EXCELLENCE IN RESEARCH & INNOVATION

Friday, November 19, 2021

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25 YEARS

A SOLID PAST, A BRIGHT FUTURE

THE RIGHT HONOURABLE PAUL MARTIN
FORMER PRIME MINISTER OF CANADA

Twenty-five years ago, a group of university leaders confirmed an unfortunate fact: many of Canada's most notable scientists were leaving the country in the "brain drain."

Scott Clark, the deputy minister of Finance at the time, and I were pleased to lend our support to the establishment of the Canada Foundation for Innovation (CFI) to provide the environment, labs and state-of-the-art equipment needed to retain top researchers in Canada.

Today, the CFI continues its work to serve researchers here and also to enrich their work by attracting engaged innovators from around the world to join them and by providing support and inspiration for the next generation of researchers across Canada.

We can find stellar examples of the CFI's successful investments, for instance, in artificial intelligence, where researchers continue to break new ground in understanding the principles of machine-learning techniques, and the CHIME radio telescope, which is figured in the news this year by identifying mysterious bursts of radio waves from outer space.

Support for researchers at the University of Manitoba to build the digital architecture for an archival repository of more than five million documents collected by the Truth and Reconciliation Commission of Canada will help to make these important documents accessible. And just as the Perimeter Institute in Waterloo opened doors 25 years ago for Canadian researchers in theoretical physics, a project to create a Centre for Indigenous Knowledge and Learning at the University of Guelph is now opening its doors to the next generation of scholars in Canada.

We should all be proud of the CFI, which has enabled – and will continue to enable – researchers to flourish across Canada.

Measuring matter

McGill research furthering our knowledge of the cosmos

When a groundbreaking new radio telescope begins operating in a sheltered valley near Penticton in British Columbia in 2024, the first signals it detects will be pulses that have travelled for billions of light years from the outer-most edges of the universe – and they may unveil new physics about the cosmos.

These signals will be both fast and faint, perhaps lasting only a fraction of a millisecond, but the data they provide could help scientists answer some of the most perplexing questions about both the origin and future of the universe.

Called the Canadian Hydrogen Observatory and Radio-Transient Detector (CHORD), the next-generation radio telescope is leveraging Canadian leadership in radio astronomy to produce breakthrough measurements of the cosmos, says Matt Dobbs, a physics professor at McGill University in Montreal, and director for the project, which is supported in part by the Canada Foundation for Innovation (CFI).

The $23-million CHORD project is building on the advances in radio astronomy achieved by the Canadian Hydrogen Intensity Mapping Experiment (CHIME) telescope, which has also received CFI support, located near Penticton.

While both telescopes detect deep space radio pulses, known as fast radio bursts (FRBs), CHIME has been a "discovery machine," while CHORD will provide more precise measurements, having better sensitivity and broader frequency coverage.

"Those changes are some of the most fascinating, new and important parts of astronomy today," says Dr. Dobbs. "Almost everything we look at in the sky historically over the last thousand years has been the unchanging part of the sky. Presently, for the first time, we're focusing on things that change at the millisecond level."

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>
> **Dr. Matt Dobbs**
> Physics Professor, McGill University

He says astronomers have been surprised to find that enormous explosions and changes in the night sky are happening at that time scale – and CHORD will be able to record them.

CHORD's detection of FRBs will further elevate Canada's world-leading position in that field, says Dr. Dobbs, but it is only one of the new telescope's three primary functions. It will also help astronomers map the cosmic structure back to when the universe was about a fifth of its current age, and further explore dark energy, a little-understood phenomena of the observed accelerating expansion of the universe. It's possible that CHORD could shed light on the physics behind dark energy.

Unlike some of the mega-projects that have been built in recent years or are now underway, CHORD will come on stream relatively quickly and at a reasonable cost considering the data it will provide to further our knowledge of the cosmos, says Dr. Dobbs.

CHORD is what is known as an ultra-wideband, "large-N, small-D" telescope, combining a large (N)umber of small-(D)iameter dishes for extreme sensitivity over a large field of view. It will consist of a central array of 512 six-metre diameter dishes supported by two "outrigger" stations, one in Green Bank, West Virginia, and the other in another U.S. site that has not yet been finalized.

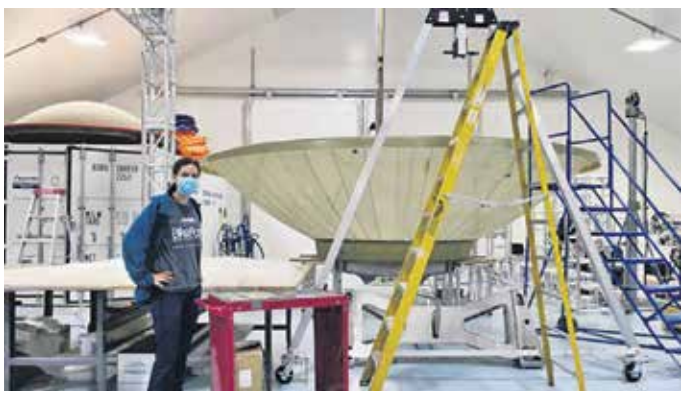
Everything that makes CHORD possible was developed in Canada, says Dr. Dobbs, including the composite dishes that were developed by the National Research Council in Penticton. The technology to process, calibrate and condense massive quantities of data – up to 10 terabits per second – in real time was developed at McGill and the University of Toronto, and special amplifiers to enhance the signals are being developed at the University of Calgary.

With breakthrough sensitivity, bandwidth and localization capabilities, CHORD will measure the distribution of matter over a huge swath of the universe, detect and localize tens of thousands of FRBs and undertake cutting-edge measurements of fundamental physics, says Dr. Dobbs.

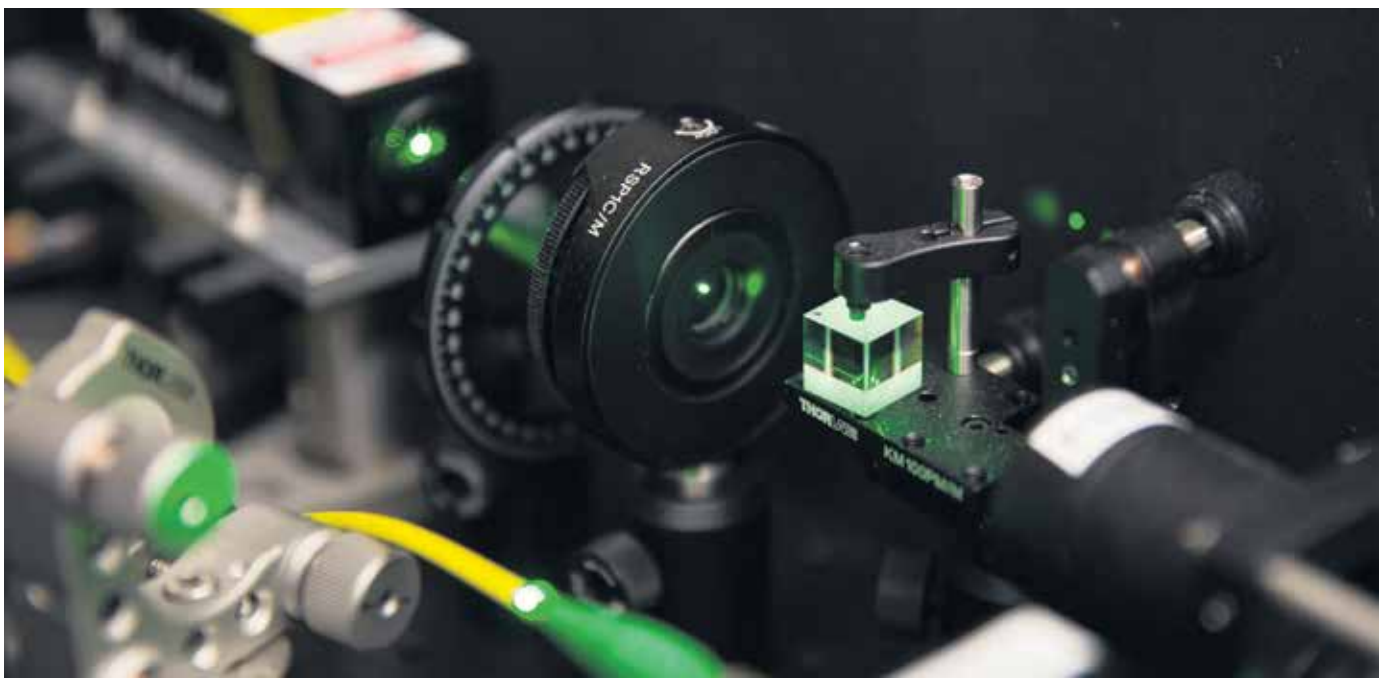
The advantage of the B.C. location is that the valley shields the telescope from other radio signals such as cell phone towers and television that could interfere with the detection of signals from space, he adds.

Dr. Dobbs hopes for at least two big wins from the CHORD project: to detect an unprecedented number of FRBs and use them as a tool to measure the cosmos. In parallel, measurements of emission from hydrogen could unlock the mystery behind the dark energy that is accelerating the expansion of the universe.

"We are going to do amazing things with CHORD, but in addition to that, the people who were trained on CHORD are going to develop into scientists who do even more amazing things," he says. "And that's going to be the multiplying, exponential growth of the science we do at CHORD. That we're building new talent in Canada alongside this new telescope. These trainees will, in turn, do even better science when they build their new instruments after CHORD."



The CHIME collaboration (top) builds on advances in radio astronomy. A CHORD prototype telescope dish is visible behind McGill graduate student Elizabeth Pieters at the Dominion Radio Astrophysical Observatory (bottom left), which is also shown in an artist's interpretation (bottom right) of the CHORD telescope array with the CHIME telescope visible on the right. SUPPLIED



Research infrastructure and expertise has helped to activate Calgary as 'quantum city,' a sought-after headquarters for international companies in quantum communication and quantum computing. **SUPPLIED**

The secret sauce for economic growth

Beyond supporting economic and social well-being, CFI funding helps attract talent and advance partnerships

Marc Nantel remembers being a postdoctoral fellow at the University of Michigan and wondering if there was a future for him in Canada. It was the late 1990s and he was deeply immersed in the field of laser, plasma and X-ray spectroscopy.

"Then I learned that the Canadian government at the time had announced that it would use $500-million in surplus federal money to fund innovation," recalls Dr. Nantel, who is now vice-president of research and external relations at Niagara College in Niagara-on-the-Lake, Ontario. "That sent a strong message to me that Canada was serious about building a strong environment for research."

That announcement heralded the creation of the Canada Foundation for Innovation (CFI), an independent not-for-profit corporation that invests in research labs, facilities and equipment in Canada's universities, colleges and research hospitals. Its main goal is to expand the country's capacity to conduct world-class research and technology development while supporting economic growth and job creation, improving health and environmental quality, training the next generation of researchers, and strengthening collaboration among academic and research institutions and with the private sector.

> "A big part of our ability to attract these companies is the success we've had with CFI-funded projects in quantum science. In fact, we have a program right now that's creating a quantum internet, which is very important because it's linking quantum computing across the country.
>
> **Dr. Ed McCauley**
> President and Vice-Chancellor, University of Calgary

Today, almost a quarter-century since it was launched, the CFI has awarded $9-billion to almost 12,000 projects at 170 research institutions in 80 municipalities across Canada.

"Innovation is one of the secret sauces to economic growth, and it's also a key ingredient to addressing the challenges of our time," says Goldy Hyder, president and CEO of the Business Council of Canada, a 170-member association of business leaders and entrepreneurs that advocates for policies in the interests of growth, prosperity and inclusion for all Canadians. "Innovation is how Canada becomes a magnet for talent and investment, and how we create an academic and private-sector environment where we can solve pressing issues such as climate change."

Partnerships between schools, other research-focused institutions and industry are also key to Canada's economic and social well-being, and to its ability to compete on the global stage, says Mr. Hyder.

