If you live in Alberta, have a look at the University of Alberta High School Youth Researcher Summer Program (**ualberta.ca/en/current-students/undergraduate-research-initiative/opportunities-for-high-school-students/high-school-youth-researcher-summer-program**). "This programme gives high school students the chance to take part in a health-related research project and get paid a stipend over the summer," says Vanessa.

Download Vanessa's resources from **futurumcareers.com/how-do-researchers-make-sure-new-vaccines-are-safe**

Explore careers in *medical research*

"Start with the basics," says Vanessa. "Try to find opportunities (paid or unpaid) where you can learn more about what research is about and what it can entail. There are institutions, researchers and companies who are constantly seeking people. Be proactive and take the initiative to reach out to them."

Watch this video of Vanessa working in her lab and explaining her job: **facebook.com/watch/?v=1932984887547172&ref=sharing**

There are many ways to be involved in medical research. "Research work is diverse. There are studies involving bench/wet lab work, chart review work, patient/participant-facing work and so on, which means there is more than one type of area that may pique your interest," says Vanessa.

The Certified Clinical Research Professionals Society has some useful information about the different roles and responsibilities in medical research: **ccrps.org/clinical-research-blog/the-clinical-trials-team-roles-amp-responsibilities**

Meet *Vanessa*

Being a doctor and a researcher can be highly stressful. There are a lot of demands on my time, and I want to ensure I'm doing my best in all areas. The implications of poor performance on the clinical side might impact a patient's length of stay in hospital or, in the worst-case scenarios, their health or life. The implications of performing poorly in the lab are wasted materials and time, so the stakes are much lower, but we need to ensure we're doing good research or we won't be able to retain funding. The stresses are different for my different roles, and if a patient (or trial participant) has an issue that comes up that I need to address, all other things take a backseat until it's been dealt with.

My patients continue to remind me of the bigger picture of what we're doing. In my lab, it's the excitement of discovery – the potentials and 'what ifs'. It's also incredibly rewarding to be part of those 'aha' moments, when a student finally figures out a challenging experiment they've been working on or comes up with a neat idea for what to do next based on their data. What drives me to do the clinical trial work is the potential to bring a basic science discovery into the medical realm where it can actually benefit patients – from bench to bedside.

Science is absolutely a team effort; there is no way I could do this alone. On the clinical trial, I work with many other clinicians who help monitor patients to spread the workload. And we have research nurses and pharmacy personnel who also have important roles in the trial process. The most central member of our team is our study coordinator, Kelly. She's the one who keeps us all organised and ensures the day-to-day operations run smoothly.

Vanessa's *top tips*

1. Don't feel forced into a specific path. Keep looking for opportunities and seek diverse experiences.
2. It's okay to not have everything figured out — just work hard at each thing you do, and you'll learn more about yourself and your passions along the way.
3. Don't internalise failure. If an experiment doesn't work, ask why and learn from it. Sometimes, a 'failed' experiment opens up a whole new area of discovery.

Meet *Kelly*

Kelly Kim, Study Coordinator, Hepatitis C vaccine clinical trial

When I was growing up, my dad couldn't run or play with me like the other able-bodied dads could with their kids, as he had a severe limp which limited his mobility. There was a part of me that was determined to become a doctor to fix his leg, and my enthusiasm and passion for medicine took effect from there.

My career has been shaped by curiosity. As an undergraduate student, I volunteered at my local children's hospital. The opportunity to support research within the emergency department arose, and I've been working in research ever since!

My role as Study Coordinator involves reviewing and developing protocols, informed consent forms, data collection forms, databases and manuals; submitting to our local ethics board; recruiting and following up with participants; communicating with study/clinical care teams and the participants; being organised and detail-oriented; prioritising deadlines; and managing day to day activities, just to name a few!

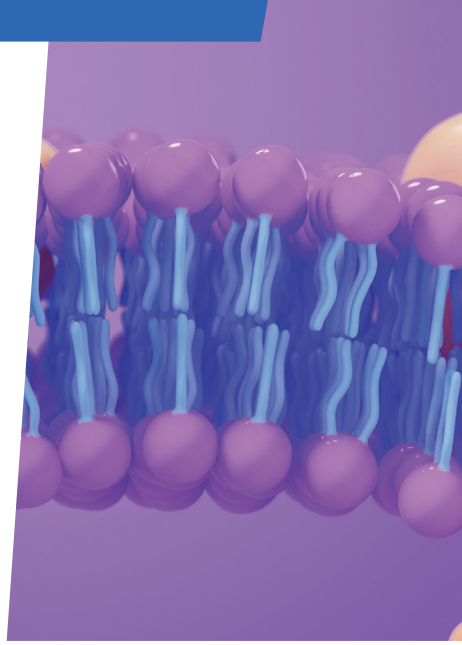
While the fundamentals of research remain the same, every study is different and you need to start anew for each study you work on. Figuring out the logistics of how best to run the study with the resources you are allocated is a massive jigsaw puzzle.

The rewarding part is when you get a study up and running seamlessly and you're one step closer to success and completion. Somehow, whatever you think will work in theory doesn't translate into practice, so you end up troubleshooting until you get it just right. But that's the beauty of working in research because you really don't know what to expect. It keeps you on your toes!

Kelly's *top tips*

1. There are no 'dumb' questions so keep asking them! Keep engaging with the work even if it makes you uncomfortable and uncertain.
2. Keep learning, because that's how you'll increase your potential. Don't limit yourself by what you believe is the extent of your abilities and capabilities.

Can understanding V-ATPase help fight disease and ageing?



