GLOBAL FUTURES 2024

UNIVERSITY OF WATERLOO
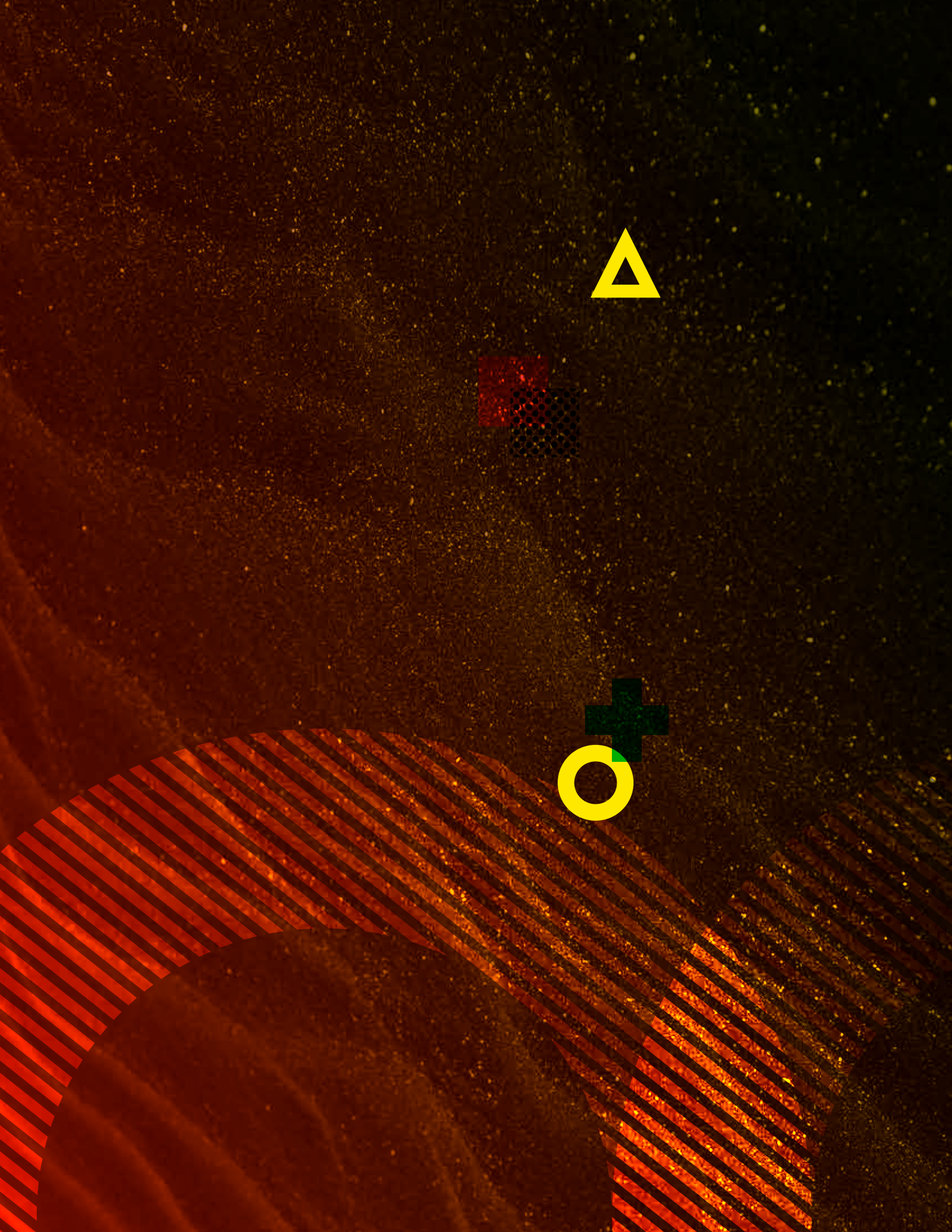
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THE FUTURES WE IMAGINE FOR HUMANITY AND OUR PLANET

Since our founding in 1957, the University of Waterloo has sought to uncover solutions to the most pressing, complex challenges facing humanity and our planet. As these challenges evolve, we are evolving too.

The world continues to face compounding major crises, meaning universities are essential for ensuring society has the knowledge, technology and talent necessary to tackle these challenges head-on. Waterloo faculty, staff, students and alumni are developing solutions that cut across society, health, the environment, technology and the economy. It's through interdisciplinary collaboration that research, innovation and imagination thrive.

The future we imagine for humanity and our planet is at the core of our Global Futures. I invite you to read these inspiring stories about Waterloo community members who are working to change the world for the better. From leading decarbonization policies for cities to improving immunotherapy through application of deep learning, Waterloo provides a foundation for researchers, entrepreneurs and changemakers to create meaningful and lasting progress.

Progress and research applications like these don't happen overnight – they are often based on decades of basic science research and fundamental scholarship. What sets Waterloo apart is our engaged approach to research and deep connections to industry that bolster learning opportunities for our students. We continue to have bold ambitions for the impact we want to make on the world. We will lead with our strengths in boundary-breaking research, experiential education and entrepreneurship to inspire innovation and optimism for a better world.

Dr. Vivek Goel

President and
Vice-Chancellor,
University of Waterloo

SOCIETAL FUTURES

How do we promote knowledge and research to positively advance society's future and ensure communities and everyone within them thrive?

There is a deeper understanding of the global legacies of colonialism and social injustices being felt in our collective consciousness, but our social echo chambers are contributing to the spread of disinformation. Within our campuses, which are mirrors of society, we can innovate and apply new models to ensure every member of our community belongs and thrives.

⊕ WATERLOO STUDENTS IN 1986 HELD A MARCH TO PROTEST THE GOVERNMENT'S UNDERFUNDING OF POST-SECONDARY EDUCATION.

ARE WE SUFFERING A CRISIS IN TRUST?

BRIDGING THE GAP BETWEEN THE PEOPLE WHO DESIGN AND BUILD NEW TECHNOLOGIES AND THE PEOPLE WHO USE THEM

Dr. Mary Wells is the dean of the Faculty of Engineering at the University of Waterloo. An accomplished materials engineer, she chaired the Ontario Network of Women in Engineering from 2013 to 2018.

Wells is a founding member of the Trust in Research Undertaken in Science and Technology scholarly network. We asked her how we can strengthen trust in science and technology to positively advance society.

The rising trend of "fake news" came to prominence during the COVID-19 pandemic as people turned to social media channels to read and distribute information that often fell far short of offering reliable information or verifiable data. The unchecked spread of misinformation led to serious harm for many people, especially those who decided to forgo scientifically proven treatments to combat the novel coronavirus.

I doubt the engineers who first built those social media platforms were aware of how their products could one day be weaponized in campaigns of damaging misinformation. This is why we need to find a way to bridge the gap between the people who design and build new technologies and the public who use them.

Measuring trust

At the University of Waterloo, we looked at several surveys measuring how Canadians' trust in science, academia, health, technology and government has changed over the years. Although there have been relatively few surveys measuring trust in science, the most consistent trend is that trust in most institutions and individuals – especially the government – rose at the beginning of the pandemic but has since waned back to near pre-pandemic levels.

We can't afford to sit on the sidelines and let the trust that Canadians have in science and academic institutions continue to erode. That's why we created the Trust in Research Undertaken in Science and Technology Scholarly Network (TRuST), alongside my Waterloo colleagues, Nobel Laureate Donna Strickland and Canada Research Chair Ashley Mehlenbacher.

TRuST is the first multidisciplinary research network of its kind in Canada and aims to combat the growing trend of disinformation to understand better why some people deny, doubt or resist scientific findings and explanations. We're exploring how engineers, scientists and researchers can find ways of embedding trust into the technologies that they are currently building. We hope this can lead to further considerations of the intended and unintended consequences of what those technologies can do.

Shaping policy to build trust

It won't be easy, but researchers and governments need to work together to think about how policy can shape how we consider future technologies and online tools to prevent the spread of damaging misinformation.

New pharmaceuticals must undergo rigorous study and clinical trials before they are brought to market. This measured approach could be adopted when considering introducing new technologies into the wild. Before a company launches a new technological product into the marketplace, it could undergo a series of trials with a small group of people to identify any unintended issues that could be addressed before allowing expansion to more people.