The CFI's funding model is designed to foster partnerships through every project it supports. The organization typically provides up to 40 per cent of research infrastructure costs for a project, which attracts additional investments from public-, private- and non-profit-sector partners.

This approach has allowed the CFI to help build research capacity in every province in the country. In turn, the research infrastructure it funds provides platforms for some of the country's most leading-edge academic, research and commercialization programs, and promotes economic development on regional and national scales.

In the province of Alberta, for instance, CFI funding has helped to foster research and commercial ecosystems in such sectors as health technology, energy, artificial intelligence, quantum science and space technology.

Calgary, in particular, has taken a leadership role in quantum science, says Ed McCauley, president and vice-chancellor at the University of Calgary, which is home to the Institute for Quantum Science and Technology.

"We are activating Calgary as a quantum city, and we've been successful in attracting an international company in quantum communication and quantum computing to come and establish its Canadian headquarters in Calgary," he says. "A big part of our ability to attract new companies is the success we've had with CFI-funded projects in quantum science. In fact, we have a program right now that's creating a quantum internet, which is very important because it's linking quantum computing across the country."

A major CFI-funded project that has had immediate societal impact is Advancing Canadian Wastewater Assets – or ACWA for short – a partnership between the university and the City of Calgary that features a research facility integrated into a fully functioning municipal wastewater treatment plant.

The $38.5-million facility, which received $10.4-million from the CFI, allows researchers to analyze the city's wastewater and study the real-time effects of effluent on living ecosystems. Calgary has been able to use its ACWA partnership with the University of Calgary to detect COVID-19 viral particles in wastewater and use the data to predict community infection rates.

"So now we have this amazing predictive tool that helps the city understand community transmission of COVID-19 and better inform health policies," says Dr. McCauley.

For Dr. Nantel at Niagara College, CFI funding has been transformative not only for the institutions where he has worked but also for his career.

"The first grant proposal I wrote was for the CFI, and that was to build a laser micro-machining facility at the University of Toronto, where I worked after I came back from Michigan," he says. "When I moved to Niagara College in 2011, the first proposal I wrote was also for grant funding from the CFI because we needed new equipment for our food and beverage research."

Support from the CFI has helped transform research at Niagara College, says Dr. Nantel. The school now has four specialized labs in chemistry, biology, sensory analysis, shelf life and packaging.

"We opened the labs in 2013 and our work in these labs has really taken off," he says. "Since then, we've received another large grant from the CFI for an innovation centre with an emphasis on beverage research and which includes a beverage production facility."

These CFI-funded facilities have enabled commercial partnerships with industry, says Dr. Nantel. Recent projects include development of an award-winning gin with zero per cent alcohol as well as microbiology analyses of a company's meat curing process to ensure that the finished product was free of all bacteria.

"Right now we're gearing up to work on cannabis-infused edibles and drinkables," says Dr. Nantel. "Thanks to funding from the CFI, we're able to help all these companies develop and commercialize products so they can be competitive in their markets. And when they succeed, they create jobs for our students and other Canadians, and help improve the economy. CFI funding really has a big impact."

SNOLAB: WHERE DISCOVERIES INFORM OUR MODEL OF PHYSICS

Questions about the early evolution of our universe are inherently difficult to answer, yet scientists believe understanding neutrinos – and especially explorations into a rare process called neutrinoless double-beta decay – can help to unlock some of these mysteries.

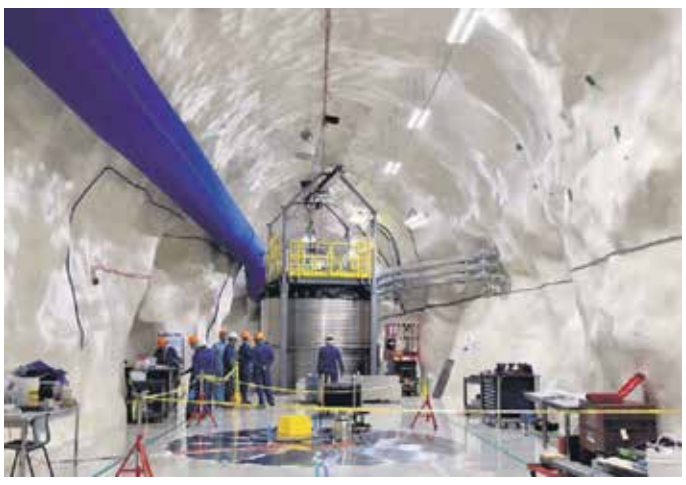
Although they are one of the most abundant subatomic particles in the universe, neutrinos are difficult to detect since they have no electric charge and interact very weakly with matter. "Previous research findings inspired the hypothesis that neutrinos are their own antiparticles," says Clarence Virtue, interim executive director at SNOLAB, Canada's deep underground research laboratory, located in Vale's Creighton mine near Sudbury, Ontario. "That's a property that no other elementary particle has and, if proven, this will allow us to build neutrinos correctly into the standard model of particle physics."

Understanding this type of radioactive decay could yield significant insights on how we ended up with a matter-dominated universe when equal amounts of matter and antimatter should have been created in the Big Bang. Dr. Virtue reports that two leading experiments probing neutrinoless double-beta decay – nEXO and LEGEND-1000 – have both indicated SNOLAB as their facility of choice.

Observing neutrinoless double-beta decay wouldn't be the first time a discovery at the SNOLAB site fundamentally changed physics: in 1990, scientists from several Canadian universities started an experiment that eventually led to the discovery that neutrinos have mass. This changed our understanding of the innermost workings of matter and shifted our view of the universe.

At the same time, SNOLAB secured funding from the Canada Foundation for Innovation, which enabled the expansion into a world-class facility with 5,000 square feet of clean lab space and a broad multi-experiment program. Operating at a depth of 6,800 feet, "there are two kilometres of rock above SNOLAB, shielding the detectors from cosmic radiation that bombards the Earth's surface," says Dr. Virtue. "That's a significant advantage for experiments looking at very rare and subtle events. Another advantage is that the entire lab operates as a Class 2000 or better cleanroom."

In addition to the astroparticle physics that makes up the bulk of SNOLAB's scientific program, the unique environment in the lab also facilitates research in biology, geology and quantum computing. Since first receiving CFI funding, SNOLAB has significantly expanded its infrastructure and scientific support capabilities for many types of experiments.



SNOLAB is Canada's deep underground research lab, where background radiation is reduced by a factor of 50 million and further mitigations allow experiments to detect interactions such as those generated by a single neutrino. **SUPPLIED**

Beyond providing an opportunity for Canadian research teams to participate in world-leading research, SNOLAB also contributes to the development of highly qualified personnel, training hundreds of students as well as engineers, technicians, tradespeople and other professionals.

This powerful combination of talent and infrastructure recently catalyzed a timely response when the coronavirus pandemic led to a shortage of ventilators, says Dr. Virtue.

In partnership with colleagues around the world and with Canadian Nuclear Laboratories, TRIUMF and McDonald Institute in Canada, SNOLAB scientists leveraged their expertise in gas handling systems to develop the Mechanical Ventilator Milan (MVM), a simplified ventilator made from easily available parts, he says. "The idea was to make the design and manuals freely available. All the expertise that was needed – from project management, quality control, testing and writing the manuals to shepherding the project through Health Canada approval – existed within the particle physics community, which made the development very efficient."

By attracting major experiments with Canadian as well as international participation and diversified projects that go beyond astroparticle physics, SNOLAB is well positioned for the future, emphasizes Dr. Virtue. "Our lab is now completely booked, and we are looking for opportunities to fund an expansion."

INSIDE

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

MONA NEMER
CHIEF SCIENCE ADVISOR OF CANADA

As a recipient of Canada Foundation for Innovation (CFI) grants for my own research, as a vice-president research who oversaw numerous research projects across faculties and disciplines and as chief science advisor who represents research across Canada, I appreciate the importance of research infrastructure in Canada from many perspectives.

Our ability to pursue scientific excellence and attract outstanding faculty ... requires the spaces and equipment the CFI provides.

Our ability to pursue scientific excellence and attract outstanding faculty, to educate the next generation of researchers and highly skilled professionals who will innovate and develop industry and employment in all sectors of the economy requires the spaces and equipment the CFI provides.

The CFI has played a transformative role in terms of research and innovation in Canada. As we look at the challenges that lie ahead, the CFI's investments will be more important than ever.

Ryerson University is a vibrant and dynamic institution located in downtown Toronto. SUPPLIED

Green and inclusive

Ryerson researchers modelling a sustainable future that includes smart buildings and autonomous vehicles

As a vibrant and dynamic institution in downtown Toronto, Ryerson University's research mandate is all about future-forward and cutting-edge innovation. The university's focus on evidence-based research, technology-based solutions, and social responsibility and sustainability has attracted a swath of inventive academic minds who are proactively working on groundbreaking solutions to many of the real-world challenges that Canadians face as we think about the future.

Steven N. Liss, Ryerson's vice-president of Research and Innovation, knows that the key to fostering innovative teams of academic researchers is to create a long-term commitment to supporting research with a keen eye on matters like environmental stewardship, city building and creating connections between colleagues both within and outside of Ryerson. The university has a strategic plan that looks forward toward the year 2030, prioritizing innovation and sustainability as the cornerstones of the university's culture and academic programs. It makes for a campus where students and researchers are encouraged to follow lines of inquiry that will help them to envision their future in Canada, even in the face of immense challenges like climate change.

"Climate change and sustainability figure into so many disciplines here at Ryerson – those values are in our institutional DNA," Dr. Liss says. "Our plans look forward with respect to how we envision the future in relation to disruption, work, sustainable cities, climate change, artificial intelligence, science and technology, and health and wellness."

> "Instead of waiting until the future arrives and reacting to it, we are proactively envisioning that future in a virtual digital twin.
>
> **Dr. Bilal Farooq**
> Civil Engineer and Canada Research Chair in Disruptive Transportation Technologies and Services, Ryerson University

BUILDING FOR THE FUTURE

Those values hold true in many of Ryerson's various research projects that have received funding from the CFI. Researcher and architectural science professor Jenn McArthur recently received CFI funding for the Smart Campus Integration and Testing Lab (SCITLab), which will be physically hosted on the Ryerson campus and remotely accessible to colleagues from eight other institutions across Canada. The lab will be a standalone structure and the world's first 100 per cent digitally enabled building, allowing Prof. McArthur and her colleagues to conduct experiments that will help inform the building of sustainable infrastructure in the future, while also shedding light on how to optimize older buildings' existing systems to significantly reduce energy use.

From the outside, the SCITLab (which is scheduled to open by late 2022) will just look like a well-designed modern building, but every inch of its construction – from its mass timber walls and sensor-laden smart panels that can record how the building reacts to varying conditions, to multiple HVAC systems and cybersecurity equipment – is formulated to facilitate experimentation and gather data. The ground floor of the lab will be a mock-up of a smart home and the data centre tying it to the broader Ryerson Smart Campus project, with a smart office mock-up – both closed and open offices – and visualization suite on the second floor of the building.

"The lab is not so much a venue for research as it is the research. It really is a living lab," Prof. McArthur says. "There are many things that might otherwise be considered building components, but in this lab they're actually our research infrastructure. It's like our equivalent of an electron microscope – every piece of it is an experimental apparatus."