V-ATPase is a vital molecular machine that helps control the pH levels within cells and their organelles. **Professor Patricia Kane**, a molecular biologist at **Upstate Medical University** in the US, is investigating V-ATPase function, activity and regulation. Her research explores how problems with this molecular pump may contribute to diseases such as Alzheimer's disease, cancer and osteoporosis, as well as the ageing process itself.

Professor Patricia Kane

Department of Biochemistry and Molecular Biology, Upstate Medical University, USA

PROFILE

Field of research
Molecular biology

Research project
Investigating V-ATPase regulation and how it contributes to disease and ageing

Funders
US National Institutes of Health (NIH); National Institute of General Medical Sciences (award number R35 GM14525); National Institute of Aging

The contents of this work are solely the responsibility of the authors and do not necessarily represent the official views of the NIH.

doi: 10.33424/FUTURUM692

Talk like a ...

molecular biologist

ATP – the primary energy carrier in cells, used to power molecular machines like V-ATPase

Cytosol – the jelly-like fluid that surrounds organelles within a cell

Lysosome – an acidic organelle that degrades and recycles damaged proteins and organelles within cells

Osteoclast – a cell that uses V-ATPases to break down bone tissue

Osteoporosis – a disease causing bones to lose density and become fragile, leading to a higher risk of fracture

pH – a measure of acidity, with lower values indicating more acidic conditions and higher values indicating more basic conditions

Proton – a positively-charged particle pumped by V-ATPase to acidify organelles

Reversible disassembly – the process by which V-ATPase subcomplexes separate and later reassemble to regulate activity

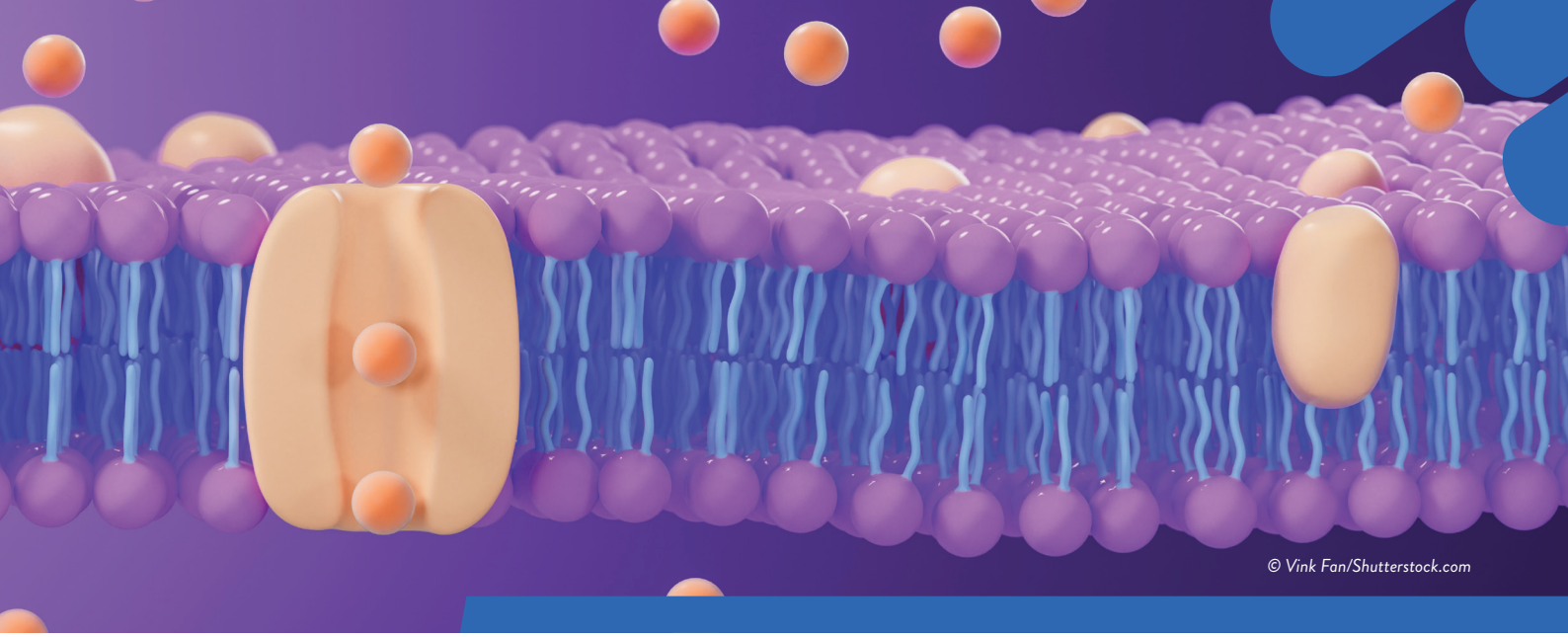
V-ATPase – a molecular motor that pumps protons into organelles to maintain acidic conditions

The human body is made up of roughly 30 trillion cells. These cells are highly organised structures, filled with cytosol and divided into membrane-bound compartments called organelles. Each organelle has its own internal environment, including a specific pH that allows it to function properly. Although the cytosol is maintained at a near-neutral pH, some organelles need to be more acidic to carry out their roles.

One of the most important acidic organelles in animal cells is the lysosome. Plant and fungal cells have a similar organelle called a vacuole. "Lysosomes and vacuoles are the recycling centres of the cell," says Professor Patricia Kane, a molecular biologist at Upstate Medical University. "They use enzymes to break down old or damaged cellular proteins and organelles, allowing the cell to reuse their building blocks." The enzymes that carry out this degradation only work well at acidic pH.

What is V-ATPase?