Another approach could be for governments, in partnership with industry, non-profits and academia, to introduce a series of ethical standards that all technology companies will have to adhere to if they want to make their products available to the public.

Although these suggestions may appear to go against the grain of conventional thinking, we need to begin this conversation of how to regain trust across science and technology. We have already seen how the risks of avoiding this direct approach have created an environment of distrust toward researchers, scientists and policymakers in the post-pandemic period. Tackling this challenge now is critical to ensure that future ideas and technological advances don't suffer a similar fate.

Dr. Mary Wells

Dean, Faculty of Engineering

Trust in Research Undertaken in Science and Technology (TRuST)

**Hebron Gebre-Mariam
(BASc '07)**

Alum, Faculty of Engineering

Kids on Campus, Engineering
Outreach Program

IGNITING CURIOSITY AND INTEREST IN STEM

THE KIDS ON CAMPUS PROGRAM EMPOWERS CHILDREN TO REALIZE THEIR POTENTIAL

Waterloo Engineering alum Hebron Gebre-Mariam is an educator with the Waterloo Region District School Board. He knows from experience that early exposure to higher education subjects and environments is important for children's development and, by extension, society at large.

⊕ ENGINEERING OUTREACH PROGRAM PARTICIPANTS

"I'm a teacher, but I'm also an engineer. Both callings developed from my experience in and exposure to certain learning environments. As a child, the UC Davis College of Engineering, where my father worked, was my playground," he says. "Post-secondary education was not some future unknown, it was my everyday norm, my obvious pathway – particularly in the STEM fields."

While pursuing this passion for engineering at Waterloo, Gebre-Mariam became a camp counsellor with the Engineering Outreach program, Engineering Science Quest (ESQ), which ignited a calling to teach. "I loved how experiential it was for the kids. Watching them have fun through active learning was an absolute delight for me. Pursuing a career in education just felt right."

In 2022, Gebre-Mariam helped launch Kids on Campus, a new Engineering Outreach program that provides 8,000 fourth graders in Waterloo region an opportunity to play and learn on the University's campus. He hopes to inspire them to pursue higher education and imagine themselves as future STEM professionals.

"It is our job as community leaders to think ahead and build partnerships now that will ensure our society continues to thrive in the future. The success of the Kids on Campus program is an example of this very mindset in action. Children develop their interests through experience and exposure. If they know what opportunities exist and how to access them, who they can be and how to get there, they are more empowered to realize their potential. Investing in our children, as a community, enriches us all."

CREATING SPACES FOR BELONGING

EMBEDDING INDIGENOUS KNOWLEDGES AND SPACES INTO SCIENCE SCHOLARSHIP

⏱ SLOAT ADDRESSING A CROWD OF STUDENTS, FACULTY AND STAFF GATHERED FOR THE LAUNCH OF THE URGENCY OF SOCIAL JUSTICE SPEAKER SERIES.

When Savannah Sloat joined the University of Waterloo as the manager of Science Indigenous Initiatives, she knew that to make meaningful change, she would have to operate primarily from the responsibility she has to her community and then apply the institutional framework. As Tuscarora and a registered member of Six Nations of the Grand River, Sloat purposefully uses the Indigenous parts of her identity to centre her work on identity, politics and personhood.

This approach led her to create Waterloo's new Indigenous Science Centre, a space providing support and engagement with Indigenous knowledges and culture for students, staff and faculty.

"I think this initiative was a unique position for the University of Waterloo to be real leaders in Indigenization. Intersections of environment and health are very common, but folks don't always perceive Indigenous folks being present in the hard sciences," Sloat says.

Savannah Sloat

Staff, Faculty of Science

Manager, Science
Indigenous Initiatives

Committed to being a leader in preserving and sharing Indigenous histories and cultures on campus, the Faculty of Science embarked on several purposeful initiatives to offer Indigenous students spaces that support their identity and sense of belonging.

Deliberate also about operating in the spirit of community, Sloat collaborated with Madison Hill, who is Mohawk and a registered member of the Six Nations of the Grand River, to co-lead the development of Indigenous curriculum modules for all first-year students, with support from the Departments of English and Communication.

In fall 2023, the science communications course, a core requirement for all science students, included a traditional ecological knowledge module. This work is currently being extended to other science courses, sprung from faculty members' curiosity to find "natural places" to fit Indigenous frameworks into their teaching methodology and courses.

"For me, I'm always thinking about how we can open up the institution to make it more inclusive to Indigenous knowledges and how we can bridge those gaps between one another more holistically."

Read about Waterloo's new residence that is prioritizing Indigenous design principles
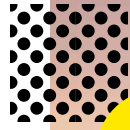
How will we enact the social, economic and geopolitical changes required to ensure a prosperous future for humanity and the planet?

The sustainability of our quality of life is intricately connected to our social, economic and environmental well-being. The global climate emergency is the greatest threat to our collective future, and science and research play a critical role in moving us forward with sustainable solutions.

SUSTAINABLE FUTURES

SOLVING THE PUZZLE OF SUSTAINABILITY, SOCIETY AND OUR PLANET

LOCAL GOVERNMENTS ARE A KEY DRIVER OF GLOBAL SUSTAINABILITY

Dr. Amelia Clarke has been working on environment and sustainability issues for decades, including as president of Sierra Club Canada, the first director of the University of Waterloo's Master of Environment and Business program and the associate dean of research for the Faculty of Environment.

She is now a professor in the School of Environment, Enterprise and Development (SEED) and project lead for the Municipal Net-Zero Action Research Partnership (N-ZAP). We asked Clarke how local governments can be major players in enacting meaningful policy changes to ensure a sustainable future.

As someone who has been immersed in environmental efforts for more than three decades, I see the growing urgency to mitigate climate change. My journey has taken me through various roles, from leading Sierra Club Canada to directing academic programs and conducting research. Today, I'm a professor advancing informed environmental policies, procedures and actions.

I co-lead Municipal Net-Zero Action Research Partnership (N-ZAP) with the Federation of Canadian Municipalities and ICLEI Canada. N-ZAP is a national project supporting Canadian municipalities' pursuit of climate mitigation goals.

Why is this mission so essential? Because local climate action is pivotal to achieving global sustainability.

Dr. Amelia Clarke

Professor, Faculty of Environment

School of Environment,
Enterprise and Development
Waterloo Climate Institute

Reducing emissions to align with Canada's commitments

In Canada, 52 per cent of greenhouse gas emissions come under the direct and indirect control or influence of local governments. These emissions are mainly from heating our buildings, transportation, electricity generation and waste.

N-ZAP's goal is to ensure municipal initiatives for reducing emissions align with Canada's net-zero commitments and are informed by the United Nation's Sustainable Development Goals (SDGs). We're not just advocating for change – we're taking action by developing measurement and monitoring systems for municipal emissions. Our approach is rooted in the belief that local governments, businesses and organizations can lead the way in addressing climate challenges.

Our project involves five working groups:

Assessing municipal climate action: We recently conducted a comprehensive survey to understand the state of Canadian municipal climate action planning. This survey, aimed at municipalities with populations of 10,000 or more, provides valuable insights into current practices and guides future actions.

Measuring climate progress: To gauge progress effectively, we're updating climate indicators, considering not only emissions but also social equity, green economic opportunities and nature-based solutions. By providing municipalities with the right tools, we empower them to monitor their climate mitigation efforts.

Enhancing carbon accounting: Working with larger Canadian municipalities, we're developing standardized climate-related financial risk disclosure practices and climate budgeting procedures. This not only helps municipalities report their climate risks, but also creates standards to integrate climate considerations into financial decisions.

Community-wide emissions: Recognizing the importance of inclusive climate action, we're exploring ways to involve vulnerable citizens and prioritize social equity and Indigenous reconciliation. We know certain people will find it more difficult to transition to zero-emission solutions and we need to ensure they aren't left behind.

Knowledge mobilization: We want to engage communities and provide training and support for their climate action. The tools and insights we develop will be accessible to all Canadian municipalities.

A localized solution

In addition to N-ZAP, I'm a strong advocate for youth-led change and co-lead the Youth and Innovation Project. Young people have unique characteristics that are needed for innovation: risk-taking and a willingness to challenge norms. They are a huge driving force behind climate movements and social justice initiatives and listening to their voices is vital.