DRIVING TOWARDS NEW FRONTIERS

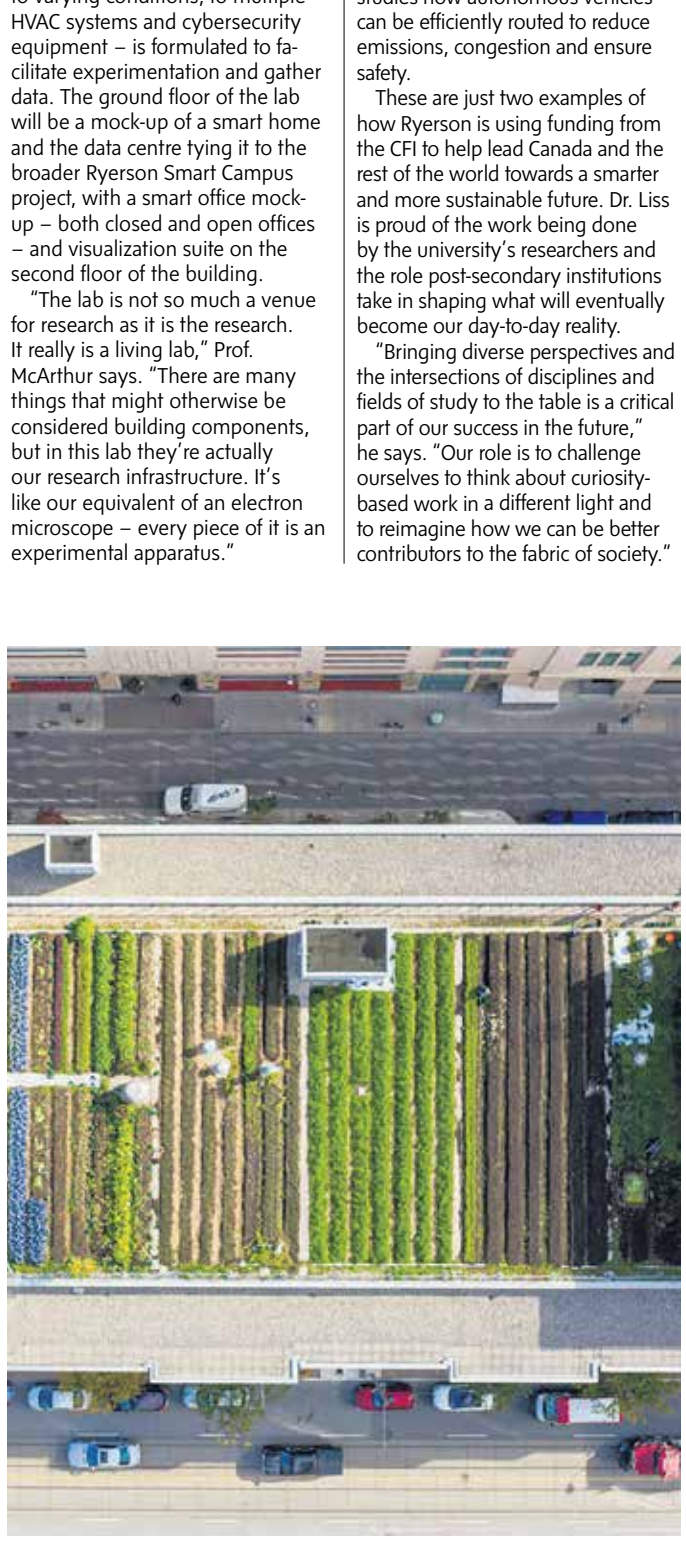
Civil engineer and Canada Research Chair in Disruptive Transportation Technologies and Services Bilal Farooq moves in the realm of one of the most talked-about technologies in our collective vision of the near future: autonomous vehicles. Dr. Farooq works in the CFI-funded Laboratory of Innovations in Transportation (LiTrans) at Ryerson's Centre for Urban Innovation. His focus is on studying how autonomous vehicles will interact with pedestrians and other real-world factors once they're unleashed on Canadian roadways.

"Instead of waiting until the future arrives and reacting to it, we are proactively envisioning that future in a virtual digital twin," Dr. Farooq says. "Through this technology, we can imagine autonomous vehicles coexisting with pedestrians."

Dr. Farooq and his team used this digital twin's virtual reality technology to collect information on behaviour patterns from volunteers of all ages who crossed virtual streets in front of both autonomous and traditional vehicles, creating a data set that is then turned into detailed behaviour modelling. The intention is to use this research to design predictive software for autonomous vehicles and also potentially influence policy and safety regulations for autonomous and mixed traffic roadways. Dr. Farooq's team also studies how autonomous vehicles can be efficiently routed to reduce emissions, congestion and ensure safety.

These are just two examples of how Ryerson is using funding from the CFI to help lead Canada and the rest of the world towards a smarter and more sustainable future. Dr. Liss is proud of the work being done by the university's researchers and the role post-secondary institutions take in shaping what will eventually become our day-to-day reality.

"Bringing diverse perspectives and the intersections of disciplines and fields of study to the table is a critical part of our success in the future," he says. "Our role is to challenge ourselves to think about curiosity-based work in a different light and to reimagine how we can be better contributors to the fabric of society."



Roof gardens at Ryerson University demonstrate the potential for producing food in urban spaces and contribute to the health and well-being of the community as well as the environment. SUPPLIED

FROM THE

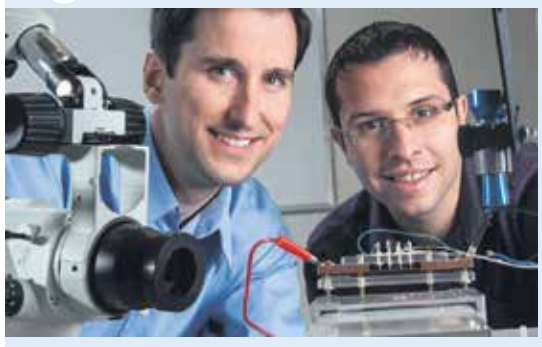
NANOSCOPIC

TO THE

GIGANTIC

With the CFI's support, we are able to measure the major challenges facing society—at every scale!

We are grateful to the Canada Foundation for Innovation (CFI), whose support has enabled our research teams to benefit from exceptional infrastructures to carry out work ranging from the nanoscopic (thin-film and nanomaterials) to the gigantic (experiments on the behaviour of huge civil engineering structures). These infrastructures allow them to complete their projects aimed at providing Canadians and the world with a healthy, safe and sustainable future.



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POLYTECHNIQUE MONTRÉAL

TECHNOLOGICAL UNIVERSITY

UT TENSIO SIC VIS

More than **$300** million invested over the last **25** years, and **142** projects supported in cutting-edge areas: biomedical technologies, new-materials characterization, civil engineering solutions, and more.

Thanks to the CFI!

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

THE RIGHT HONOURABLE DAVID JOHNSTON
FORMER GOVERNOR GENERAL OF CANADA

The true sovereignty of nations in the decades ahead will not be determined by the size of gross national product or extent of military budget – but rather by the degree to which a nation builds its talent pool.

This will happen best through a clear vision of a smart and caring nation, which demonstrates that equality of opportunity and excellence go hand in hand.

The leadership for that vision will require bold investments in ensuring that all citizens are able to acquire the knowledge to develop their talents to the very limits and participate to the best of their ability. Only by accessing such a broad pool of talent and rigorously practising continuous innovation – doing things better – can we succeed in achieving higher levels of excellence.

Knowledge is the new coin of the realm. Canada is well placed to be a world leader in this new kind of sovereignty.

Investing in science and facts

Small insights blossoming into large breakthroughs at Université de Montréal

One of the most extraordinary things about investing in university-level research is that it is impossible to know where even a seemingly small research project will lead. Over the last 25 years, the Canada Foundation for Innovation (CFI) has funded over 665 projects at Université de Montréal, helping the university secure its status as a top research facility, particularly in matters of artificial intelligence (AI), neuroscience and health sciences.

Part of the university's success has been seeking funding for a diversity of projects with the recognition that even research that may not seem crucial today can be world-changing at some point down the road.

Yves Joanette, the associate vice-principal of research at the university, says that his institution's research program wouldn't have had the opportunity to flourish without consistent funding that allows academics to engage in scientific investigations leading them down a wide range of paths.

"The funding has propelled Université de Montréal and other universities in Canada into the 21st century," says Dr. Joanette. "There has been nearly one billion dollars' worth of projects at the university that have been made possible by the CFI. It's an investment that has made Canada and the Université de Montréal leaders in many areas of science and research today."

Dr. Joanette points to five areas of research that have received CFI investment: new areas of inquiry that are being pioneered by Canadian academics; fundamental research that promises to have a significant impact in the long run; the development of life-changing drugs; projects that directly address existing clinical or social challenges; and research related to what he calls "responsible" AI.

At Université de Montréal, these areas of research have included exploring the once under-researched topic of how music can impact brain function and chemistry experiments in the field of continuous flow synthesis that started over a decade ago and have proven to be relevant in addressing drug supply chain challenges throughout the COVID-19 pandemic.

Cutting-edge research facilities at the Université de Montréal include the chemistry lab in the new science complex on the MIL campus. SUPPLIED

> "(Research is) an investment in a Canada that is driven by science and facts, which then propels not only businesses but the quality of life of all Canadians.
>
> **Dr. Yves Joanette**
> Associate Vice-Principal of Research, Université de Montréal

Dr. Joanette says it's also important to note that most of the hundreds of Université de Montréal projects that have received funding from the CFI haven't necessarily needed huge investments in equipment or materials – many have been fairly small asks that often blossom into larger breakthroughs. More important than project size or dollar amounts is consistency: when researchers are regularly provided with the funding they need to follow the path their findings take them over the long term, universities are able to retain top researchers who can take their work in new and unexpected directions.

Through the regularity of CFI funding, Université de Montréal has been able to develop what Dr. Joanette calls "intersectoral research," which means that different departments and disciplines often work together to combine their research findings in new ways. That spirit of big-picture thinking permeates the culture of the university, largely because researchers know that their ideas will have the necessary support to help them make a difference in society.

Research doesn't happen in a straight line, where the journey from A to B is predictable from the beginning, says Dr. Joanette. "It's an investment in a Canada that is driven by science and facts, which then propels not only businesses but the quality of life of all Canadians."

Life-saving discoveries

Visionary facilities at U of T helping to protect Canada from future health threats

From insulin and stem cells to deep learning and neural networks, some of the world's most significant discoveries began in University of Toronto (U of T) research labs. Throughout its 194-year history, Canada's largest university has advanced innovations in a vast range of sectors, driven by researchers from diverse disciplines.

U of T scientists have identified genes linked to such diseases as breast cancer and childhood brain cancer. They've built a portable diagnostics platform for measles and rubella that was tested in a refugee camp in Kenya. They've made headlines in recent months with a "firefly" method for measuring immunity to COVID-19 using a modified version of the enzyme that makes fireflies glow.

These innovations, which have changed and saved millions of lives, were made possible by the support of a critical partner: the Canada Foundation for Innovation (CFI). Over the years, the CFI, with funding from the Government of Canada, has awarded U of T more than $524-million toward infrastructure and resources that enable the university to leverage its tremendous interdisciplinary research expertise into groundbreaking discoveries.

"We are a unique institution, one with a depth and breadth of research across biotechnology and health sciences, strong collaborative relationships with our hospital partners, and a robust ecosystem to support entrepreneurship from concept to commercialization," says Christine Allen, U of T's associate vice-president and vice-provost, strategic initiatives. "The CFI has helped us get to where we are today and has also launched and supported so many great careers. Its support will continue to be central to U of T's ability to respond to urgent challenges."

One example of CFI-funded infrastructure is the Terrence Donnelly Centre for Cellular and Biomolecular Research in the Temerty Faculty of Medicine, an open-concept building designed to encourage collaboration among disciplines.

Over the past 16 years, leading researchers at the Donnelly Centre – many of whom have come from the most prestigious institutions in Canada and around the world – have made dozens of key discoveries that range from mapping how genes interact to determine healthy and disease states, to developing new technologies that can manipulate human cells and regenerate tissue in the lab.

> "At the time we built the Donnelly Centre, having all these talented, like-minded people from different disciplines together in one open-concept space was quite visionary, and it positioned Canada as an international force in post-genome biology."
>
> **Dr. Brenda Andrews**
> Founding Director, Terrence Donnelly Centre for Cellular and Biomolecular Research

> "EPIC is all about creating an innovation ecosystem beyond this pandemic so that, going forward, we will have a spectrum of expertise actively working together to focus on problems."
>
> **Dr. Scott Gray-Owen**
> Professor, Department of Molecular Genetics, Temerty Faculty of Medicine, University of Toronto

"At the time we built the Donnelly Centre, having all these talented, like-minded people from different disciplines together in one open-concept space was quite visionary, and it positioned Canada as an international force in post-genome biology," says founding director Brenda Andrews. "Colleagues around the world have told me that they've modelled their department or centre after the Donnelly Centre."