To maintain the acidity of lysosomes and other organelles, cells rely on a molecular machine called V-ATPase. This protein complex acts as a molecular motor, using energy from ATP – the cell's main energy source – to pump protons across membranes and into organelles. By concentrating protons inside organelles, V-ATPase makes them more acidic than the surrounding cytosol, allowing their enzymes to function properly.



V-ATPase is made up of two subcomplexes – groups of proteins that work together. One subcomplex breaks down ATP to release energy, while the other uses this energy to rotate within the membrane, allowing protons to pass through.

In humans, mutations in V-ATPase genes can cause serious health problems. For example, when V-ATPases in certain kidney cells do not function correctly, the body cannot regulate blood pH properly, which can make the blood dangerously acidic. "Almost all organisms die if they have no V-ATPase activity," says Patricia.

How do cells control V-ATPase activity?

V-ATPases maintain the specific acidic conditions needed for a cell's organelles to function properly. However, cells do not always require the same level of V-ATPase activity, so they must regulate when and where the pump is active. "For example, when yeast cells lack glucose, their favourite nutrient, they reduce V-ATPase activity to conserve energy, then increase it again when nutrients become available," explains Patricia. This adjustment occurs through a process called reversible disassembly, in which the two V-ATPase subcomplexes separate, stopping ATP breakdown and preventing proton pumping. When conditions improve, the subcomplexes quickly reassemble and restore acidification. Reversible disassembly also occurs in mammalian cells where it regulates V-ATPase activity and can help restore lysosome acidity if membranes become damaged.

How does Patricia study V-ATPase?

From yeast to humans, V-ATPases in different organisms are remarkably similar and share the same basic structure. "We often study V-ATPase in yeast because yeast cells can survive without V-ATPase activity (although they grow slowly) while most other organisms cannot," explains Patricia. Her team introduces mutations into yeast V-ATPase genes and examines how these changes affect cell growth, protein recycling and organelle acidity. They also isolate the yeast's vacuoles to measure how efficiently V-ATPase breaks down ATP and pumps protons, and use fluorescent labels to track where the complex is located inside cells.

Much of what Patricia and her team learn from yeast can be applied directly to human cells. Although human V-ATPases can be more complex, the basic structure, function and regulation are the same, providing a blueprint for understanding how the system works in humans.

How can V-ATPase dysfunction lead to disease?

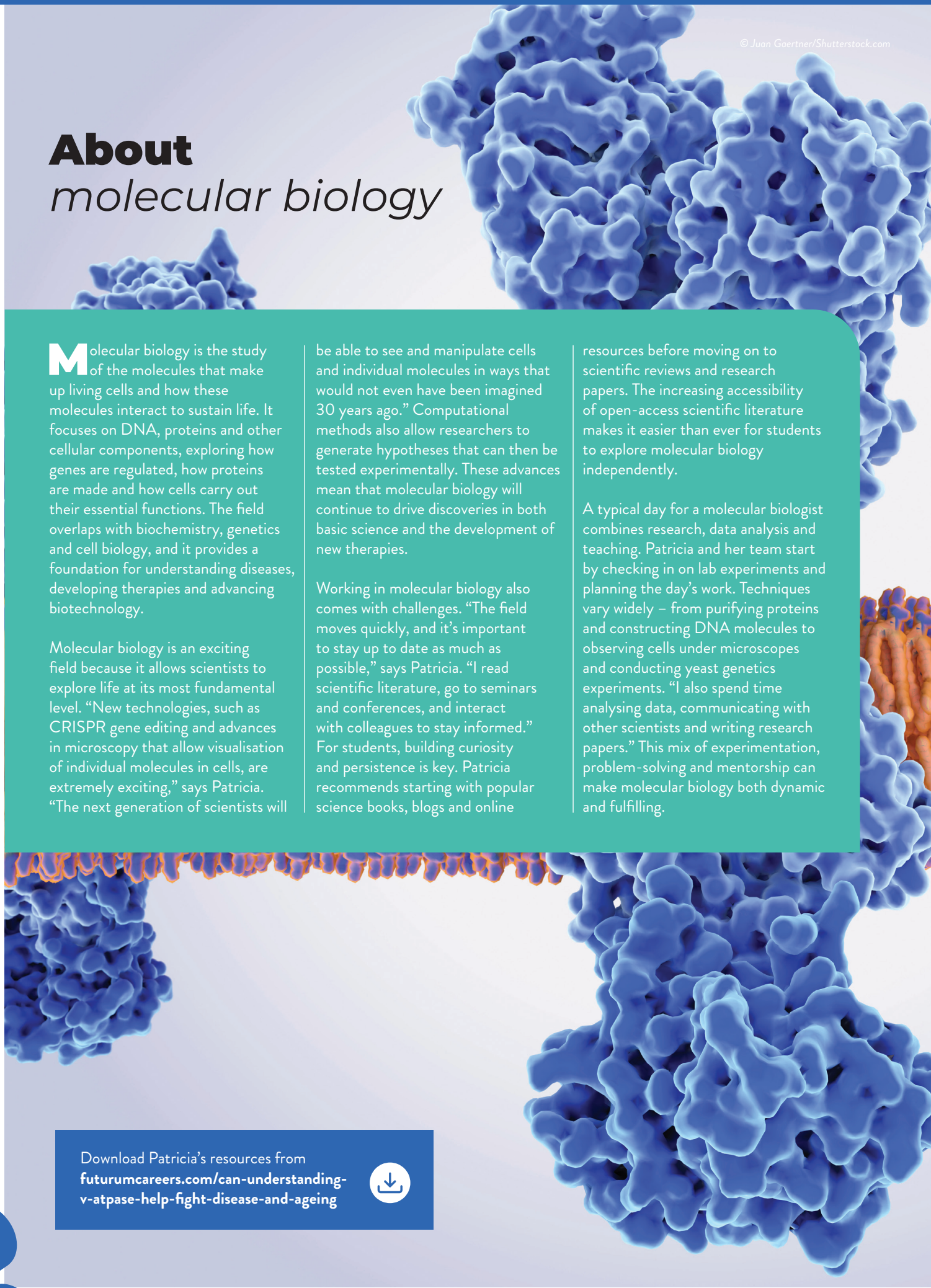
When V-ATPases do not function properly, lysosomes become less acidic, which makes it harder for cells to break down damaged proteins. The accumulation of these faulty proteins is a hallmark of neurodegenerative diseases such as Alzheimer's and Parkinson's. Lysosomes also naturally become less acidic with age, which may help to explain why these conditions are more common in older people. "To treat these diseases, we need to figure out why V-ATPases become less active and reverse this process," says Patricia. "This is why we are interested in the reversible disassembly of V-ATPase in ageing cells."