Local governance isn't just a piece of the sustainability puzzle – it's a centerpiece. By empowering municipalities and citizens to align with the United Nations SDGs, we are not only addressing climate change. We're building a more resilient and sustainable future for all, one community at a time, together.

TAKING THE WASTE OUT OF 3D PRINTING

3CYCLE AIMS TO EXPAND ITS 3D PRINTED WASTE RECYCLING PROGRAM BEYOND A REGIONAL SCALE

⊕ 3CYCLE WINS AT GREENHOUSE'S SPRING 2022
SOCIAL IMPACT SHOWCASE.

In recent years, 3D printing has become a manufacturing resource used in small- to large-scale projects. Jason Amri, a student and Schulich Leader in the Faculty of Mathematics, says he has been 3D printing for more than a decade and eventually started accumulating a lot of plastic waste from his 3D printed projects. This has become a problem globally, where 3D-printed waste is rarely recycled and ends up in landfills.
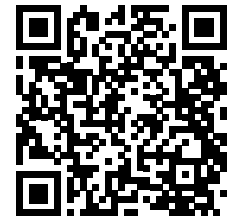
**Jason Amri
(BCS in progress)**

Student, Faculty of Mathematics
Co-founder, 3cycle
GreenHouse
Velocity

SPOTLIGHT

To address this problem, Amri co-founded 3cycle – a University of Waterloo student-run venture that uses a localized circular supply chain to collect, recycle and transform 3D-printed waste into brand-new filament to give back to the community.

"Looking how we consume and dispose of anything that we use as a society is very important," Amri says. "But understanding how we can find opportunities to take what we dispose of and turn it back into something that can be useful for us is even more important."

In the fall of 2022, Amri and the 3cycle team launched their first pilot by partnering with various community organizations around the Waterloo region, including public libraries, school boards, labs, universities and small businesses nearby, to collect their 3D-printed waste.

Within a year, 3cycle has received funding from Waterloo's Velocity incubator, the United College GreenHouse Social Impact incubator and the Sustainability Action Fund on campus. Now, the 3cycle team is partnering with more than 24 organizations and has collected more than 140 kilograms of plastic waste across the Waterloo region to turn it back into spools of 3D filament.

Amri looks forward to expanding the 3cycle team as they continue to branch out to other regions and share their sustainable solution.

"Being able to show what it looks like for a group of university students to have this impact at a regional scale can be an inspiration to look into circular supply chains and see the impact they can offer across consumption as a society."

NANOSIZED SOLUTION IS MAKING A BIG IMPACT IN ALBERTA'S OIL SANDS

UNLOCKING THE POWER OF THE SUN WITH H2NANO'S SUSTAINABLE WATER TREATMENT TECHNOLOGY

Zac Young (BASc '15, MASc '20)

Alum, Faculty of Engineering
Founder and COO, H2nanO
Velocity

ⓘ H2NANO'S TECHNOLOGY PROVIDES A REUSABLE, CATALYZED REACTION TO CREATE TREATMENT COMPOUNDS FROM CONTAMINATED WATER. PHOTO COURTESY OF H2NANO.

The oil sands industry relies heavily on water for its extraction processes, resulting in significant volumes of contaminated water. For every barrel of oil, it takes two to five barrels of water to extract crude bitumen from oil sands. Although oil producers recycle this water in their extraction processes, ponds of contaminated water eventually form that can't be utilized or returned to the environment.

Working closely with Canada's Oil Sands Innovation Alliance (COSIA), an alliance of oil sands companies working with scientists, academics and innovators to make Canadian energy part of a sustainable environment, H2nanO is committed to addressing the pressing need for new, sustainable water treatment solutions.

The startup's patented technology, SolarPass, harnesses sunlight to produce oxidants that degrade contaminants in process-affected water. This remediation can work within days to reduce aquatic toxicity – outperforming more energy-intensive and harsh chemical-dependent methods to improve water safety and reuse potential.

Zac Young, COO for H2nanO, believes Waterloo provided an ideal environment for incubating their technology. "The freedom to operate and maintain ownership of the intellectual property, the collaborative research relationships that the university fosters, the access to talent through the co-op program and Velocity's entrepreneurial ecosystem helped us grow and navigate the transition from research to commercialization smoothly," he says.

As the world seeks sustainable alternatives in industries noted for their environmental impact, H2nanO has emerged as a trailblazer, offering both effective water treatment and a tangible contribution to restoring the environment from the effects of oil extraction. Their journey from lab-based research to full-scale commercialization underscores the immense potential for visionary startups to shape a cleaner, greener future.

HEALTH FUTURES

There is growing knowledge of how the many physical and social determinants of health contribute to our well-being, but we face a resource crisis in addressing these needs in our current health systems. New research, technologies and health data applications will play a critical role in redesigning these systems.
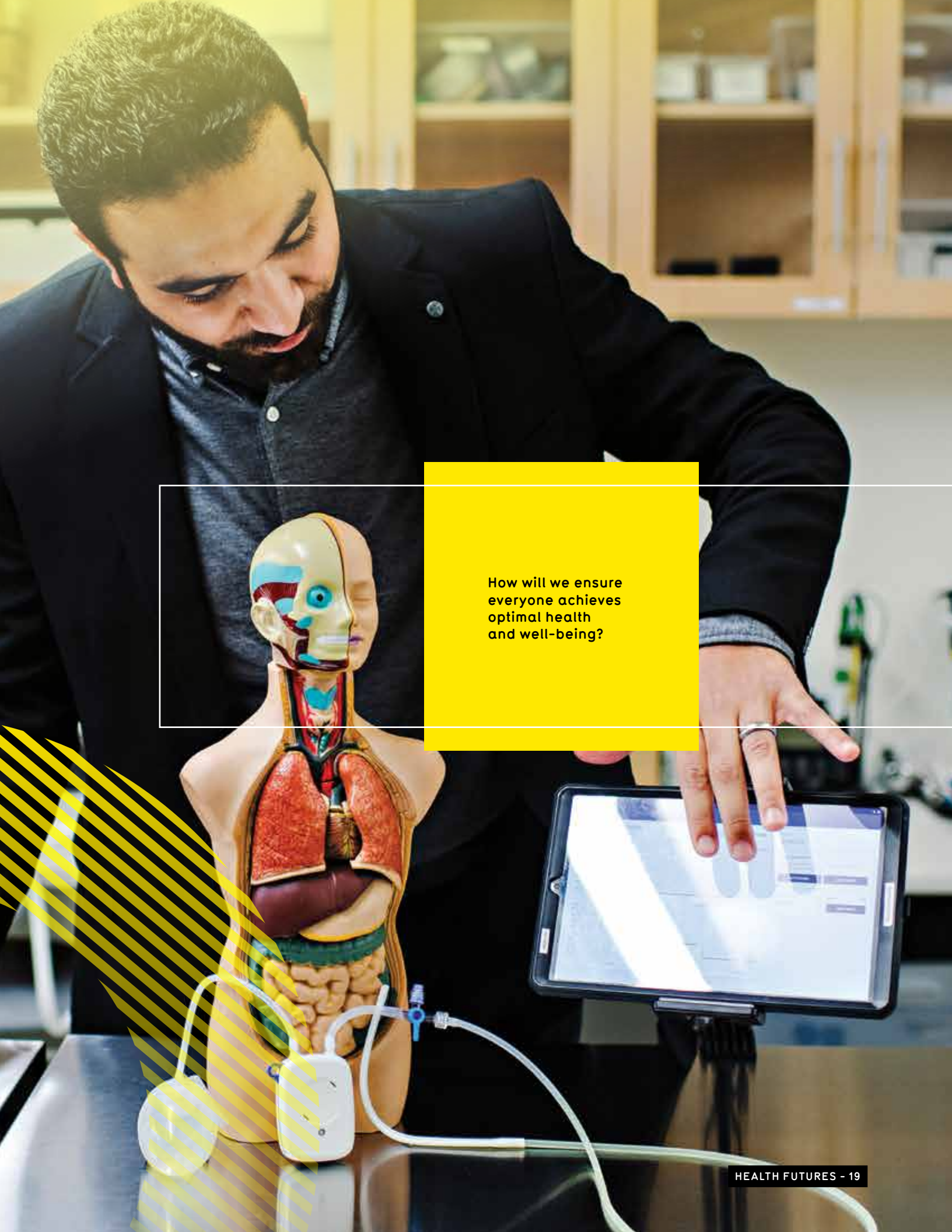
How will we ensure everyone achieves optimal health and well-being?