Temerty Medicine's Combined Containment Level 3 lab – or C-CL3 for short – is another example of how CFI funding sets the stage for discoveries that truly make a difference. Designed for the study of serious or lethal pathogens, the lab has become a hub for COVID-related research, with projects ranging from disinfection studies to validate procedures for reuse of personal protective equipment for front-line hospital workers, to the development of rapid diagnostics and new vaccines for COVID-19.

The lab's team of roughly 60 investigators is even helping the Bank of Canada and the Royal Canadian Mint evaluate whether the surface of bank notes and coins sustains the transmission of the SARS-CoV-2 virus.

"When COVID-19 hit, we fast-tracked approval to start working with the virus, so we converted all work in the C-CL3 into SARS-CoV-2 research," recalls Scott Gray-Owen, a professor at the university's Department of Molecular Genetics, part of the Temerty Faculty of Medicine. "It's fair to say that, in some respects, we became Canada's C-CL3 facility."

This work has led to the formation of a consortium, called the Emerging and Pandemic Infections Consortium (EPIC), to lead research and innovation that will bolster Canada's health security. Through EPIC, U of T will work with affiliated hospitals, industry partners and other organizations to prevent future pandemics, epidemics and emerging infections and to tackle the heavy public health burden of infectious diseases that persists globally.

The next stage in the 20-year-old lab's development now depends on investments to make it Canada's primary training and research site for a new generation of work in infectious diseases, says Dr. Gray-Owen, who is leading EPIC.

"EPIC is all about creating an innovation ecosystem beyond this pandemic so that, going forward, we will have a spectrum of expertise actively working together to focus on problems – such as antibiotic resistance or future pathogens – that continue to emerge," he says. "It's about building on the advances we've achieved so far."

Since the University of Toronto's Combined Containment Level 3 lab (C-CL3) allows scientists to study serious or lethal pathogens, it has become a hub for COVID-related research. SUPPLIED

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

ARINJAY BANERJEE, RESEARCH SCIENTIST AND PRINCIPAL INVESTIGATOR LABORATORY OF ZOONOTIC VIRUSES AND COMPARATIVE IMMUNOLOGY, VACCINE AND INFECTIOUS DISEASE ORGANIZATION (VIDO), UNIVERSITY OF SASKATCHEWAN

The COVID-19 pandemic has highlighted the lightning speed at which science can progress when we collaborate across multiple disciplines. I really believe that we can conquer most challenges if we set aside our differences, align our silos and come together to tackle common problems.

We are threatened by multiple challenges that will affect all of us in this lifetime, including global warming, emerging infections, food security, to name a few. The only way to tackle these complex, interdisciplinary problems is by adopting a collaborative and multi-pronged approach. Partnerships across all facets – academia, industry and government, along with involvement of stakeholders from our communities – will be key to solving the big challenges of today and tomorrow.

Realizing that research cannot happen without the latest, cutting-edge equipment and facilities, I moved to Canada in pursuit of higher education and research. Throughout my doctoral and postdoctoral research at USask, VIDO, McMaster and University of Toronto, I have used facilities and equipment funded by the CFI and deeply appreciate the commitment and vision of the CFI to support Canada's research infrastructure for a "one health" benefit to humans, animals and our environment.

Basic research is at the core of scientific breakthroughs. In Canada, we have received Nobel Prizes, most recently awarded to Dr. Houghton at the University of Alberta for making tremendous contributions in understanding and improving human health.

Such advancements do not happen overnight – but take years and decades of dedicated work by trainees, technicians and principal investigators. I truly believe that to keep Canada future-ready, we need to continue to fund basic science, along with dedicated funds for risky and ambitious but high-reward projects. As researchers and scientists, we can only compete at the global level when the playing fields are even and we have access to the resources we need.

The continued support from the CFI is now allowing me to lead my independent research group at VIDO, USask and Canada's new Centre for Pandemic Research. We are performing cutting-edge science and training the next generation of scientists to protect Canada and Canadians from current and future emerging infectious diseases.

Architectural renderings show the interior of the University of Ottawa's new advanced medical research centre, for which construction is slated to start in 2022. **PARKIN ARCHITECTS LIMITED**

Probing the heart-brain interface

How critical infrastructure at the University of Ottawa makes groundbreaking health research possible

In Canada, one person dies every five minutes from heart disease, stroke or vascular cognitive impairment, as reported by the Heart and Stroke Foundation of Canada. This outpaces other diseases, with more people dying of heart-brain related conditions than from all cancers combined. Even though heart disease and brain and mind disorders are often connected, they are usually treated as separate conditions even when they occur in the same patient. Patients with heart failure, for instance, are at an increased risk for depression, cognitive impairment and sleep disorders while those with cognitive disorders commonly experience heart issues.

"In medicine, we divide up organs by specialty," says Peter Liu, chief scientific officer and vice-president of research at the University of Ottawa Heart Institute and professor at the University of Ottawa's (uOttawa) Faculty of Medicine. "But the brain and heart are totally connected. Heartbeats correlate with brain waves. When the heart is not working right, it will affect the brain and vice versa. And yet, heart doctors only look after the heart, and brain doctors only look after the brain. We need to address this paradox."

This is where the Hub of Excellence for Cardio-Neuro-Mind Research (HCNMR) can make the difference. Led by Dr. Liu and Ruth Slack, HCNMR aims to further understanding of how brain and heart diseases intersect. The HCNMR brings together experts in cardiology, neurology, psychiatry and multidisciplinary scientists.

"Up until now, brain-heart diseases have been treated and studied as separate entities, despite the overwhelming evidence that these conditions are intimately connected and develop together," emphasizes Dr. Slack, a professor at uOttawa's Faculty of Medicine and director of the university's Brain and Mind Research Institute. "HCNMR is groundbreaking as it creates a network of top researchers from across multiple disciplines to discover how the heart signals to the brain to affect neurological function and vice versa, a critical step in developing novel therapies. This will have a major impact in treating brain-heart conditions as a whole, and will transform patient care."

HCNMR researchers are developing new screening tools for early disease detection as well as new drugs and psychological therapies. They're also working towards creating a neurocardiac care model where all cardiac patients are screened for brain disease (and conversely for brain disease patients) and treated with both conditions in mind. "We want to figure out the best tools and approaches to collaborate to make care effective and efficient," says Dr. Liu. "We're forging the frontier for novel neurocardiac care, and we hope it becomes the rule rather than exception."

> "We're very grateful for the support from the university and partners like the Canada Foundation for Innovation. Having the tools to carry out our pioneering research is truly a paradigm shift allowing us to accelerate to the next stage.
>
> **Dr. Peter Liu**
> Chief Science Officer and Vice-President of Research at the University of Ottawa Heart Institute and Professor at the University of Ottawa's Faculty of Medicine

HCNMR exemplifies the revolutionary collaborative research happening on a broader scale at uOttawa. In fact, uOttawa's Faculty of Medicine and its affiliated research institutes are ranked third in research intensity in Canada.

INFRASTRUCTURE IS KEY TO RESEARCH

Vital investments in large infrastructure projects to enhance health research are being made on campus, including the new Advanced Medical Research Centre (AMRC), a 300,000-square-foot, state-of-the art, bilingual innovation space that will support 200 researchers, more than 1,000 students and trainees, and 200 private-sector employees. Slated to begin construction in 2022, the AMRC will expand and transform uOttawa's research enterprise, strengthen collaboration and accelerate discoveries by connecting government, academia, industry and the health-care sector to support the development of Canadian health innovations. Doing so helps to future-proof Canada's capacity to respond to urgent health crises.

Add to that, an essential part of the process involves getting innovations to market so that Canadians can access them. To address this, the Ottawa Health Innovation Hub will be housed within the AMRC. This hub will specifically promote translational research and commercialization, investment and talent development in partnership with local universities, colleges, research institutes, startup companies and industrial partners to help propel Ottawa's transformation into a global smart health and precision medicine leader to ultimately improve healthcare delivery and patient outcomes.

"The hub addresses critical gaps in Canada's innovation ecosystem by supporting the creation and growth of new health and life sciences firms that commercialize our homegrown technologies, creating jobs, supporting economic growth and delivering these cutting-edge therapies, treatments and health innovations to Canadians more rapidly," says Ken Lawless, executive director of the Ottawa Health Innovation Hub.

Beyond great ideas and talented people, innovations require the right equipment to bring them to fruition. That's why infrastructure investments are vital to the success of any research project. "We're very grateful for the support from the university and partners like the Canada Foundation for Innovation," affirms Dr. Liu. "Having the tools to carry out our pioneering research is truly a paradigm shift allowing us to accelerate to the next stage. We now have imaging tools and computational platforms where we can look at brain and heart function in a live setting so we can see how heart damage can affect brain blood flow and vice versa. With our patients, we can get brain and heart images in the same setting for comparison. It's a whole new world."

Sylvain Charbonneau, uOttawa's vice-president, research and innovation, agrees. "uOttawa's investment in large infrastructure projects such as the AMRC are once-in-a-generation undertakings that are truly transformative. They in turn propel research and clinical advances that accelerate the development of new innovative therapies and treatments for our most pressing health concerns, from the research bench to patient care. These innovations directly benefit Canadians' health, well-being and quality of life."

Ultimately, it comes down to improving the lives of patients. "As a clinician scientist, I feel the daunting challenges our patients and their families face daily," explains Dr. Liu. "Our patients remind us that finding real solutions and healing our fragmented health care cannot happen fast enough."

Architectural renderings of the outside of the University of Ottawa's new advanced medical research centre. **PARKIN ARCHITECTS LIMITED**

Advancing clinical trials in Canada

Sustaining innovation on the global research stage

Canadians are in the enviable position of living in a country that ranks fourth in the world in total number of clinical trial sites. From headache pills to chemotherapies, every medical drug dispensed or administered by a pharmacist, clinic or hospital across the country goes through a stringent clinical trial process. For many therapies that are developed all over the world, this process happens in some of Canada's leading research institutes.

Among the most critical parts of this process are the clinical trials that enable scientists to study a drug's effectiveness, safety, potential adverse side-effects and optimal dosage in humans.

"Without clinical trials, none of the treatments we have now would exist," says Lillian Siu, medical oncologist at the Princess Margaret Cancer Centre, University Health Network, professor of medicine at the University of Toronto. "Emerging science becomes medicine because patients and researchers participate in clinical trials."

"The safety and well-being of trial participants is the utmost priority when designing these trials," says Reginald Dias, head of clinical operations for Bristol Myers Squibb in Canada, one of the world's largest biopharmaceutical companies.

Clinical trials do more than just advance treatments through the research phase. For patients, they provide access to novel treatments that are not yet available.

Wilson Miller, director of the Clinical Research Unit at the Jewish General Hospital in Montreal, says patients who participate in clinical trials tend to get a high standard of care. This is because of trial protocols that call for strict monitoring, precise documentation and are overseen by experts in a particular disease. Wait times for procedures such as scans also tend to be shorter for patients in clinical trials.

"Most importantly, they get access to new drugs sooner. For some patients, this could mean the difference between whether or not they survive their disease," says Dr. Miller.

Mr. Dias notes that most major international pharmaceutical companies conduct a large portion of their clinical trials in Canada. Canadian researchers are known worldwide for their quality and expertise as well as their ability to conduct clinical research in complex therapeutic areas with diverse population bases.

"Canada has the most ethnically diverse population within the G7," says Troy André, general manager of Bristol Myers Squibb Canada. "This helps increase the diversity of the participants in trials, which would otherwise have to be done across multiple countries. And because Canadians are overwhelmingly located in major city centres within each province, travel is less of a burden to participants, which supports enrolment into trials."