In other conditions, such as cancer and osteoporosis, problems can be caused by too much V-ATPase activity or pumping taking place in the wrong location. Osteoclasts use V-ATPases to break down bone, and excessive activity can lead to osteoporosis. In cancer cells, V-ATPases can move to the cell surface, acidifying the surrounding environment and helping tumours spread to nearby tissue. "In both cases, we need to block V-ATPase activity only in specific locations, but that's challenging because all cells rely on these pumps to survive," explains Patricia. "Any treatment must either be very carefully targeted or focus on features found only in cancer cells or osteoclasts."

How does ageing affect V-ATPase function?

As organisms age, lysosomes gradually become less acidic, which can cause a buildup of defective proteins. Patricia's team recently found that V-ATPases in yeast are more often disassembled in older cells, even though all the protein components are still present. This disassembly likely contributes to the reduced acidity of lysosomes with age. "We found that when we introduced a mutation forcing the V-ATPase to stay assembled, yeast cells lived much longer," says Patricia. "Now, we want to understand why V-ATPases disassemble with age, identify factors that can prevent or delay this, and see if the findings apply to mammalian cells."

Patricia and her team continue to study V-ATPase regulation, including reversible disassembly. After disassembly, V-ATPases rely on a protein complex called RAVE to reassemble. Mammalian cells have similar complexes, and the team recently discovered that a protein linked to severe genetic epilepsy is a subunit of the mammalian RAVE complex. "While this discovery will not provide a cure for the disease, it suggests a mechanism, which can eventually allow us to develop therapies," explains Patricia.



About *molecular biology*

Molecular biology is the study of the molecules that make up living cells and how these molecules interact to sustain life. It focuses on DNA, proteins and other cellular components, exploring how genes are regulated, how proteins are made and how cells carry out their essential functions. The field overlaps with biochemistry, genetics and cell biology, and it provides a foundation for understanding diseases, developing therapies and advancing biotechnology.

Molecular biology is an exciting field because it allows scientists to explore life at its most fundamental level. "New technologies, such as CRISPR gene editing and advances in microscopy that allow visualisation of individual molecules in cells, are extremely exciting," says Patricia. "The next generation of scientists will be able to see and manipulate cells and individual molecules in ways that would not even have been imagined 30 years ago." Computational methods also allow researchers to generate hypotheses that can then be tested experimentally. These advances mean that molecular biology will continue to drive discoveries in both basic science and the development of new therapies.

Working in molecular biology also comes with challenges. "The field moves quickly, and it's important to stay up to date as much as possible," says Patricia. "I read scientific literature, go to seminars and conferences, and interact with colleagues to stay informed." For students, building curiosity and persistence is key. Patricia recommends starting with popular science books, blogs and online resources before moving on to scientific reviews and research papers. The increasing accessibility of open-access scientific literature makes it easier than ever for students to explore molecular biology independently.

A typical day for a molecular biologist combines research, data analysis and teaching. Patricia and her team start by checking in on lab experiments and planning the day's work. Techniques vary widely – from purifying proteins and constructing DNA molecules to observing cells under microscopes and conducting yeast genetics experiments. "I also spend time analysing data, communicating with other scientists and writing research papers." This mix of experimentation, problem-solving and mentorship can make molecular biology both dynamic and fulfilling.

Download Patricia's resources from **futurumcareers.com/can-understanding-v-atpase-help-fight-disease-and-ageing**

Pathway from school to *molecular biology*

At school, build a strong foundation in biology, chemistry and physics. Mathematics and basic computing skills are also helpful, as modern molecular biology increasingly relies on data analysis.

At college or university, relevant courses include molecular biology, biochemistry, genetics, cell biology, microbiology and biotechnology. "A strong science background is important for this field, though you can enter from multiple directions," says Patricia. "For example, while many people major in biology or biochemistry, both my undergraduate and graduate degrees are in chemistry, and I have colleagues that have degrees in physics."

"Big data is also a critical element of modern biology, so learning basic programming and data analysis skills would be helpful," says Patricia.

Explore careers in *molecular biology*

If you are interested in molecular biology, organisations such as the American Society for Cell Biology (**ascb.org**), the American Society of Biochemistry and Molecular Biology (**asbmb.org**), the Biochemical Society (**biochemistry.org**) and the Federation of American Societies for Experimental Biology (**faseb.org**) offer webinars and useful resources for students and early-career researches.

Textbooks such as *Molecular Biology of the Cell* by Bruce Alberts and *Principles of Biochemistry* by Albert Lehninger, David Nelson and Michael Cox are widely used in undergraduate, graduate and medical courses and provide a holistic background in cellular and molecular biology.