CREATING AN EQUITABLE HEALTH-CARE SYSTEM IN CANADA

A NEED FOR STANDARDIZED RACE-BASED DATA COLLECTION IN CANADIAN HEALTH CARE

Rachel Almaw (BSc '23, master's in progress)

Student, Faculty of Health
2022 Co-op Student of the Year

Rachel Almaw was awarded the 2022 Faculty of Health Co-op Student of the Year. She worked for three co-op terms in the Mobilize Clinical Biomechanics Lab, which is based in Waterloo's Department of Kinesiology and Health Sciences. It was through these co-op terms that she found her calling.

Almaw focuses her research on the intersection of health and race. We asked her what needs to change in Canada's approach to data collection and research to create a more equitable health-care system.

Today, 4.6 million people are living with osteoarthritis (OA) in Canada, a number that is projected to rise significantly in the coming years. In some cases, OA patients experience extreme pain that might render them immobile or unable to carry out daily life tasks.

Sadly, many Black and other racialized OA patients report a lack of trust in health-care providers. They tell stories of how their symptoms and the impact of OA on their lives are not validated by health professionals. Data from the United States suggests that although Black and other racialized people are known to have more severe disease symptoms, they are less likely to receive the gold standard treatment, causing them to live with the perpetual pain of just existing.

Unfortunately, there is no data in Canada to explore whether similar issues of systemic racism exist in this country. This lack of data, in and of itself, is a critical example of our system's failure to adequately provide accessible, quality care for Black and other racialized patients with OA. Hence, it begs the question, "What are the real experiences of Black and other racialized OA patients in Canada?"

Co-op helped me find my purpose

When I started at the University of Waterloo, I had no idea what OA was, and I had some very clear ambitions: I was going to finish my undergraduate degree, then go straight to medical school. Now, I can't imagine a career where researching the intersection of race and health in OA from a Canadian perspective wasn't part of it.

That's why I kept returning one co-op term after another (for a total of three terms) to the Mobilize Clinical Biomechanics Lab, based in Waterloo's Department of Kinesiology and Health Sciences. I've found my purpose is to pursue equitable health care for all, but this is not something that I can achieve alone.

The fact that Canada does not have a standardized and consistent approach to race-based data collection in the health-care system makes answering my earlier question a bit more challenging. However, I can confidently deduce that a lack of data does not mean the absence of inequalities in health-care treatment of Black and other racialized OA patients here.

I believe the solution for a more equitable health-care system in Canada can be achieved by adopting the four following approaches. Firstly, we need to create a standard for collecting race-based data. Second, we must individualize care that reflects the person and their context. Third, improved bedside approaches are needed to validate patient experience and engage patients in shared clinical decision-making. Finally, we must engage the Black and other racialized communities in the health-care system as clinicians to create a more equitable future for health care in Canada.

DEVELOPING PERSONALIZED CANCER VACCINES

DEEP LEARNING TECHNOLOGY IS MAKING IMMUNOTHERAPY TREATMENT MORE ACCURATE AND AFFORDABLE

Cancer is the leading cause of death in Canada with an estimated 230,000 people are diagnosed with cancer every year, according to the Canadian Cancer Society.

Ming Li, a professor in the Faculty of Mathematics, is using deep learning technology to make personalized cancer vaccines accessible to everyone. Li initially began doing cancer research when his wife, Jessie W. H. Zou, was diagnosed with breast cancer. Although she died in 2010, her legacy continues in Li's research.

Traditional cancer treatment consists of three pillars: surgery, chemotherapy and radiation. In the past 30 years, researchers have been developing a fourth pillar: immunotherapy. "This is essentially using your immune system to fight the cancer," Li says.

Although some immunotherapy drugs have been around since the 1990s, scientists have begun developing individualized cancer vaccines that teach a patient's immune system to recognize and destroy cancer cells. The problem with this exciting treatment? It's prohibitively expensive.

"Every person's cancer is different," Li says. "You have to do a lot of time-consuming, labour-intensive experiments that cost millions of dollars."

Li's team and Bioinformatics Solutions Inc. developed a process that uses deep learning technology to streamline and automate a key part of the vaccine-development process. Their process, a program called DeepImmu, analyzes tumour samples from

Dr. Ming Li

Professor, Faculty of Mathematics
Cheriton School of Computer Science
Canada Research Chair in Bioinformatics
Founder, Bioinformatics Solutions Inc.
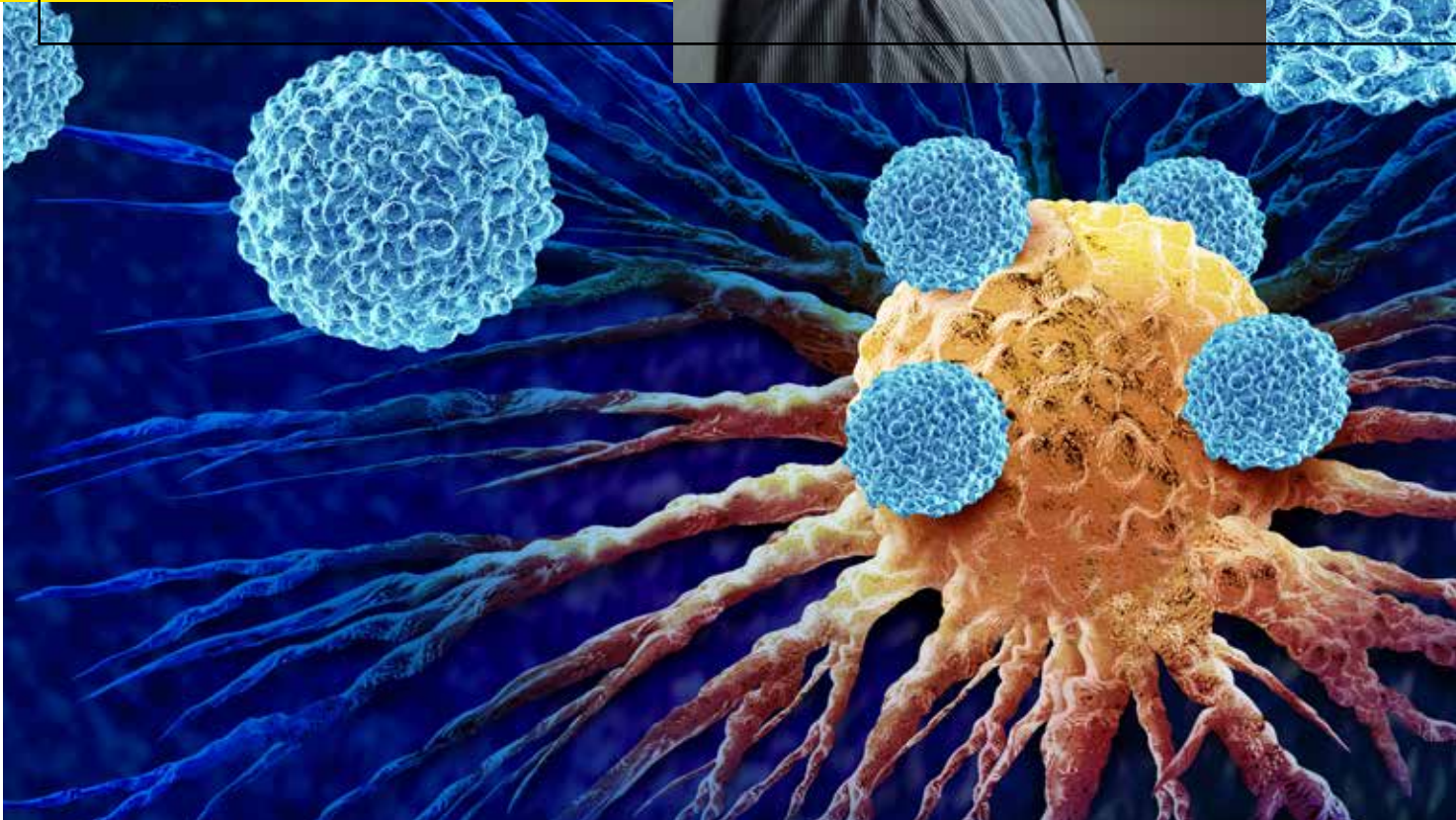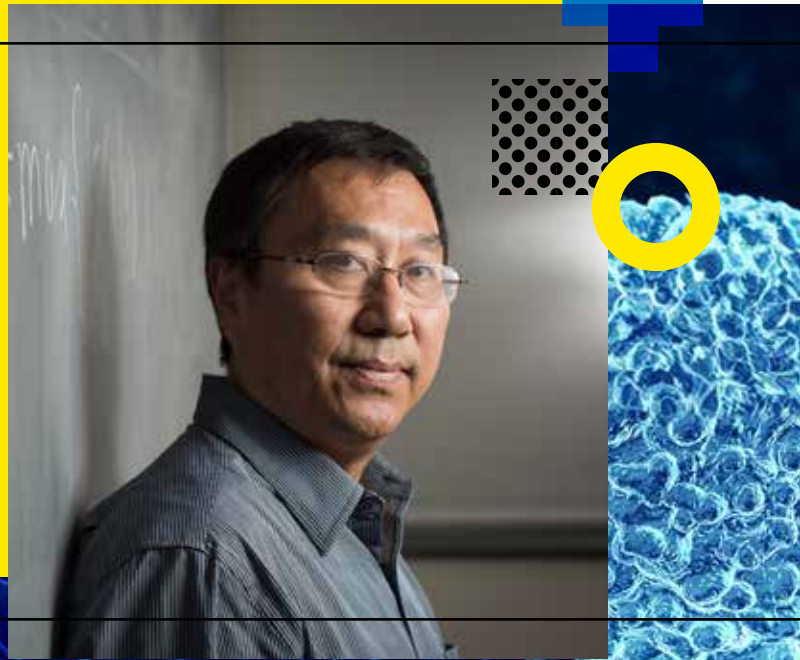
a biopsy, identifies all peptides on the surface of the cancer cells, and then selects a vaccine blueprint for medical researchers to fabricate the final cancer vaccine.