A number of other factors have driven strong investments in Canadian clinical trials, says Mr. Dias. These include a world-leading education system, a publicly funded health-care system known for its quality, as well as an extensive and internationally recognized clinical research network that includes 17 medical schools, approximately 40 groupings of academic health-care organizations and about 13,600 researchers – all dedicated to clinical trials in a vast array of fields such as cancer, cardiovascular diseases and rheumatology.

"As the network of research and researchers grows, we find there is smoother alignment and communication across our research network," adds Mr. Dias, whose organization had about 150 active clinical trials across Canada last year and has enrolled approximately 4,000 Canadian patients over the years.

For Canadian researchers, clinical trials provide opportunities to gain early experience with potential new therapies – experience that often leads to new areas of research.

"For example, when the first wave of immunotherapies came into early clinical development, we got involved," recalls Quincy Chu, a medical oncologist at the Cross Cancer Institute in Edmonton. "This collaboration fostered other research ideas, including how we can treat arthritis that arises in some patients undergoing immunotherapy."

Dr. Siu at Princess Margaret says clinical trials also bring benefits at a higher, societal level. A country that advances research builds and sustains innovation and is able to stay competitive on the global stage. "As researchers, we hope that patients will continue to participate in clinical trials, because this is the only way we can move the needle forward."

> "As researchers, we hope that patients will continue to participate in clinical trials, because this is the only way we can move the needle forward."
>
> **Dr. Lillian Siu**
> Medical Oncologist, Princess Margaret Cancer Centre, University Health Network, Professor of Medicine, University of Toronto

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> Medical Oncologist, Cross Cancer Institute

For Canadian researchers, clinical trials provide opportunities to gain early experience with potential new therapies – experience that often leads to new areas of research. SUPPLIED

ABOUT CLINICAL TRIALS

Clinical trials are carried out in three phases. Health Canada defines each phase as:

- **PHASE 1 -** Tests a new treatment drug on a small group to look at the drug's safety, finds the appropriate dosage range and monitors for side-effects.
- **PHASE 2 -** Focuses on how well a treatment works, checks its safety on a larger group of participants – about 100 or more – and determines the best dose.
- **PHASE 3 -** Compares the drug to commonly used treatments and collects information that will allow the drug to be released and used safely in the market. The trial is also expanded to a group of 1,000 or more participants, to make sure it is still effective and to monitor side-effects.

While these are broad definitions of the clinical trial categories, some elements may overlap. For example, the trial size and focus can differ, such as when studying rare diseases or niche market medicines.

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

EUGÉNIE BROUILLET
VICE-RECTOR RESEARCH, CREATION AND INNOVATION, UNIVERSITÉ LAVAL

We live in a time when multiple major societal challenges are emerging. Addressing them requires scientific effort – not only to answer the questions they raise but also to find solutions.

We can think about climate change, which is observed at a faster pace in Northern Canada than many other places. Or we can think about pandemics, which seem to happen more frequently due to the increase in human population and mobility. Also, many issues concerning the health of our populations are still relevant – and the challenges of achieving sustainable health will need to be answered. Furthermore, secure and sustainable access to healthy food remains a challenge in many parts of the world, including in Canada.

Canada has gained a world wide reputation as a leader in numerous fields, such as telecommunication technologies, new materials, neurosciences, infectiology and vaccine development, artificial intelligence and climate change studies, to name a few. Thanks to investments from the Canada Foundation for Innovation (CFI), research teams from Université Laval and throughout Canada have risen among the world's research elite. With research equipment and infrastructures funded by CFI, our research teams have pushed the limits of knowledge.

Yet to keep our place in research across the world, Canada needs to continue to invest in tools, equipment and infrastructure so that our researchers can continue to make new discoveries, create and innovate. At Université Laval, we believe it is essential to support researchers at every step of their career path. We especially think it is important to fully equip young researchers – tomorrow's experts – and to support them in the pursuit of their scientific program.

In addition, it is crucial for Canada to establish links with other major international networks and share our unique research infrastructure to better respond to current and future societal challenges. Often, what we can achieve together goes beyond what we do alone.

In our view, partnership between Canadian academic institutions and other organizations across the world is absolutely necessary to solve the most crucial international societal issues. Also, many countries cannot develop the major infrastructure needed to solve such issues.

By unifying our forces, countries can innovate and offer access to shared infrastructure to all researchers. But even more important is the partnership across disciplines, sectors and fields to look simultaneously at complex problems from multiple analysis angles.

Partnerships between academic institutions, governments and industries are also pivotal in order to allow for the adoption of innovations by communities. Without this proximity, technological and knowledge transfer is harder and longer, and the solutions suggested might not fit the needs of the end users.

The new home for Canada's Global Nexus at McMaster Innovation Park will integrate world-class biomedical research infrastructure, front-line clinical care facilities, multidisciplinary education and workforce training space, plus co-located public and private pandemic preparedness teams. MCCALLUMSATHER, LNG STUDIOS

How to fight a pandemic

Marshalling a response to COVID-19 and future health risks at Canada's Global Nexus for Pandemics and Biological Threats

When the first COVID-19 case in Canada was identified in January 2020, McMaster University was uniquely equipped to immediately begin fighting it on multiple fronts, thanks in large part to early and ongoing investment by the Canada Foundation for Innovation (CFI). The agency has enabled McMaster – Canada's most research-intensive university – to attract and retain world-class scientists and to build the infrastructure they need to carry out cutting-edge work.

McMaster was ideally positioned to help lead Canadian efforts to isolate and purify the SARS-CoV-2 virus from patients soon after some of our country's first COVID-19 cases were identified. The university's reputation as a leader in infectious disease research, its Level 3 containment facilities for studying serious pathogens, and being home to the country's only bat-breeding laboratory (led by neuroethologist Paul Faure) allowed Karen Mossman, a virologist and McMaster's vice-president of research, to recruit some of Canada's top talent to her lab.

Like professional athletes, outstanding scientists have the power to choose the team with the greatest championship potential. McMaster has scored big with recruits, including then post-doc Arinjay Banerjee, who joined Dr. Mossman's laboratory within the Michael G. DeGroote Institute for Infectious Disease Research (IIDR) – both of which have been built with CFI funding. Dr. Mossman and her team had been working on virus host interactions, and Dr. Banerjee had developed the special skills necessary to culture and grow coronaviruses, which are notoriously finicky. And early in 2020, their expertise was suddenly in high demand.

"When our clinical colleagues in Toronto started to see patients who were COVID-19 positive, our team was able to work collaboratively to isolate the virus out of patient samples," says Dr. Mossman, adding that a $1.5-million award from CFI's Exceptional Opportunities Fund, specifically for COVID-19 research, enabled her to upgrade the Level 3 facility to work on SARS-CoV-2 – and to move forward even more quickly on the COVID-19 front.

Dr. Mossman points to McMaster's collaborative approach to research as pivotal to what happened next, after her McMaster colleague, Andrew McArthur, an expert in bioinformatics, took up the baton, sequencing and verifying the genome of the SARS-CoV-2.

From there, says Dr. Mossman, it was all about growing the virus and sending it to other Canadian institutions with Level 3 facilities, recognizing that the more scientists there were investigating its different aspects, the better possible outcomes for everyone around the world.

McMaster was at the forefront of the field long before anyone had ever heard of COVID-19. In fact, discoveries made by McMaster professor emeritus Frank Graham nearly five decades ago are used in AstraZeneca and Johnson & Johnson vaccines. And Gerry Wright, founding director of the IIDR, and the institute's trans-disciplinary team have been leading the fight against superbugs for decades.

According to Dr. Wright – who chose to build his research program in Canada in large part because of the CFI's creation – the most innovative discoveries come when discipline-specific boundaries are eliminated.

> "When our clinical colleagues in Toronto started to see patients who were COVID-19 positive, our team was able to work collaboratively to isolate the virus out of patient samples."
>
> **Dr. Karen Mossman**
> Virologist, Vice-President of Research, McMaster University

> "Not only do these big infectious disease problems require well-resourced biomedical research to deliver new vaccines and new drugs, they also require a societal response."
>
> **Dr. Gerry Wright**
> Infectious disease expert and Lead of Canada's Global Nexus for Pandemics and Biological Threats

"Since its inception, the IIDR has prided itself on multidisciplinary work, from biomedical research and mathematical modelling to population biology, anthropology and engineering," Dr. Wright says. He notes that it is this collaborative approach that allows the institute to attract and retain global talent, including researchers like Jonathan Stokes, the newest member of Dr. Wright's group, who was lured from MIT to continue his research using artificial intelligence to identify new antibiotics. None of this would have been possible without the support of the CFI, Dr. Wright adds.

Building on this track record, in 2020 McMaster announced it was marshalling this deep well of expertise to fight COVID-19 and prepare for the inevitable pandemics to follow with the creation of Canada's Global Nexus for Pandemic and Biological Threats.

"Not only do these big infectious disease problems require well-resourced biomedical research to deliver new vaccines and new drugs, they also require a societal response," says Dr. Wright, who is the inaugural lead of Global Nexus.

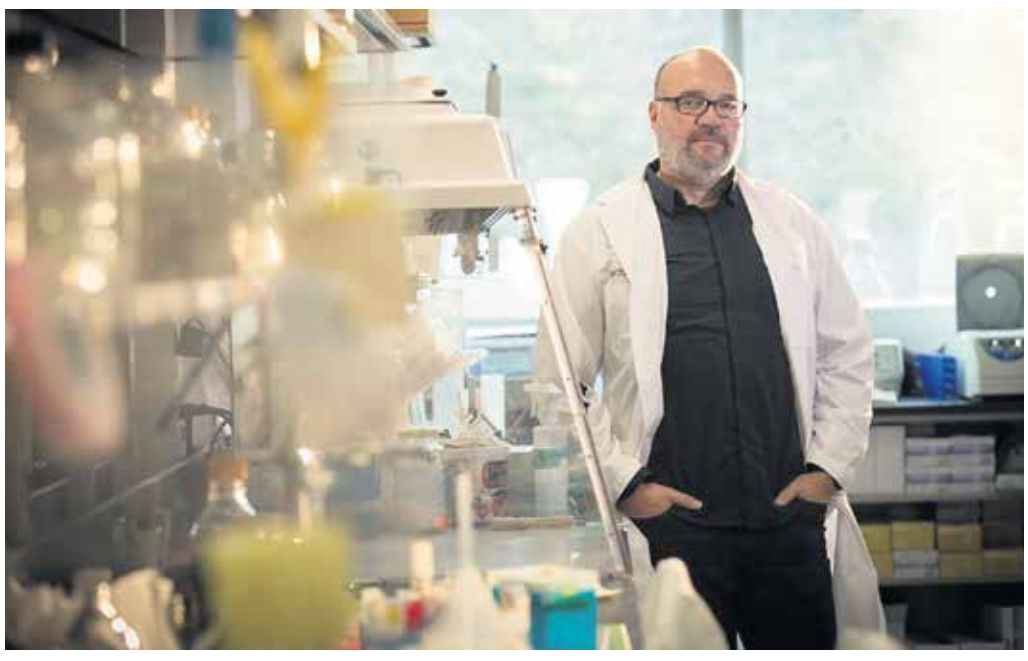
"The impact on the economy, on society as a whole, on information, on trust, really becomes an issue, and we can't solve one problem without solving the others," he says. "The objective of Global Nexus is to integrate all these disciplines and bring the best scholarship, the best research tools and infrastructure, and the best minds to bear on these big problems, because the current pandemic is not going to be the last one."