Meet *Patricia*

I grew up on a farm and went to school in a small town, so I didn't have any exposure to research careers. I did grow up with a great appreciation for the natural world, and that fits well with biological research.

I wasn't interested in science until I took chemistry and physics with an excellent teacher in my last two years of high school. When I started college, I planned to major in English, but changed my major to chemistry in my second year. Over time, my interests became more biochemical. However, despite my change in major, I still do a lot of writing, and my English skills help with that!

I love the thrill of discovering something new through our research and working with students in my lab. It's great to see students experience the thrill of discovery.

I continue to be fascinated by the microscopic world – there is so much happening that we can't see directly and so much more to discover.

I think curiosity and persistence have helped me in my career. I love doing research because I'm very curious about how things work and excited by the possibility of new discoveries (both little and big). However, in scientific research, there are many experiments that don't go as expected, so persistence, patience and some optimism are also important.

I go for a walk after work most days. This helps me process my day and shift gears. I live in a snowy place, so I like to ski in the winter, and I garden in the summer.

Patricia's *top tip*

Don't be intimidated if molecular biology seems complicated at first. It can seem like learning a new language, but as you get used to it, it will make sense. You don't have to understand everything immediately.

Redlining: how do racial disparities in financial practices affect health?

In the 1930s, the US government began 'redlining' – demarcating poor neighbourhoods, often home to Black and immigrant populations, as risky for financial investment. **Dr Andrea Richardson** from **RAND** in the US is investigating how that decision has led to cascading impacts and disparities to this day – not least how people from redlined neighbourhoods are more likely to suffer from obesity and other health conditions.

Dr Andrea Richardson

Senior Policy Researcher, RAND;
Professor, RAND School of Public Policy, USA

Fields of research
Nutrition epidemiology; health disparities; neighbourhoods and health for all

Research project
Investigating the impacts of racial disparities in mortgage lending on obesity

Funder
US National Institutes of Health (NIH)

Research reported in this publication was supported by the National Heart, Lung, And Blood Institute of the National Institutes of Health under Award Number R01HL155187. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

doi: 10.33424/FUTURUM693

PROFILE

Talk like a ...
nutrition epidemiologist

Body mass index (BMI) – a measurement used to assess if someone is a healthy weight, calculated by dividing body weight by height

Epidemiology – the study of health and disease within populations

Home Owners' Loan Corporation (HOLC) – a US agency set up in the 1930s to refinance home mortgages

Obesity – a complex chronic disease defined by an excessive accumulation of body fat that poses risks to health

Mortgage – a loan for the purchase of property

Redlining – a practice where neighbourhoods' credit-worthiness ratings were conflated with race

Socioeconomic – related to social and economic factors

Throughout the 1930s, the US was wracked by economic hardship in the form of the Great Depression. Almost everybody in the country was affected and millions found themselves without income. In an attempt to help homeowners pay their mortgages, the government created the Home Owners' Loan Corporation (HOLC), which offered financial relief to those unable to make payments through no fault of their own. "A few years later, HOLC produced maps that rated neighbourhoods based on how safe or risky they were for investment," says Dr Andrea Richardson from RAND. "The mapmakers factored in details such as the condition of houses but also the race and ethnic background of the people who lived there."

These HOLC maps reflected decades of racial segregation. At the bottom of their rating scale were the red-marked neighbourhoods – a practice that became known as redlining. "These neighbourhoods were often where Black families and immigrant communities lived," says Andrea. "This reinforced racial and economic segregation, which went on to affect families for generations." It is unknown if the maps had any influence on mortgage lending, but they mirror the racist attitudes entrenched in the real estate industry.

"Although the Civil Rights Act of 1968 formally prohibited redlining, informal practices of housing disparity still persist today," says Andrea. "People in formerly redlined neighbourhoods may still face unfair treatment when seeking investment and mortgages." If someone is denied a mortgage by a lender, such

as a bank, they become locked in to the expenses of renting, without the benefits of home ownership.

These disparate mortgage practices mean that people living in historically redlined neighbourhoods may still experience the negative impacts of redlining, not just in terms of their ability to secure a mortgage or their financial security, but also in terms of their health. According to a growing body of research, this location-based housing disparity can lead to poor health outcomes.

Redlining ramifications

Health is complicated; as well as your biology and lifestyle choices, it depends on your environment and the lifestyle opportunities available to you. Andrea suspected that redlining may be connected to health because of how it prevents resource investment in certain neighbourhoods, and there is plenty of evidence to support this theory. "For instance, in Chicago, it was found that Black women living in areas with a history of redlining were more likely to have premature births," says Andrea. "Another study in Atlanta found higher rates of death from breast cancer in women from such neighbourhoods."

In her current research, Andrea is focusing on obesity, characterised by high body mass index (BMI). While obesity is often thought of as an individual issue, the truth is far more complicated. "Obesity is influenced both by biology and environment," says Andrea. "For instance, if a neighbourhood has fewer healthy grocery options and fewer safe places to exercise, the community may be more prone to obesity." It is unclear how much historical redlining drove neighbourhood factors that increase today's residents' obesity risk.

> ***...if a neighbourhood has fewer healthy grocery options and fewer safe places to exercise, the community may be more prone to obesity.***

Honing in on health

Andrea and her team used data from the Coronary Artery Risk Development Study (CARDIA), which tracked the health of over 5,000 people from 1985 to 2016. "The study followed Black and white adults who were 18-30 years old when the study started," says Andrea. "The study collected detailed data on diet, medical health, physical activity, neighbourhood environments and social background."

Participants were from four US cities heavily affected by redlining: Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California. "We used CARDIA data to see how past and current mortgage lending discrimination may influence BMI, diet and levels of physical activity," says Andrea.