Recent clinical trials have proven the technology to be effective. The price tag, about $10,000, is a far more reasonable cost for the average patient.

"In my wife's day, chemotherapy and similar treatments didn't work for late-stage cancers," Li says. "With personalized immunotherapy, we will be able to help millions of people."

TAKING A FAMILY–CENTRED APPROACH TO MENTAL HEALTH CARE

With growing awareness about mental health challenges, Dr. Dillon Browne's FamilyPsyle Lab has carved a unique path. Recognizing a gap in Canada's predominantly individual–focused mental health landscape, FamilyPsycle integrates a family–centric perspective into mental health–care services.

THE FAMILYPSYCLE LAB IS PREPARING FUTURE CLINICIANS FOR TRAUMA-INFORMED FAMILY THERAPY

By adopting a holistic approach, the lab addresses the intricate and complex influences shaping mental health – from genetic vulnerabilities and socio-cultural factors to profound life adversities.

"We fit our treatments to the complexity of family life, rather than trying to fit families into our treatments," Browne says. The lab is located in a shared clinic, the Centre for Mental Health Research and Treatment, that offers services to children and families in Waterloo region.

For many families, traumas stemming from war or natural disasters introduce a multidimensional challenge. It's not just about the overt repercussions like loss or violence, but also the nuances like separation from loved ones and disrupted routines. Browne asserts that we shouldn't make assumptions about trauma as each family's experience is distinct. Rather, treatments must be tailored to reflect trauma's multi-faceted nature.

Dr. Dillon Browne

Professor, Faculty of Arts

Canada Research Chair in Child
and Family Clinical Psychology

FamilyPsycle® Lab

FamilyPsycle harnesses psychological, epidemiological and clinical methodologies to explore the intersection between relationships, mental health and adversity. By collecting extensive data, Browne and his team trace connections between mental health and family challenges, preparing future clinicians for trauma-informed family therapy. This innovative approach optimizes resources in our stressed health-care system and broadens its impact beyond the lab's confines.

"By training clinicians in family therapy, we can reach more people in the scope of a single intervention."

Browne has a clear vision for the future: building a health-care system that inherently values the family unit. As the world becomes more technologically adept, he emphasizes the need for advances such as AI-assisted therapy, to stay rooted in evidence-based practices and ethical innovation.

In the advancing landscape of health care, Browne's FamilyPsycle Lab stands as a testament to innovation, resilience and the unwavering commitment to bettering family mental health care.

Waterloo's new Innovation Arena is connecting researchers, health practitioners, investors, businesses and community networks to bring transformative solutions and technologies to the world's most pressing health challenges.

How will we lead the
next technological
transformation to
ensure a safe and
human-centred
digital future?
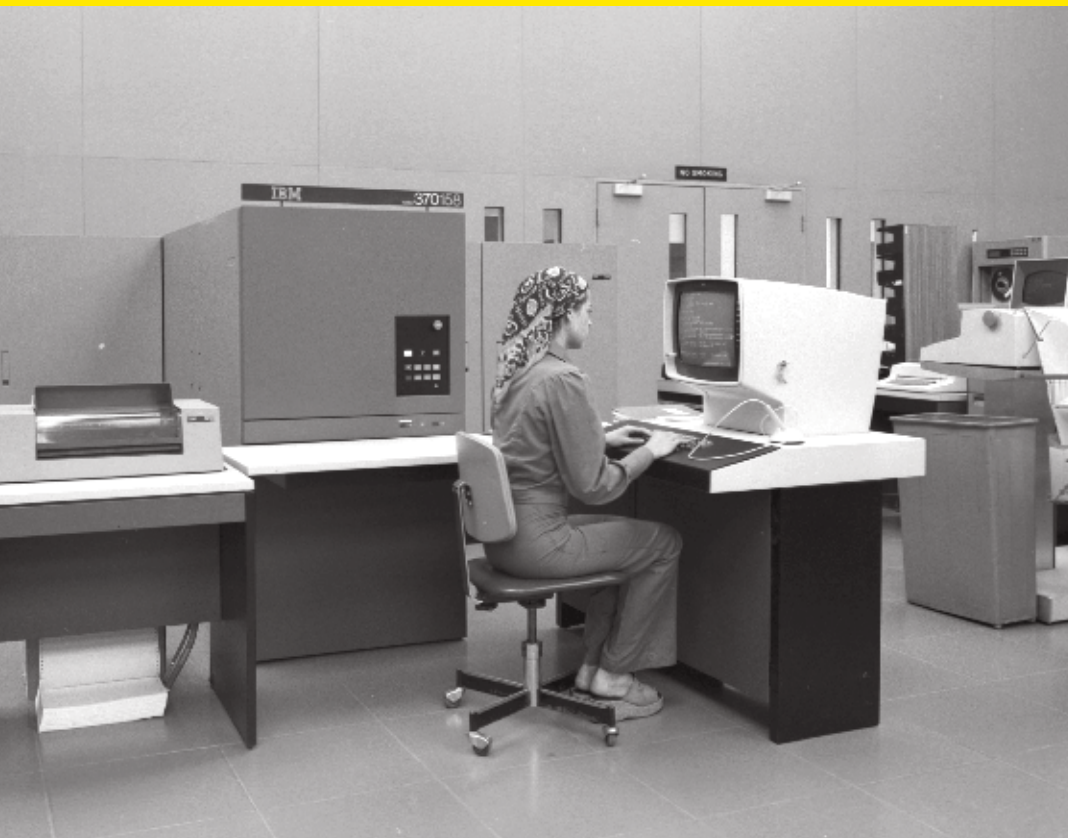
⊕ STUDENT USING AN IBM 370-158 COMPUTER IN 1974. WATERLOO WAS AMONG THE FIRST UNIVERSITIES
IN THE WORLD TO GIVE UNDERGRADUATES ACCESS TO STATE-OF-THE-ART COMPUTERS.