McMaster researchers are mobilizing their knowledge to better serve Canadians. As co-lead of the Canadian Network for Modelling Infectious Diseases (CANMOD), they're studying how diseases spread and helping to anticipate the future course of an outbreak and, through the COVID-19 Evidence Network (COVID-END) hosted at McMaster, they're rapidly synthesizing the best available evidence about key COVID-19 topics to ensure decision-makers have timely access to the best science. They're evaluating the torrent of studies and reports to determine if the use of a specific drug or intervention (hydroxychloroquine, for instance) is backed by scientific evidence – critical information to guide decision-making and policies at all levels of government. And researchers in the Canadian Research Data Centre Network, a consortium of universities and Statistics Canada headquartered at McMaster, are helping to drive policy change in areas like education, while research from the Canadian Longitudinal Study on Aging, a landmark national project based at McMaster, is providing insight into how the pandemic has affected older Canadians.

McMaster is one of just a few academic institutions in Canada with the capability of manufacturing vaccines for human trials, with researchers also developing new methods for delivering vaccines that advance the science in this field. McMaster researchers already have two vaccine projects that use this technology: one for tuberculosis, which is already in phase II clinical trials, and a next-generation coronavirus vaccine that is moving forward through the pipeline.

"We started the Global Nexus initiative to bring together great biomedical researchers, engineers, evidence experts, sociologists and humanists to rapidly solve big problems on a global scale, supported by the right infrastructure," says Dr. Wright. "By doing this, we're now better prepared to fight future pandemics and biological threats that we will inevitably face."

Virologist Karen Mossman, McMaster's vice-president of research, believes a collaborative approach is essential for achieving tangible impact. SUPPLIED



Gerry Wright, infectious disease expert and lead of Canada's Global Nexus for Pandemics and Biological Threats, credits CFI funding for helping to attract top talent to the team. SUPPLIED

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25 YEARS

A SOLID PAST, A BRIGHT FUTURE

RÉMI QUIRION
QUEBEC CHIEF SCIENTIST

Partnerships and dynamic, open collaboration at the national and the global levels are the only way to succeed in solving big societal challenges, such as climate change and pandemics. Canada can and should lead the way by promoting and facilitating all aspects of global science collaborations.

The Canada Foundation for Innovation (CFI) has been a critical game changer for science, research and innovation in Canada. I was awarded one of the very first, if not the first, major CFI grants in the field of mental health when I was the scientific director of the Douglas University Institute in Mental Health, McGill University. This critical support allowed us to markedly improve research facilities – leading to the recruitment of a dozen scientists, all of whom have become stars and leaders in their fields.

Due to being involved in creating this great legacy in a challenging research field, I have come to view "grey matter" as a top priority for ensuring a future-ready Canada. Excellence and recruitment of the best minds were challenging before the pandemic – and will be even more in the coming years as many countries have decided to make major investments in research and deep tech as a means to recover from the impacts of COVID-19 and ensure a strong economy for their citizens.

Canada must do the same to not be sidelined.

Thanks to major investments in research infrastructure in universities, colleges and research institutes, the CFI has helped to foster excellence in all research fields, which has enabled us to recruit and retain the best talents in partnerships with other federal programs, such as Canada Research Chairs.

We have to continue this trajectory with even greater, larger investments in basic, fundamental research and related infrastructure. This will be the best way to ensure the strongest post-pandemic socio-economic recovery for Canada.

The Canadian Cancer Trials Group has grown to become the largest research group at Queen's University with a network of scientific leaders from all the cancer centres and hospitals in Canada and a global network of nearly 20,000 investigators and clinical trial staff. SUPPLIED

Trialled and true

Clinical trials at Queen's University advancing life-changing cancer diagnostics, treatments and prevention

Cancer continues to be a leading cause of death in Canada and around the world. The Canadian Cancer Trials Group (CCTG), based at Queen's University in Kingston, Ontario, plays a critical role in the fight against cancer by designing and administering clinical trials in cancer therapy, supportive care and prevention across Canada.

"Cancer touches everybody," says Janet Dancey, CCTG's director. "Through clinical trials, we help reduce the burden of cancer by defining new standards of care, diagnostic tests and roles of therapies for different cancers." Since its establishment in 1980, CCTG has supported more than 600 phase I-III trials enrolling approximately 100,000 patients from 40 countries on six continents. At any given time, CCTG has 60 to 70 active clinical trials.

CCTG has grown to become the largest research group at Queen's, with a network of scientific leaders from all the cancer centres and hospitals in Canada and a global network of nearly 20,000 investigators and clinical trial staff. "We are capable of executing a whole range of trials for Canadians who have or may be at risk for cancer," says Dr. Dancey. "Where we distinguish ourselves is that we have the largest portfolio of cancer trials, a great track record and routinely engage international partners. We tend to be the academic organization that does the largest, the most complicated and the best-executed clinical trials."

"CCTG is a huge point of pride for Queen's," affirms Nancy Ross, vice-principal of research at Queen's. "The dedication and professionalism of the CCTG team has led them to be a global leader in this important work. They have set the standard for expertise and quality in their ability to quickly get platforms in place to launch important trials that have real impact on medical treatments."

> "Where we distinguish ourselves is that we have the largest portfolio of cancer trials, a great track record and routinely engage international partners. We tend to be the academic organization that does the largest, the most complicated and the best-executed clinical trials.
>
> **Dr. Janet Dancey**
> Director, Canadian Cancer Trials Group

Putting together a clinical trial, especially a large one with thousands of participants, can be a monumental task. "There is nothing more collaborative than mounting a clinical trial," Dr. Dancey says. "You need investigators not just to lead the study, and to collect and analyze the data, but you need an army to organize and make sure it runs smoothly, plus patient volunteers willing to participate."

This is true for drug trials, but also for trials examining non-pharmaceutical interventions that may improve cancer outcomes such as diet, lifestyle, surgery and psychosocial aspects. "Part of our mission is to do trials that wouldn't be done by industry," Dr. Dancey says. While CCTG takes pride in global collaboration, it also pays particular attention to what's pertinent to Canadians. "The best way to help Canadians is to focus on questions that are relevant to Canadian patients and our health-care system."

Much of the work that takes place through CCTG has led to important treatments and continued research. One trial from 15 years ago showed that for lung cancer patients, chemotherapy improved survivorship after surgery. "That is still standard treatment now," Dr. Dancey affirms. "The trial is an example of how the Canadian lung cancer community is a leader. We help researchers to collaborate, and lead trials testing Canadian-developed ideas that have the potential to become new treatments for patients across the world."

Similarly, a recent CCTG trial, published in 2021, was the first to show that stereotactic body radiation therapy (SBRT) is more effective than conventional radiation treatments in alleviating pain from spinal metastases. The study showed that using fewer and higher doses of precisely delivered SBRT is more effective than the standard treatment, with 35 per cent of patients reporting an enduring, complete control of pain at three months post-radiation. "There's been lots of uptake following the results of that trial being published, and it's now considered the standard of care," says Dr. Dancey.

Support from funders including the Canadian Cancer Society and the Canada Foundation for Innovation (CFI) has been critical to the CCTG's ability to have such impact. "Prior to CFI funding, CCTG was at an inflection point," she says. "Trial funding was limited, yet trial complexity had increased due to scientific advances and regulatory compliance requirements. CFI funding allowed us to continue to grow to conduct first-class research."

"The support of the CFI has been indispensable to the success of the CCTG," agrees Dr. Ross. "This global effort takes a great deal of operational and administrative coordination with hundreds of staff and faculty managing the processes from recruitment to analysis. Ultimately, though, it's important to remember that the CFI is investing in improved survival and quality of life for cancer patients."


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25 YEARS

A SOLID PAST, A BRIGHT FUTURE

ROBERT MYERS
DIRECTOR AND BMO ISAAC NEWTON CHAIR IN THEORETICAL PHYSICS AT PERIMETER INSTITUTE

Great science requires great research infrastructure.

Perimeter Institute – an independent, global hub for theoretical physics research, training and outreach – is an example of a cutting-edge facility that attracts outstanding physicists and students from across the globe to collaborate in an area of science where breakthroughs can literally change the world.

Perimeter's facility was designed as a laboratory for collaboration and discovery. While it is a stand-alone organization with resident physicists, there are many partnerships with organizations throughout Canada on joint talent and scientific activities that have led to groundbreaking scientific insights and helped to raise national research impact.

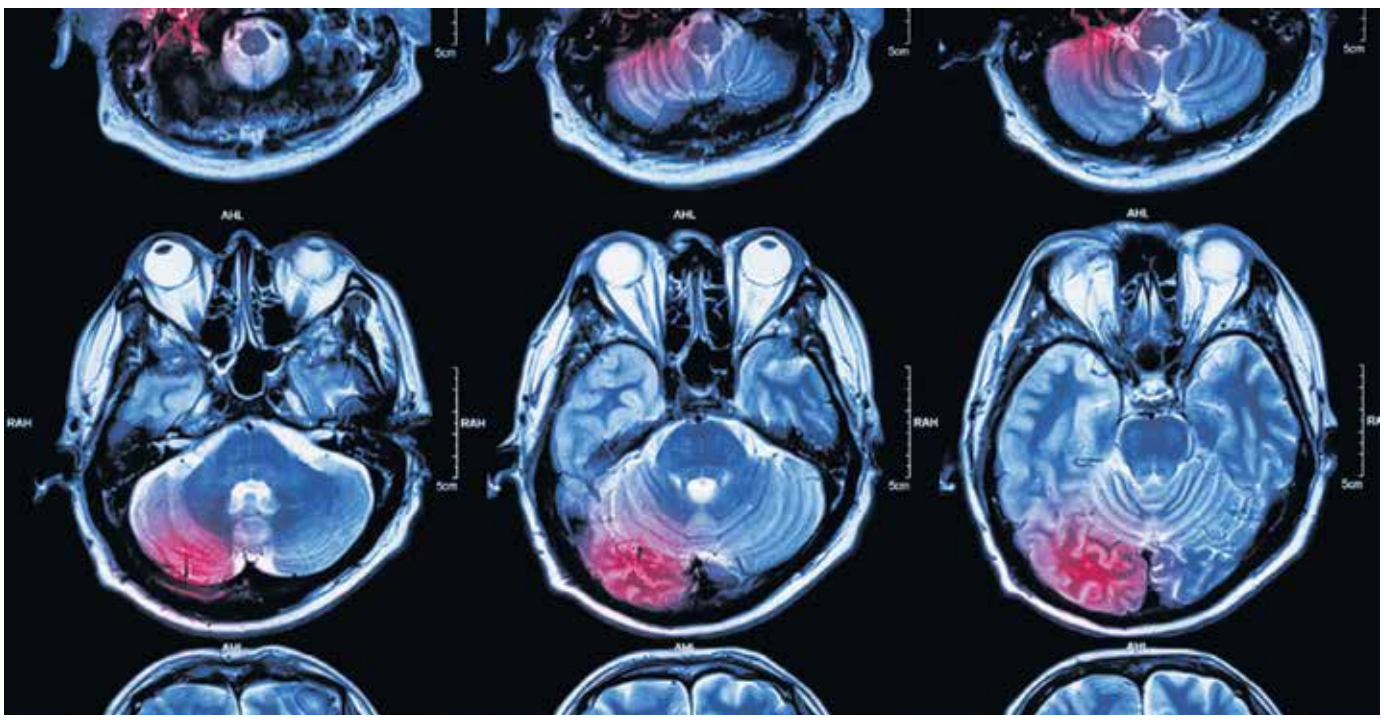
The fundamental research happening at Perimeter – and with colleagues across the country – is putting Canada at the forefront of a new understanding of our universe and laying the foundation of future technologies.

Investments from the Canada Foundation for Innovation (CFI) enabled the construction of the original facility in the Region of Waterloo, Ontario, plus an expansion called the Stephen Hawking Centre at Perimeter Institute, helping to create the foundation for what has become a world-leading centre of theoretical physics.

These are exciting times: longstanding scientific challenges are coming within reach. The fundamental research happening at Perimeter – and with colleagues across the country – is putting Canada at the forefront of a new understanding of our universe and laying the foundation of future technologies.

Multidisciplinary research at Perimeter ranges from quantum information to cosmological investigations, and the facility has played key roles for Canada in developing the area of quantum intelligence (at the nexus of quantum information and artificial intelligence), in partnering on humanity's first ever photo of a black hole and in contributing to the success of the Canadian CHIME telescope team with unique software.