First of all, the team wanted to examine the link between historical redlining and neighbourhood economic conditions from 1985 onwards. "The results were clear," says Andrea. "Neighbourhoods historically marked as 'high-risk' by the HOLC remained more socioeconomically deprived 50 years later than other areas." This was one of the first pieces of evidence the team gathered about the far-reaching impacts of those red lines drawn many years ago.

When the team examined how these factors relate to health, things became more complicated – though the trends were clear. "This long-term disadvantage may have led to poorer diet quality for all groups," says Andrea. "For white adults and men, living in historically redlined neighbourhoods was linked to higher BMI, but for women and Black adults, the relationships were more nuanced." For all groups, the link between historical redlining and socioeconomic deprivation was present.

"These results highlight that the connections between redlining, neighbourhood environments, gender, race and BMI are complex and can differ across groups," says Andrea. "Overall, the study suggests that the economic disadvantages created by housing disparities many decades ago still affect health and body weight differences across race and gender today."

About *nutrition epidemiology*

Nutrition epidemiology investigates the relationship between diet and health outcomes – how the types of food we eat can either cause or prevent diseases. "I love how broad our field is," says Andrea. "We all eat, but how and what we eat varies for so many reasons from individual choices to policy decisions." The field is broad but also deep, encompassing the molecular mechanisms involved in digestion and investigating how the nutrients that enter our body interact with our cells and tissues.

For many nutrition epidemiologists, such as Andrea, the global obesity epidemic is a focus of their work. In 2022, the World Health Organization estimated that 1 in 8 people in the world were living with obesity – double what the number was in 1990. Given that rates are going up in both developed and developing countries and across many different demographics, there is no simple explanation for this growth. Though less active lifestyles and increased consumption of processed foods are thought to be key drivers, a huge range of socioeconomic factors are likely at play – and nutrition epidemiologists are committed to untangling and tackling these issues.

"So many people are unable to achieve nutritious diets, and policy efforts will rely on good science to address this," says Andrea. "At the same time, there is increasing interest in how the body responds to food – especially in preventing chronic diseases." This creates a huge range of research opportunities for the next generation of nutrition epidemiologists.

Pathway from school to *nutrition epidemiology*

Nutrition epidemiology draws strongly on both mathematics and medicine, so building skills in these areas is vital. At school, mathematics, statistics, biology and chemistry will help you build a strong foundation.

At university, courses in biology, biochemistry, nutrition and epidemiology can all lead to a career in the field.

Explore careers in *nutrition epidemiology*

The RAND website has a huge range of freely available studies on contemporary topics, including nutrition and health: **rand.org/topics/health-health-care-and-aging.html**

To learn more about obesity and to connect with professionals working in the field, Andrea recommends looking into The Obesity Society: **obesity.org**

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Download Andrea's resources from **futurumcareers.com/how-do-racial-disparities-in-financial-practices-affect-health**

Meet *Andrea*

I studied for a master's degree in public health with a focus on genetic epidemiology. Straight after graduation, I started working with nutrition epidemiologist Marjorie McCullough at the American Cancer Society, which sparked my interest in diet and its links to health. Over the next ten years, I supported research groups and became increasingly concerned by the obesity epidemic I saw growing in every dataset I used.

This motivated me to get my doctorate. I realised I needed a better foundation in methods to answer the research questions I cared about. I went back to school when my sons were five and seven years old. It was harder than I thought it would be, but so worth it. It is a challenge to balance career goals with family, but it forces me to constantly re-evaluate my priorities.

I first heard about redlining on a radio programme while in my car. I was incensed that I was never taught this in school: how deeply entrenched racism is, and how it continues to support unjust barriers. Then it hit me that the CARDIA cohort was the perfect group for examining how redlining relates to obesity.

Building multi-faceted research programmes like this gets me excited. I am often jumping between projects and proposals, so sometimes I turn off email alerts and focus my time on the questions that interest me the most. I aim to continue to learn and grow professionally, and mentor more students and early-career researchers.

Andrea's *top tips*

1. Follow your interests and never give up.
2. It's really important to fail. These are the moments we learn the most.

Driving road safety forward through connected insurance

Traditionally, car insurance prices are based on factors such as the driver's age and driving history. The introduction of technologies such as GPS tracking and in-built cameras presents the opportunity to monitor driver behaviour, which could allow for more personalised car insurance. At **New York University** in the US, **Daniel Vignon** is using mathematical models to explore how monitoring driver behaviour could impact the car insurance industry, road safety and the future of automated driving.

Daniel Vignon, Ph.D.

Assistant Professor, Department of Civil and Urban Engineering, Tandon School of Engineering, New York University, USA

PROFILE

Field of research
Transportation economics

Research project
Investigating how monitoring driver behaviour could impact car insurance, road safety and automated driving

Funder
US National Science Foundation (NSF)

Website
featsnyu.com/wordpress

doi: 10.33424/FUTURUM697

Talk like a ...

transportation economist

Automaker – a car manufacturer

Automated vehicle – a vehicle that can drive to its destination without human intervention

Car insurance – a legally required financial product that provides drivers with compensation if they have an accident

Demographics – information about a group of people, such as age, gender or occupation

GPS (Global Positioning System) – a satellite-based navigation system that provides precise location information

Mathematical model – a description of a real situation using mathematical equations to explain or predict how the situation may change given changes in the variables

Telematics – the use of technology to record and analyse data about how a vehicle is driven, such as speed, location, braking or acceleration, often in real-time

What do you have in common with your classmates? You are all students, roughly the same age, and probably live in the same region. But on the whole, that is where things end. These similarities do not make you all equally artistic or interested in sports. So, after you have learnt to drive, how would you feel if you were all deemed equally good at driving?