TECHNOLOGICAL FUTURES

Technology is dramatically transforming the way we work, live and connect. In a future where big data, artificial intelligence and new machines bring both promise and risk, innovators are designing breakthroughs for real–world solutions at a rapid pace.
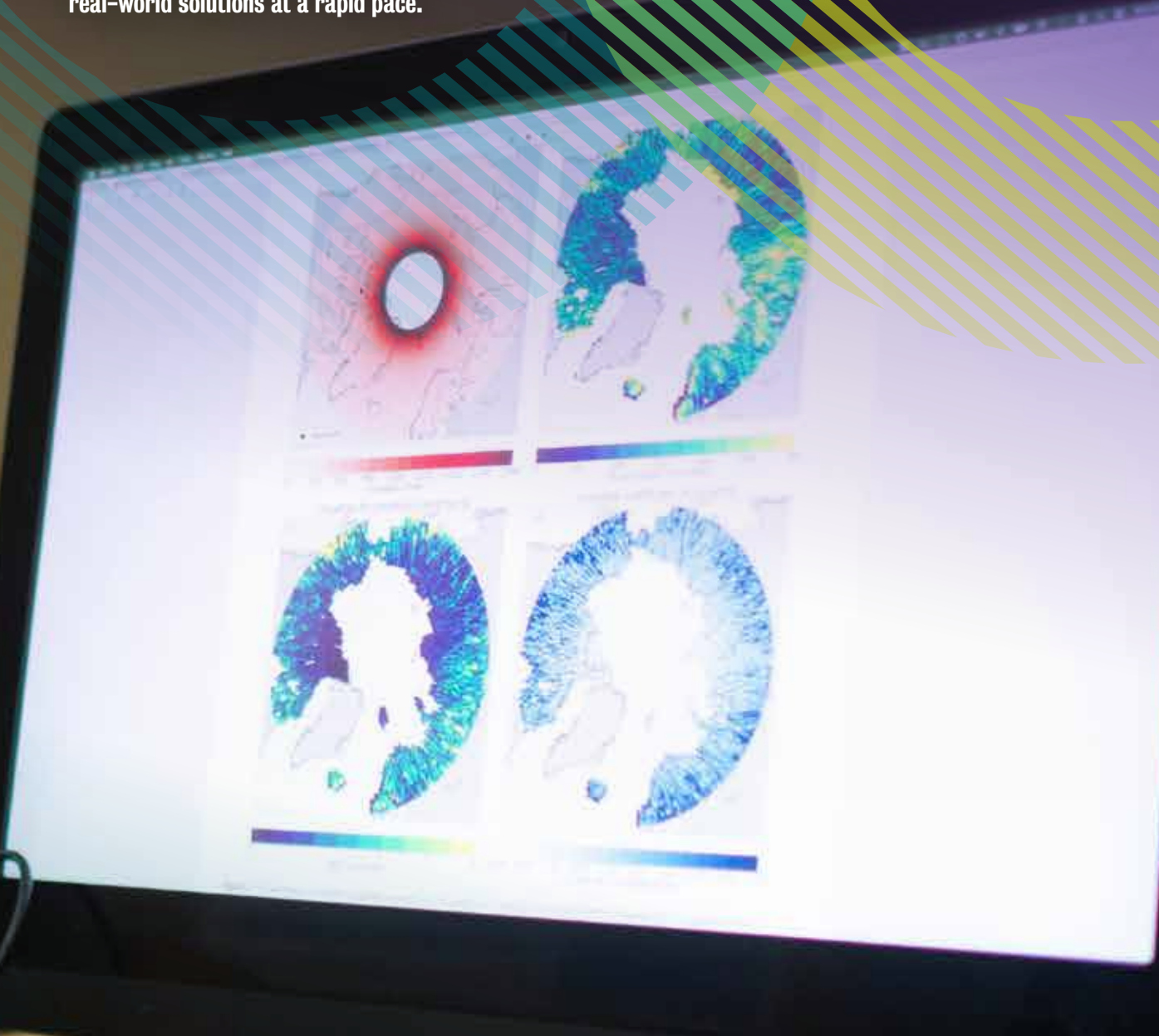
USING TECHNOLOGY TO HELP HUMANS FLOURISH

PRIORITIZING PURPOSE AND VALUES OVER MOVING FAST AND BREAKING THINGS WHEN IT COMES TO NEW TECHNOLOGY
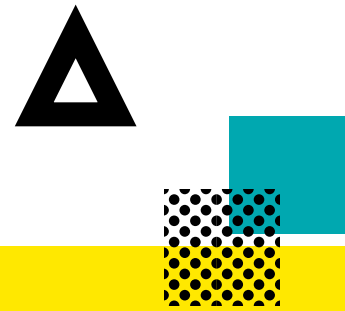
Edith Law is a professor at the David R. Cheriton School of Computer Science, where she co-directs the Human-Computer Interaction Lab. Her research delves into social computing technology, machine intelligence interactions and the design and user experience of technology that upholds important human values.

We asked Law how we can ethically harness the power of new technologies for the betterment of humanity.

Human-Computer Interaction (HCI) goes beyond technology development to critically assess how technology impacts people's lives. It shapes the future of computer science by making us question how and when technology advances society and the economy amidst our rush for rapid innovation.

In my work in HCI, I've developed projects exploring technology's role in well-being and how technology-mediated coordination can have an impact on realizing our values and steering society's future. My research leads me to appreciate the importance of blending human and machine intelligence to achieve results neither can attain independently.

Dr. Edith Law

Professor, Faculty of Mathematics
Cheriton School of Computer Science
Co-director, Human-Computer Interaction Lab
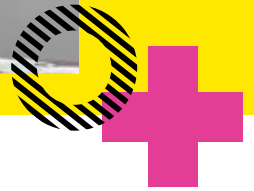
In collaboration with a neurologist at Sunnybrook Hospital, we designed a platform for sleep pattern analysis. This study revealed the nuanced nature of human categorization and how vital human intervention can be to collecting research data. It uncovered the pressing need for AI systems to handle ambiguity, especially in health-related tasks.

One ongoing project, in collaboration with KW4 Ontario Health Team, YMCA and Community Healthcaring Kitchener-Waterloo, aims to develop a health navigation platform that connects newcomers with organizations. This app addresses social determinants of health, including employment, transportation and social connections, to improve the newcomer's well-being and belonging.

There are many opportunities to use technology in education. We developed a platform that enables children to teach a robot how to classify objects while learning through teaching. Having a less knowledgeable robot helped children feel more engaged in teaching a robot that knew less than they did.

Technology also enables collaboration. My team is beginning to partner with various communities, working to create collaborative authoring tools for curriculum development. This new platform will enable diverse groups, across cultures, to incorporate values into educational content through storytelling.

Another project focuses on decentralizing the process of classical music production. Traditional orchestras and choirs operate under centralized direction, but this platform aims to empower musicians, directors and even audiences to collaboratively shape concert programs to reflect their ideas and values.

Incorporating human values into technology is a complex but a worthwhile endeavour. Values are deeply personal and shaped by cultural, philosophical and societal influences. The ethical dimensions of technology development and deployment demand thoughtful consideration. It's crucial to assess when technology should be used and when it may be better to abstain, always putting human welfare first.

Furthermore, addressing biases in machine learning and data labelling is a pressing concern. My team is actively developing tools that help people who label machine learning data to recognize and reflect on their own biases. Our premise is that we should address the problem at the human level first, before the data even reaches the machine learning pipeline. This promotes awareness and enhances the quality of labeled data, contributing to more ethical and unbiased datasets.

I envision a future where collaborative systems prompt people to reflect on their values. I'm convinced that technology, when harnessed thoughtfully and ethically, can bridge divides and ultimately foster human flourishing.

RESPONDING TO CLIMATE CHANGE WITH SPACE TECHNOLOGY

A GENERATION-DEFINING MISSION WILL DEVELOP SATELLITE TECHNOLOGY TO HELP PLAN OUR RESPONSES TO CLIMATE CHANGE

At a time when we are experiencing the effects of floods, fires and heatwaves like never before, a new space mission aims to improve climate projection models to help us understand what future scenarios may be possible.