Twenty-five years of investments from the CFI have given an enormous boost to Canadian science. Canadians can be proud of living in a country where there is strong support for research and where thoughtful organizations like the CFI make this support concrete.



Combining engineering and medicine can lead to world-leading tools like the Raman spectroscopy, which can help to distinguish cancer cells from healthy cells; for example, in brain tumour surgery. ISTOCK.COM

Detecting the previously undetectable

New surgical cancer-detection device helps fuel research collaboration at Polytechnique Montréal

One of the biggest challenges in brain tumour surgery is making sure that all cancer cells are removed. "If you leave a few cancer cells behind, the cancer will come back," says Frédéric Leblond, an engineer and full professor in the Department of Engineering Physics at Polytechnique Montréal. "It's a universal problem, especially with neurosurgery."

That's why Dr. Leblond, in collaboration with Kevin Petrecca, director of the brain tumour research program and chief of neurosurgery at the Montreal Neurological Institute-Hospital, developed a hand-held probe using Raman spectroscopy to distinguish cancer from healthy tissue.

Currently, CT and MRI imaging are used to examine tumours, but they do not show tumours to their full extent. With the Raman probe, laser illumination of the tumour provides a rainbow spectrum that contains detailed information about a sample's chemical structure. That information helps surgeons identify previously undetectable cancer cells.

This powerful cancer-cell detection method can be applied with minimal disruption to the surgical workflow. The Raman probe can be used in real time to help neurosurgeons differentiate cancer cells from healthy cells during tumour surgery, and has demonstrated an accuracy of more than 90 per cent after a year-long study.

"For us biomedical engineers, it's not about pushing our tech onto patients," says Dr. Leblond. "It's about finding needs and adapting our tech to meet those needs – and working with clinicians to make it work. Funding from the Canada Foundation for Innovation helped me set up a lab that was fertile ground to develop the Raman probe and help improve patient outcomes. The infrastructure support also allowed us to refurbish and adapt ourselves to the new realities of research – the impact of that is huge."

Another important lever was the Canada First Research Excellence Fund, which enabled the creation of the TransMedTech Institute. The TransMedTech Institute is a living laboratory dedicated to supporting engineers, health-care professionals, patients and companies to co-develop new medical technologies and interventions, and to train the next generation of medical technology professionals.

"Combining engineering and medicine is a more common paradigm in research now, but what distinguishes us is our living lab," says Dr. Leblond. "It's not only about the clinicians and engineers; the patients are involved, and industry stakeholders can also see what we're doing. It's an ecosystem where we involve all the necessary actors to develop technologies for patients to fully benefit."

The TransMedTech Institute has also made new detection applications of the Raman probe technology possible – in particular, for other types of cancer such as prostate cancer. Prostate cancer is the most common cancer directly affecting men in Canada. The Canadian Cancer Society says some 23,000 men will be diagnosed with prostate cancer this year, and approximately 4,200 will die from the disease during this same period.

As with other cancers, prostate cancer comes in different forms, called subtypes, which advance at varying rates. Identifying each of these subtypes is a big challenge for pathologists. Occasionally, misdiagnosis occurs and patients do not access the optimal treatment for their type of cancer. The Raman spectroscopy technology could help with the identification of prostate biopsy samples, thereby aiding in effective treatment plans.

Dr. Kevin Petrecca, director of the brain tumour research program and chief of neurosurgery at the Montreal Neurological Institute-Hospital (left), and Dr. Frédéric Leblond, an engineer and professor in the Department of Engineering Physics at Polytechnique Montréal. CAROLINE PERRON / POLYTECHNIQUE MONTREAL

> "It's not only about the clinicians and engineers; the patients are involved, and industry stakeholders can also see what we're doing. It's an ecosystem where we involve all the necessary actors to develop technologies for patients to fully benefit.
>
> **Dr. Frédéric Leblond**
> Professor, Department of Engineering Physics, Polytechnique Montréal

Similarly, Dr. Leblond and his team are using the new research infrastructure to create a saliva-based, reagent-free, rapid-screening test for COVID-19. This test uses Raman spectroscopy to analyze saliva in less than two minutes without the need for reagents such as enzymes, which all current chemical COVID-19 tests require. Reagents have become scarce because of the demand for COVID-19 testing and limited production capacity. The Raman test could facilitate self-sampling and greater accessibility.

The test-development methodology could also be adapted to other infectious diseases, such as seasonal influenza and measles, and offer improved capability to address mass testing for future waves of COVID-19.

Add to that, the Raman probe has given rise to a new company, Reveal Surgical, which will commercialize the probe to make it available at hospitals across North America. "Reveal Surgical ensures we get things right," Dr. Leblond explains. "The road to commercialization means very carefully doing the testing and making sure we get the right patents, otherwise it will never happen."

The development of the Raman probe offers a shining example of how critical research infrastructure is to scientific discovery and innovation. Laying this groundwork made vital collaborations possible, leading to lifesaving technologies, spinoff companies to make these technologies accessible and new synergetic research facilities to continue important work.

BY THE NUMBERS

TransMedTech Institute

$28-million
value of 115 supported research projects

75
researchers from several universities and major teaching hospitals

118
scholarship students

38
professionals supporting the institute's operations as well as 16 funded technology platforms

More projects with Polytechnique Montréal researchers at TransMedTech Institute:

Dr. Isabelle Villemure is developing a small medical device that improves and accelerates long bone elongation in children affected with limb length discrepancies and limb deformities without affecting growth plates.

Dr. Abdellah Ajji is working on an innovative 3D cell culture model to better understand cancer biology to support personalized cancer therapy and accelerate drug discovery.

Dr. Michel Meunier and **Dr. Dominique Trudel** are investigating the innovative use of multiple metallic nanoparticles to ensure a more quantitative diagnosis and multiplexed selection of the immune treatment for lung cancer patients.

Dr. Samuel Kadoury and **Dr. David Roberge** are examining the use of a predictive platform for radiation treatments for cancer patients using artificial intelligence.

Dr. Carl-Éric Aubin, **Dr. Marie Beauséjour** and **Dr. Hubert Labelle** are working with patient partners and interdisciplinary experts to develop a next-generation individualized orthosis focused on the concerns of adolescents with scoliosis and to integrate it into a reinvented care pathway.

McMaster University

Canada's Global Nexus for Pandemics and Biological Threats

Charu Kaushic (right), scientific director, CIHR Institute of Infection and Immunity

Gerry Wright (right), lead, Canada's Global Nexus for Pandemics and Biological Threats

CANADIAN SOLUTIONS FOR GLOBAL CHALLENGES

Headquartered at the country's most research-intensive university, **Canada's Global Nexus for Pandemics and Biological Threats** is powered by top-tier researchers, labs and technologies.

Building on a track record of research excellence and strategic investment, along with our partners across sectors and borders, we're mobilizing our knowledge to tackle health challenges to keep Canadians – and the global community – safe.

Thank you, CFI, for your confidence in our work.
We salute you on 25 years of impact and achievement.

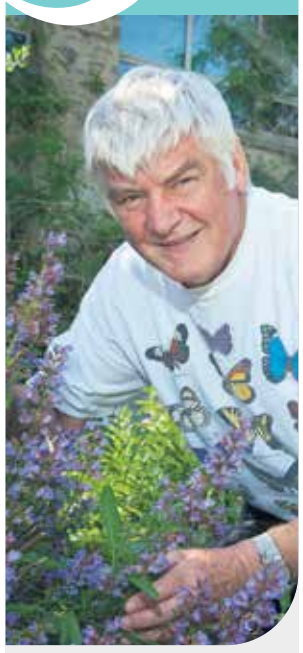
Together through research, we're building strong and healthy communities.

Learn more at globalnexus.mcmaster.ca

BRIGHTER WORLD

25 YEARS

A SOLID PAST, A BRIGHT FUTURE



JEREMY MCNEIL, PROFESSOR, DEPARTMENT OF BIOLOGY, WESTERN UNIVERSITY
PRESIDENT, ROYAL SOCIETY OF CANADA

As a panel member of the very first national funding competition launched by the Canada Foundation for Innovation (CFI), seeing the diversity and originality of the projects submitted emphasized just how important this new program was for the Canadian research community.

Thus, it is not surprising that since its inception, the CFI has allowed institutions to build on their strengths and provide researchers with cutting-edge facilities to address issues of regional, national and international importance in ways that were previously not possible. However, in order to move this community forward, new facilities providing access to the most recent technologies are not enough. We also need funding for refurbishing existing facilities, some of which may even be seen as rather "un-innovative," such as greenhouse complexes.

The need for evidence-based data – especially in consideration of both medical and social issues during the COVID-19 pandemic – has once again helped to illustrate the importance of broad interdisciplinary collaborations.

The need for evidence-based data – especially in consideration of both medical and social issues during the COVID-19 pandemic – has once again helped to illustrate the importance of broad interdisciplinary collaborations.

As we move from the pandemic to the endemic phase, we must build on the lessons learned to truly break down silos and develop the transdisciplinary teams, including members with Indigenous knowledge, that are essential to effectively addressing the diverse challenges associated with climate change in a way that benefits society as a whole.

The stark inequities existing within our communities were also laid bare during the pandemic, emphasizing the importance of ensuring that everyone's voice is heard when developing the policies required to address today's and tomorrow's pressing issues, including health threats and climate change.

Understanding space, improving life on Earth

From regional impacts to providing insights valued worldwide

Saskatchewan is known as the "land of living skies." Appropriately, the University of Saskatchewan (USask) is home to a research program focused on the outer reaches of our atmosphere.

The SuperDARN (Super Dual Auroral Radar Network) is a global network of scientific radars monitoring conditions in the near-Earth space environment. The Saskatoon component is a cluster of 20 massive radar antennas in a field just east of the city. Built to study activity in the Earth's upper atmosphere, it was one of the first such sites in a network that now includes 36 locations around the world and contributions by 11 countries.

"At USask, we are delivering research the world needs. It could not be done without the contribution of the CFI and our other generous partners," says USask president Peter Stoicheff.

"Canada is one of the countries most vulnerable to space weather effects, such as the geomagnetic storm that caused the 1989 Quebec Hydro blackout," says USask physicist Kathryn McWilliams, director of SuperDARN and chair of the international SuperDARN Collaboration.

She explains that SuperDARN helps position Canada as a global leader in monitoring space weather conditions, as the study of forecasting of space weather is in its infancy.

"Right now, we essentially look out the window to see space weather disturbances coming our way between the sun and the Earth," she says. "Researchers are building rudimentary models of the solar wind's interaction with the Earth's magnetosphere, ionosphere and atmosphere. Like early research in predicting weather, models will be built and tested with data from global space weather facilities – like SuperDARN – and from space."

Dr. McWilliams says her work, and that of her collaborators, would not be possible without the Canada Foundation for Innovation's (CFI) Major Science Initiatives (MSI) Fund. That investment pays off in protecting the Canadian public.

"Canadian SuperDARN data and expertise are essential to mitigating damaging space weather effects," she says.

Over its 25-year history, the CFI has funded 312 USask leading-edge research infrastructure projects, including SuperDARN, that are producing work to help address global challenges – from new vaccines to sustainable food, water and energy-security solutions. In the last CFI competition, one-third of the CFI's total MSI funding was awarded to USask.

Rooted in the Prairies, the university's strategic goal is reaching beyond to provide research the world needs and to embrace courageous curiosity wherever it may lead. USask's leaders are focused on developing an environment that attracts top-tier talent and enhances research capacity. Funded projects span a wide variety of disciplines, from "one health" research, dedicated to addressing problems at the intersection of people, animals and their environments, to exploration in the social sciences.

The pandemic has, of course, put focus on the USask Vaccine and Infectious Disease Organization (VIDO) which is also supported by the CFI's MSI Fund.