Currently, car insurance costs are calculated based on driver demographics such as age, occupation and driving history. But does this give the whole picture? "Historically, factors used to determine a driver's risk and insurance costs are not necessarily tailored to that particular driver," says Daniel Vignon, a transportation economist at New York University. "By tracking individual drivers, insurers can determine more accurately how risky they are. That is, they can decide how likely a given driver is to be in an accident and, therefore, how expensive such a driver might be to insure."

How can we monitor driver behaviour?

Companies could monitor individual drivers with a combination of tools and technologies. For example, they could use in-car cameras to check for risky behaviours (like using a phone while driving) or cameras outside the car to observe how drivers deal with obstacles and other road users. However, privacy issues and the high volume of footage that would need processing tend to put the brakes on video monitoring tools. Instead, many insurers use phone and vehicle sensor data (e.g. GPS tracking, accelerometers, etc.) to monitor where, when and how fast drivers are driving.

"A number of insurers partner with telematics companies who build tools

to collect and analyse driver data for pricing insurance for individual drivers," says Daniel. For many vehicles manufactured in the past decade, automakers are also able to collect such information. "Thus, there are potential opportunities here for cooperation and competition: automakers could provide personalised insurance to their customers or they could sell the driving data they collect to insurers."

Accelerating road safety

It seems logical that closer monitoring of driver behaviour would improve road safety, partly through the promise of reduced insurance costs for safe driving, but also by drawing drivers' attention to the things they may be doing wrong. But will these factors really make roads safer? And how significant will these safety gains be? Daniel is keen to explore these questions and the many ramifications the answers may have.

For example, increased road safety is often put forward as an argument for automated vehicles. However, Daniel suggests that monitoring driver behaviour could be a cheaper way to improve road safety, potentially weakening the safety rationale for automated vehicles. "There are, of course, other advantages to automated driving such as convenience and accessibility," he says. "But there are many questions that need to be answered about how personalised insurance will affect road safety and the value of future technological innovation."

Steering solutions

To drive his research forward, Daniel and his PhD student Sen Yan have been building mathematical models of personalised insurance markets. "We start with a model of an insurer choosing the premium and coverage for a given driver," Daniel explains. "The insurance contract could be personalised and based on the driver's behaviour (or not) so that drivers have a choice of the type of contract they sign-up for." Daniel and Sen add more layers to the model, such as drivers interacting with other road users and competition between different insurers. "We build up to a model with many drivers and many insurers, and then examine how the interactions change if, for example, data is shared between insurers or between automakers and insurers," Daniel says.

> ***"There is a vast universe of questions that need to be answered about how personalised insurance will affect road safety."***

Daniel is also interviewing stakeholders to understand how monitoring affects driver behaviour. The discussions centre around how tracking drivers impacts the insurance market, whether automakers prefer to sell driver behaviour data or provide personalised insurance themselves, and how companies manage privacy.

So far, his interviews have been with telematics companies. "I ask who should own driver data – the telematics company that collects it or the driver who generated the data?" he says. "And I ask what they think their role will be when automated vehicles are integrated into transportation systems." Automated vehicles will need to include tracking devices, so this data could be sent directly to insurers without the need for telematics companies. "So I want to understand whether this is a cause for concern for telematics companies," he says. "Surprisingly, it is not, because telematics companies have the expertise in analysing large driver data that many insurers and automakers lack."

Later, Daniel will interview insurers and automakers to understand how they think technology will change their respective industries, and the challenges they will need to address to remain relevant.

The long-term journey

Daniel is keen for drivers to be supported as well as monitored. "It's not just observing drivers that makes a difference to their behaviour," he says. "It's also important to educate drivers and give them easily digestible information about how they are driving. This helps them understand what they could change to improve their safety, reduce their risk and, therefore, their insurance costs."

In the future, Daniel hopes to move beyond focusing on just insurance and monitoring. "Instead, can we quantify the benefits of monitoring at a system level?" he asks. "For example, what percentage of drivers should be monitored to improve the safety of the whole road system? By answering these questions, we hope to inform policy conversations about the benefits of personalised insurance."

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About *transportation economics*

Do you want to make people's morning commute to work or school easier? Are you interested in how to make the taxi and ride-share industries operate fairly and effectively? Transportation economists examine the problems that millions of people face every day as they commute to work or school, or journey to visit loved ones.

"Economics is the study of situations in which individuals working towards their own personal objectives affect each other's abilities to achieve said objectives," says Daniel. "For example, if I want to arrive at work at 9 am and the journey takes me half an hour when there is no traffic, then I would leave at 8:30 am. But everyone else is also trying to get to work at 9 am and this creates congestion." Economists refer to these types of situations as 'games' and the outcome of these games (such as congestion levels) as 'equilibrium'.

Transportation economists study these problems with the aim of providing solutions. They do this by using mathematical models to understand how changes to different conditions might affect equilibrium. "For example, if we began charging drivers to use the freeway at 8:30 am, would congestion fall? And would I be able to leave at 8:30 am and arrive on time if I paid?" says Daniel. "Transportation economists can model the effects of congestion charges, increased public transport services or wider roads." This allows them to recommend better policies and management strategies. Transportation economists validate their models by collecting data and making sure the models remain consistent with these data.

"Transportation economics is exciting because you get to think about and answer interesting problems that affect people's day-to-day lives," says Daniel. "You can use theoretical models to analyse and solve real-world problems."

Pathway from school to *transportation economics*

Build a solid foundation in mathematics and computing at school, which will get you ahead when it comes to mathematical modelling.