Dr. Christopher G. Fletcher

Professor, Faculty of Environment
Waterloo Climate Institute
Water Institute

SPOTLIGHT

34% of research partnership funding comes from government and private sector contracts (2022/23)

In 2022, the Canadian Space Agency awarded the High-altitude Aerosols, Water Vapour and Clouds (HAWC) mission $200 million to create novel satellite instruments for measuring atmospheric changes. Dr. Chris Fletcher, an expert in earth systems modelling, is part of this scientific consortium developing the technology that will reveal previously unseen information on variables such as cloud temperature and location.

"We already have climate prediction models, but the problem is that we need to narrow the level of uncertainty as we project further into the future, like 50 or 100 years from now," he says. "This mission will enhance our monitoring capabilities, allowing us to fill in gaps like monitoring the Arctic and other remote regions and make better predictions of climate impacts through to 2100."

With work underway to design and build the instruments, Fletcher and the team will contribute to the pre-launch equipment testing on Earth before the space launch.

HAWC is a mission that will be transformational for the next generation of climate scientists. It will not only give them improved technology to study climate change, but this mission will make Canadian universities like Waterloo a go-to destination over the next decades for students interested in space-based remote sensing."

As the largest Canadian-led space mission in more than a decade, it's part of a wider global effort to reduce uncertainties in climate projection models as identified by the United Nations' Intergovernmental Panel on Climate Change. As Canadian collaborators work with partners in Japan, France and the United States, it spotlights how critical collaborative research is for our collective future.

FIXING A PATIENT CARE COMMUNICATION GAP

A NOVEL TECHNOLOGICAL PLATFORM DEMYSTIFIES MEDICAL INFORMATION WITH HELP FROM AI

Seun Adetunji (MBET in progress)

Student, Faculty of Engineering
Founder, MedInclude
Conrad School of Entrepreneurship and Business
GreenHouse

SPOTLIGHT

Seun Adetunji combines her experience working in the health care sector with her expertise in communications and equity, diversity and inclusion, to create a patient-centred solution for understanding medical information.

Health-care providers often provide patients and their caregivers with important information that include specific medical jargon. But research has shown that about 51 per cent of those patients don't understand the medical language provided by their doctor.

⊕ **Read more about MedInclude's impact at KidsAbility**

Adetunji, a student in the Master of Business, Entrepreneurship and Technology program at the University of Waterloo, says this problem became more apparent to her while working as a communications professional in the health care sector, providing patient advisory and support for stomach cancer and cardio-oncology patients.

"The patients that I was working with were in and out of the hospitals on an average of three times a month seeing multiple specialists and doctors," Adetunji says. "At that rate, medical information became overwhelming for them and their caregivers. In my time supporting those patients, I sought out tools and solutions that could help them manage and better understand the medical information they were receiving."

When she could not find the right tool or solution, Adetunji took matters into her own hands by creating MedInclude, an AI-based data processing platform that can help health-care providers transcribe patient notes into lay terminology in real time. MedInclude also includes a text-to-audio and language translation feature for people with disabilities and English language barriers.

In 2023, the MedInclude team launched their first pilot of the new platform in partnership with KidsAbility, an organization that supports children, youth and their families through innovative programs and the latest technology.

Adetunji's goal is to leverage AI technology to make medical information more accessible for patients and their caregivers – enabling patients to have more agency in their own health-care decisions.

ECONOMIC FUTURES

How do we
build equitable
and resilient
economies to
lead us into
the future?

Technology and automation play
a central role in the future global
economy. At the same time, labour
shortages, disruptions to supply
chains, and geopolitical and
digital threats have shown us the
vulnerabilities and risks inherent
in our economy. Talent will lead
the way in shaping innovative
ecosystems to grow local and
global economies for social impact.

THE GROWING INFLUENCE OF GEN Z IN THE WORKFORCE

WORK-INTEGRATED LEARNING PROGRAMS PREPARE ORGANIZATIONS ON HOW TO ACCESS THE NEXT GENERATION OF TALENT

Waterloo partners with

7,500+ CO-OP EMPLOYERS ACROSS 60 COUNTRIES

⊕ DREWERY INTERVIEWED ABOUT GEN Z VALUES ON THE CO-OPERATIVE AND EXPERIENTIAL EXPERIENCE PODCAST WORK.LEARN.REPEAT.

Dr. David Drewery is the associate director of the Work-Learn Institute, a research, education and consulting unit at the University of Waterloo that advances work-integrated learning programs for employers and higher education institutions.

His current research investigates how employers can connect with Gen Z's work values to attract and retain talent through work-integrated learning. We asked Drewery how Gen Z can help create equitable and resilient economies in the future.

Worldwide, four out of five employers struggle to find talented people. This is a massive problem for the global economy because it means organizations need more talent to solve complex problems.

When asked about the drivers of this problem, many employers point to "Gen Z", the generation born after 1997. Some employers mention that Gen Z lacks commitment, and others assert that Gen Z lacks fundamental workplace skills.

If these claims stand up to scrutiny, we may be in trouble. The Baby Boomer generation is quickly transitioning out of the labour market and Gen Z is replacing it. In fact, Gen Z will make up at least a third of the global workforce in the coming years.

**Dr. David Drewery
(BA '11, MA '14, PhD '22)**

Alum, Faculty of Health
Associate Director, Work-Learn Institute

Fortunately, the research my colleagues and I conducted suggests a way out. The issue is that employers misunderstand what Gen Z wants out of their work. If we can resolve this misunderstanding, we might help employers find talent and can help Gen Z access meaningful work.

What does Gen Z want?

Here at the Work-Learn Institute, we have explored Gen Z work values which are qualities about a job or employer that a person might find important, such as prestige or work-life balance.

Our research suggests that Gen Z values organizational support for training and development and for equity, diversity and inclusion. Gen Z also values jobs with work-life balance, job security and financial rewards. So, Gen Z wants to work in stable roles and for employers that offer room to grow and to be one's authentic self.

Gen Z work values may differ from the values of past generations. For instance, compared to Millennials,

Gen Z places greater emphasis on job stability and security. This is a critical insight for employers: understanding Gen Z's values will give them better access to talent.

How can work-integrated learning help?

So, how can we help employers better understand Gen Z work values? My colleagues and I believe work-integrated learning (WIL) can help. WIL brings Gen Z together with organizations to work together in authentic work settings. This helps employers understand Gen Z's work values, which are on display at work.

WIL also provides an opportunity for Gen Z to educate employers, creating spaces in which they can communicate what is important to them and comment on opportunities for organizations to do better. Employers then can update policies and practices to become a more attractive destination for the next generation of workers.

Our shared economic prosperity relies on thriving organizations. As Gen Z quickly becomes a major force in the labour market, the challenge will be for organizations to think about how they can connect to younger workers. WIL programs may be an important tool to bring employers and Gen Z together, to create mutual understanding and strengthen our economic futures.

TRAINING THE TECH TALENT OF THE FUTURE

CO.LAB CO-FOUNDERS DRAW ON THEIR CO-OP EXPERIENCES TO BUILD A FORBES RECOGNIZED GLOBAL BUSINESS

An industry serving a global audience should reflect global diversity. Yet diversity in tech, with people of different backgrounds bringing unique perspectives and experiences to the table, still feels a way off.

Co.Lab co-founders and University of Waterloo alumni Helen Huang and Sefunmi Osinaike are changing that. Their company is a hands-on digital training and mentorship program for people from all walks of life who want to break into tech. Co.Lab brings together teams of product managers, designers and software engineers to help participants develop their collaborative thinking skills and create a tangible product.

Helen Huang (BSc '17)

Alum, Faculty of Science
Co-founder, Co.Lab

Sefunmi Osinaike (BASc '17)

Alum, Faculty of Engineering
Co-founder, Co.Lab

#1

school for entrepreneurs in Canada (PitchBook 2023)

Both Huang and Osinaike found their feet in Waterloo's co-op program – and having since been named to the prestigious Forbes 30 Under 30 list, their entrepreneurial star power is on the rise as they use their co-op experiences to train future talent.

"The passion for what we're working on now really came from my experience struggling to get into tech and not having the right credentials to prove I was a fit," says Huang, who majored in earth sciences.

Osinaike, whose sole focus was to enroll in Waterloo's Enterprise Co-op program when he left his home in Nigeria, did exactly what he set out to do: gain experience and learn what it was like to work in the tech industry. Both Osinaike and Huang love that they met through co-op and have since built something successful together.

Making the Forbes list has propelled Co.Lab to the next level. The company has now helped more than 1,000 people in 50 countries switch careers and land roles at Apple, Google and Amazon, among others.
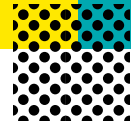
"It's great validation that we're doing really impactful work," Osinaike says. "We just hit our 1,000-learner milestone, and we're interested to see how the next couple thousand will work."

Dr. Sebastian Fischmeister

Professor, Faculty of Engineering
Cheriton School of Computer Science
Cybersecurity and Privacy Institute
Co-founder and CEO, Palitronica

PROTECTING CANADA'S ENERGY INFRASTRUCTURE FROM CYBER ATTACKS

USING TECHNOLOGY TO PREVENT COMPROMISED COMPONENTS FROM ENTERING CRITICAL SUPPLY CHAINS

Dr. Sebastian Fischmeister and his team are working to safeguard Canada's economic future by bolstering its critical infrastructure against the threat of cyber-attacks. Their research develops new security controls that shield against potential threats within the energy sector's vital supply chains.

"We are using a physics-based hardware and software integrity checkpoint system designed to scrutinize and assess the elements underpinning Canada's energy infrastructure," Fischmeister says. "Our aim is to compile these findings and present them to the Canadian government. By sharing our insights, we can empower them to make informed decisions."

Natural Resources Canada, supported by Defence Research and Development Canada, funds this initiative. Palitronica, a Kitchener-based startup born from the Real-time Embedded Software Group at Waterloo, is also part of the collaborative effort.

"Waterloo's creator-owned policy is a main reason I came to work here, it makes these types of working partnerships possible," says Fischmeister, who is the co-founder and CEO of the startup.

As various industries rely on increasingly complicated global networks, the likelihood of potential vulnerabilities increases. Visibility into supply chain security can wane as systems become more complex, heightening the urgency of these protective measures.

The cost of cyberattacks significantly burdens economies and industries worldwide, often resulting in substantial financial losses, compromised data and disrupted operations. These attacks can cripple critical infrastructure, damage reputations and impose long-term recovery expenses.

The team aspires to translate laboratory developments into real-world solutions, cementing Canada's position as a cybersecurity leader. Palitronica already collaborates with industry to integrate their technologies and services.

Fischmeister's visionary research promises to protect Canada's energy infrastructure and secure economic prosperity. This initiative shines as a guiding light in a challenging digital world, where thorough evaluation, cutting-edge technologies and strategic partnerships forge the path toward a safer and more promising future.

Launching the future of secure communication

See how researchers at the Institute for Quantum Computing are leading Canada's first quantum satellite to protect tomorrow's data.

FUNDAMENTAL RESEARCH AND SCHOLARSHIP

Our vision for Waterloo's global futures is fuelled by a relentless commitment to fundamental research and scholarship.

A spirit of curiosity and commitment to excellence in fundamental research and scholarship advances our understanding of ourselves, our planet and the universe to enable innovation and applications we cannot begin to imagine today.

⊙ WATERLOO RESEARCHERS PREPPING EQUIPMENT IN 1963 FOR THEIR FIRST CROSS-FACULTY FIELD TRIP TO STUDY THE ECLIPSE.

PEERING INTO THE COSMOS

THE CRUCIAL ROLE OF FUNDAMENTAL RESEARCH IN NURTURING CURIOSITY, CULTIVATING INNOVATION

Dr. Will Percival

Professor, Faculty of Science
Distinguished Research Chair in Astrophysics
Director, Waterloo Centre for Astrophysics

Dr. Will Percival is the distinguished research chair in Astrophysics and director of the Waterloo Centre for Astrophysics. His research delves into the properties of the universe on a vast scale, offering insights into the physics following the Big Bang and the forces driving today's cosmic evolution.

His work is at the forefront of observational cosmology, where he assumes key roles in space missions such as the Euclid satellite. We asked Percival why fundamental science is important for humanity's future.

Fundamental research is the backbone of long-term progress. Delving into the mysteries of science with no immediate applications in sight can sometimes be the best path to revolutionary discoveries.

There are classical examples of this in history. When electromagnetism was first studied, the uses of electricity were not obvious. Fundamental research is not just a curiosity-driven pursuit but has proven an indispensable driver of progress for society in health, sustainability, technology, the economy and more.

In the realm of physics, particularly within my field of observational cosmology, we confront a vast sea of unknowns within our universe. Why is the universe expanding at an increasing rate? All our standard models tell us it should be slowing down. We have no idea what the physical mechanism for this is. We call it dark energy. We've named it. But naming something does not imply understanding it.

It's work that is pushing the boundaries of our standard models while recognizing the historical precedent of fundamental physics, giving us unexpected real-world applications, from GPS using general relativity to quantum theory's role in modern electronic devices – like the cell phones in our pockets.

#1

comprehensive research
university in Canada
for the past 16 years
(Research Infosource)

Physics isn't done; it keeps going as we wrestle with new, big, unanswered questions. This can change how we understand the universe and, in ways we can't even imagine yet, change our world.

Physics is at the core of understanding the world around us. It delves into the fundamental principles that explain how things work. It is inherently interdisciplinary, combining statistical data analysis to test theories at the cutting edge of mathematical understanding. It's sometimes so deeply integrated into our research that we don't always label it as such – but it brings various research communities together.

As an astrophysicist, my research is primarily focused on galaxy surveys within observational cosmology, and I am one of the primary science coordinators for the Euclid mission. Euclid is a satellite mission, launched in July 2023, designed to study and understand the way the universe responds to dark energy. The investment in this fundamental research mission has already led to developments in cutting-edge instrumentation with potential applications beyond the mission itself. People and companies involved in these missions show remarkable enthusiasm and dedication because they are excited about contributing to ground-breaking science.

Fundamentally, the justification for such research hinges on two key factors. First, it's a long-term investment in advancing scientific knowledge for the betterment of humanity. Second, these endeavours possess significant outreach potential.

Astronomy ignites excitement in people and makes people ask questions and ponder fundamental concepts. This is vital for building a scientifically literate society. For instance, the launch of Euclid garnered global media attention, signalling a collective human curiosity and desire to explore the big questions about the universe. We will continue peering into the cosmos, even amidst the complexities of history and the challenges of modern society, in an enduring pursuit of understanding the universe and its fundamental workings.

KNOWING OUR HISTORY TO KNOW OURSELVES

WEAVING KNOWLEDGES THROUGH FUNDAMENTAL RESEARCH IN THE ARTS, HUMANITIES AND SOCIAL SCIENCES

Our modern world is driven by technological and scientific innovations that demand broad interdisciplinary approaches, including fundamental research in humanities and social sciences. These fields play a critical role in understanding who we are as individuals and as societies.

Dr. Susan Roy

Professor, Faculty of Arts
Balsillie School of
International Affairs

⊕ TRANSFORMER STONE, SHÍSHÁLH TERRITORY

Susan Roy's research examines the history of Indigenous-non-Indigenous relationships with attention to land rights activism and cultural performance, along with resource and urban development disputes in Canada.

The past is more than a sequence of events. It comprises an intricate and complex tapestry of narratives, perspectives, cultures and ideas that have shaped the human experience. Fundamental research helps to tease apart this deftly woven tapestry, providing new and deeper insights into a connected and shared human identity.

"As a non-Indigenous historian, I am honoured to partner with Indigenous communities on research endeavours that encompass legal, environmental, cultural and artistic dimensions," Roy says. Her research methodology prioritizes Indigenous initiatives, knowledge systems and cultural practices. "This ensures that the research actively contributes to cultural and language revitalization efforts and the assertion of land rights within Indigenous communities."

For instance, drawing from the colonial archive, Roy examines historical records in collaboration with Indigenous community researchers who possess deep expertise in environments, genealogies and languages. Together, they develop culturally informed perspectives that reveal the significance of these materials. Although these records often reflect the historical colonial agenda of Indigenous erasure, Roy's collaborators unveil within them the brilliance of Indigenous activisms, resistances and ongoing relationships to the land.

This form of fundamental research allows us to revitalize and preserve cultural heritage, question established narratives and recognize the diversity of human endeavour. With the insights gained from this research, we become equipped to navigate the complexities of our world and to weave a more enlightened and empathetic future.

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WATERLOO