At university, a degree in economics, engineering or mathematics could lead to a career in transportation economics. "The key is to study a degree in which you learn to think and analyse systems quantitatively," says Daniel.

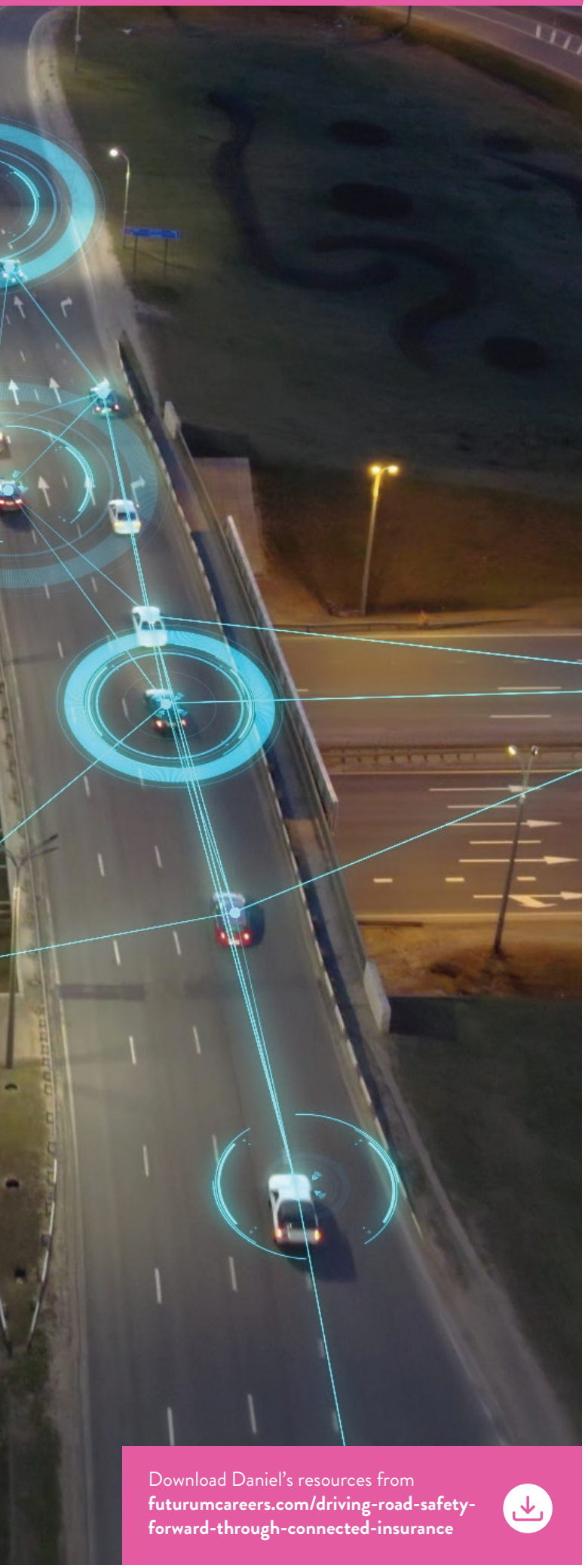
Develop your reading and writing skills. "This is key for being able to understand the work others have done and translate your own work back to people," says Daniel. "At university, take writing classes (in any topic) alongside your main field of study."

Get involved in internships or work experience opportunities, or volunteer to support research projects being carried out in university departments.

Explore careers in *transportation economics*

From academia to data science to logistics, there are many career paths in transportation economics. "There are roles in consultancy, policy and urban planning," says Daniel. "This could be for city agencies, government think tanks or private companies."

Explore the websites of the International Transportation Economics Association (**itea.science**) and the Chartered Institute of Logistics and Transport (**ciltuk.org.uk**) for useful information, resources, career advice, and opportunities to volunteer and meet professionals in the field.



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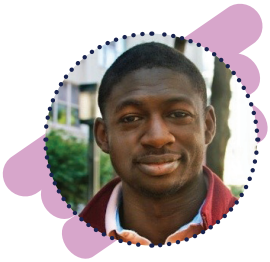

Meet *Daniel*

As a teenager, I considered a few career paths ranging from professional basketball player to commercial airline pilot. I was about to settle on studying business when my uncle (an engineer) recommended that I study engineering because I was good at math and physics. He advised that I could always switch to business after studying engineering, while the reverse wouldn't be so easy. I decided to pick mechanical engineering because it seemed the broadest of the engineering disciplines and would allow me to specialise in whatever interested me later.

While studying mechanical engineering, I enjoyed learning about fluid mechanics and thermodynamics which involved modelling systems and processes. I did an undergraduate summer internship with EDF, a large energy company, after my second year. I helped create simulations for understanding some of the components in their power plants, which involved lots of computer modelling. It was fun because I was applying my classroom knowledge of thermodynamics and fluid mechanics in a real-world context. It showed me how modelling can help companies make decisions.

But I wanted to model bigger systems and the interactions between their components. When I took a class in civil engineering taught by a professor of transportation, I realised that the field of transportation would allow me to do just that. Indeed, transportation systems have many different components and features, such as individual decision-making, regulations, engineering and technology. I was particularly drawn to understanding individual decision-making and how it shaped, and was in turn shaped by, the performance of transportation systems. So I decided to study economics.

Both the most interesting and most challenging thing about the field of transportation economics is that you're asking interesting questions. These questions are interesting because they are complex and challenging, but also relevant to everyday life.

In my free time, I enjoy reading, playing music, seeing friends in town and watching movies.

Daniel's *top tips*

1. Observe the world around you – that's how you get ideas and understand what's happening.
2. Talk to people – collaboration is important and talking to other people will give you new ideas and perspectives.

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