The aurora borealis, or Northern Lights, seen over the Saskatoon SuperDARN radar (top), one of the world-leading facilities at the University of Saskatchewan, which is led by physicist Kathryn McWilliams (bottom). The Vaccine and Infectious Disease Organization (centre) has made essential contributions to Canada's pandemic response. SUPPLIED

VIDO has some of the largest and most advanced containment level 3 (CL3) infrastructure in the world. This capacity has been critical to Canada's COVID-19 response.

Even before COVID-19 was declared a pandemic, VIDO's expert team was the first in Canada to isolate the virus, develop a model of the disease and pilot-test candidate vaccines. Their protein subunit vaccine COVAC-2 is currently in clinical trials. VIDO's unique capacity also supported the development of possible solutions to COVID-19 by scientists and organizations from across Canada and around the world.

One of these scientists, Alyson Kelvin, an infectious disease expert from Dalhousie University, came to USask to access VIDO's CL3.

"I was familiar with VIDO as the place to do world-class research on high consequence emerging viruses in Canada," says Dr. Kelvin. "I arrived as a visiting scientist, but immediately knew that I wanted to make VIDO my permanent research home and develop solutions for diseases like COVID-19 in Saskatchewan."

Dr. Kelvin has accepted a scientist position and is part of a growing team of VIDO scientists, including Arinjay Banerjee, Neeraj Dhar and Angela Rasmussen, who are an integral part of VIDO's role as Canada's Centre for Pandemic Research. The centre also includes enhanced research capacity for pandemic readiness like upgrades to containment level 4, biomanufacturing facilities and advanced animal housing. This will help ensure Canada's position as a world leader in the development of solutions to future emerging infectious diseases.

The USask research ecosystem includes the Canadian Light Source, Canada's only synchrotron, an invaluable tool for innovative science in advanced materials, agriculture, environment and health. The MSI-funded national facility is owned by USask and located on campus, and brings together Canada's brightest minds with scientists from across the planet to solve pressing problems and make major discoveries.

USask's ties to agriculture are deep and important to the institution, with a commitment to food and water security. Researchers from the College of Agriculture and Bioresources, the Global Institute for Food Security and the Western College of Veterinary Medicine are combining their diverse skillsets, discovering and applying cutting-edge technologies to agriculture, such as advanced computing and genomics to lead farming into the digital age. The Crop Development Centre at USask is celebrating 50 years of discovery, including sequencing the genomes of 15 wheat varieties, peas, lentils, canola, barley and 500 new varieties of commercially available crops.

Kirstin Bett is a USask crop scientist focused on creating new varieties of crops, including those that feed the world's growing need for plant-based proteins like lentils.

"CFI funding helped to launch my research, providing the key pieces of infrastructure critical to do genomics," says Dr. Bett, "Without the CFI, we would have had to search for alternate sources of funding instead of producing results, and would not have had access to cutting-edge equipment."

Inherent in being grounded in Saskatchewan is embracing Indigenization. By 2036, one in five residents of Saskatchewan will identify as Indigenous – a significant proportion of Indigenous Peoples in Canada live in and contribute to the social, cultural and economic life of Saskatchewan.

"Our university has a responsibility and the privilege to partner with Indigenous communities to preserve, celebrate and create space for Indigenous knowledges, stories, languages and culture," says Baljit Singh, vice-president research. "We are on a journey of decolonization and reconciliation, seeking to build a vibrant community of Indigenous faculty, graduate students and postdoctoral fellows."

John Pomeroy, Canada Research Chair in Water Resources and Climate Change, says over the past decade much progress has been made in tying research methods to the insights and knowledge of the Indigenous communities that live in a particular region.

Dr. Pomeroy has led five successful CFI-funded projects and is the director of Global Water Futures (GWF), the largest and most cited freshwater research program in the world, part of USask's Global Institute for Water Security.

For example, research on the hydrology of the Saskatchewan River Basin was deeply enhanced by working with the Mistawasis and Cumberland House communities.

"The instruments are not enough," he says, stressing local collaborations and observations help guide the creation of models formed from data. Together, a more fulsome picture of the future in a particular region is formed for all those who live there.

"What CFI grants do is allow us to build a sense of place with our research," he says, adding that working with Indigenous communities brings more meaning and richness to that work. "It's important."

Tackling real-world challenges

Sheridan College research ecosystem boosting outcomes for industry partners and students

By nurturing a culture of research, innovation and entrepreneurship, Sheridan College embodies institutional principles around "inspired questing, intentional impact and radical engagement," says Andrea England, vice provost, research.

Funding support from the Canada Foundation for Innovation (CFI) has contributed to "explosive growth" in research activities, enabling Sheridan to "increase the level of engagement for faculty and students while addressing the needs of communities we serve," says Ms. England.

Sheridan is home to six research and incubation centres. Over the years, the CFI has granted more than $5-million to the college, says Ms. England, "making it possible to build infrastructure and cutting-edge facilities and purchase specialized equipment. This critical investment has aided us in laying a strong foundation for our research ecosystem."

Sheridan's Screen Industries Research and Training Centre (SIRT) was a recent recipient of $1-million from the CFI, which allowed researchers at the centre to conduct pioneering work creating computer-generated characters or virtual humans. The grant "helped secure SIRT's position as a leader in virtual production innovation," says Ms. England.

> "Research projects give students a chance to deepen their skills by working on real-world challenges. They are exposed to state-of-the-art technologies, and they expand both their personal and professional networks.
>
> **Andrea England**
> Vice Provost, Research, Sheridan College

Sheridan College's Screen Industries Research and Training Centre (SIRT) allows researchers to conduct pioneering work creating computer-generated characters or virtual humans. SUPPLIED

Another opportunity arose in 2020 when the Centre for Mobile Innovation (CMI), along with a team of researchers from the Sheridan Faculty of Applied Science and Technology, were awarded a grant from the CFI to advance development of Remote Patient Monitoring (RPM), in collaboration with health-care technology companies. Research in this area could help alleviate the strain on health care, intensified by the COVID-19 pandemic, says Ms. England.

Research projects give students "a chance to deepen their skills by working on real-world challenges. They are exposed to state-of-the-art technologies, and they expand both their personal and professional networks."

Partners gain "access to the talent of Sheridan's students, plus the expertise of our amazing faculty and staff," says Ms. England, "along with access to our specialized equipment or infrastructure."

These supports help industry partners become more productive and competitive, she says. For community partners, "it's often about delivering social benefits and enhancing their impact.

"In either case, we help solve challenges that matter to them."

In 2020-21, 821 Sheridan students were hired to work on research projects, while more than 2,000 students participated in curriculum-based research, engaging with approximately 630 community, academic and industry partners. The numbers attest to Sheridan's commitment "to increasingly lean into research and entrepreneurship as drivers of academic innovation.

"We're proud of being consistently ranked as a top 10 research college in Canada," she adds.

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

SANTA ONO
PRESIDENT AND VICE-CHANCELLOR OF THE UNIVERSITY OF BRITISH COLUMBIA

Investments in scientific research are absolutely critical to Canada's ability to lead globally and respond to emerging challenges.

The COVID-19 pandemic is a great example of this, as we've seen Canada's research community make remarkable contributions to the global response – including technologies

...broad, sustained and long-term support for research holds the key to Canada's future ...

behind mRNA vaccines – all of which have been underpinned by decades of investments from institutions like the Canada Foundation for Innovation.

This kind of broad, sustained and long-term support for research holds the key to Canada's future, whether it's building a more innovative and sustainable society, addressing racism and inequality, or tackling challenges to come.

Market-ready, future-proof

Georgian College helping companies make 'Industry 4.0' leap

Quench Buggy's founder Darryl Hindle had a problem. His company, which had been providing mobile hydration stations at more than 175 festivals and events across North America – and selling outright to 15 to 25 municipalities – needed to automate its station's taps to comply with COVID-19 protocols. To help solve the problem, his mind immediately turned to Georgian College, where he'd studied mechanical engineering and automotive manufacturing.

"Georgian was our go-to place because it has a wide base of knowledge in engineering and business and computer technology," Mr. Hindle says. "We were matched with the right faculty and student researchers. We're now going through the build stage."

Through the Department of Research, Innovation and Entrepreneurship (RIE), faculty, mentors and students come together to help innovators. Students get hands-on experience, and researchers get to sink their teeth into real-world projects.

The Georgian College program, from which hundreds of companies have now benefited, is part of a concept called RICCO – the Research Innovation Cluster of Central Ontario.

"The concept is that there are a number of business support organizations all over our region, and through RICCO, they all interconnect into one big web," says Jamie Doran, executive director RIE at Georgian College. "It's a network of people and resources. If we all understand what our economic goals are across the region, we can work together to reach them."

Innovative companies – such as Quench Buggy – that want to be competitive in their industries are channelled into the applied research stream where they can further develop their technologies. On the entrepreneurship side, they can access mentorship through Georgian's Henry Bernick Entrepreneurship Centre (HBEC) to achieve their growth goals.

"One of the values of working together in this network environment is seeing what we can do to build a robust local supply chain," says Mira Ray, director of research and innovation at Georgian College.

Innovative companies like Quench Buggy are turning to Georgian College's applied research facilities for help in updating their products or services. SUPPLIED

Dr. Ray's side of things is the industry-led applied research, drawing on the skillsets, capabilities, infrastructure, expertise and capacity the college has.

"A major program we offer right now is called Competitive Smart Manufacturing, working with manufacturers and product developers to help them on their advanced manufacturing and Industry 4.0 journey," says Dr. Ray, adding that this includes how to go digital and optimize productivity to best serve their markets.

HBEC invites students, members of the community and staff to bring their business ideas or fully formed businesses to the centre.

"We surround that entrepreneur with the mentors we have on our team. Our goal is to ensure the time they need to grow is shortened," says Sara Bentham, director of HBEC, who adds that part of Georgian's hope is that the businesses hire its students.

"We see at least one new client every single day," Ms. Bentham says. "That really speaks to the need in the region for the services and supports that we offer."

Medicine's future: living drugs

The Ottawa Hospital's Biotherapeutics Manufacturing Centre harnessing the life-saving power of biological therapies

Tucked in between a cancer treatment centre and a stem cell research lab at The Ottawa Hospital is a facility at the forefront of medical innovation: this is where biomedical research is helping to provide the medical community with a new line of defence against some of today's most pressing health concerns.

"This is where the magic happens," says Duncan Stewart, executive vice-president of Research at The Ottawa Hospital. He's referring to the hospital's Biotherapeutics Manufacturing Centre (BMC), which is leading the way in developing and manufacturing biologically based medicines and treatments for a range of conditions, including cancer and cardiovascular disease, as well as experimental vaccines and biological therapies for COVID-19.

For example, the BMC is the only facility in Canada that can manufacture clinical-grade viruses that can be used for gene therapies and to fight cancer. In the latest breakthrough, viruses are used to turn white blood cells into cancer-seeking missiles called CAR-T cells. "We take a patient's T-cells, which are part of the immune system, and re-engineer them in the lab," explains Natasha Kekre, a hematologist and scientist at The Ottawa Hospital. "Then we give them back to the patient. This type of therapy allows us to enhance the immune system's ability to fight cancer."

Triggering a person's immune response to fight disease is not new, but what makes such therapies unique is that they are highly targeted and personalized, says Dr. Kekre, who envisions that CAR-T cell therapy, which is currently used for treating blood cancers, could potentially be used for other diseases as well.

USHERING IN THE FUTURE OF MEDICINE

Research findings in cancer, cardiovascular and degenerative brain disease – even COVID-19 – attest to the seemingly limitless potential of biotherapeutics, which are often referred to as "living drugs" because they use cells and components of cells to prevent, treat and cure life-threatening conditions. Dr. Stewart considers them "the future of medicine."

The BMC, which was established in 2006, has manufactured more than a dozen biological therapies for clinical trials in Canada and around the world, making it the most experienced and successful clean-room facility of its kind in Canada. Its products include not only immunotherapies for cancer but also stem cells for heart and lung diseases, gene therapy for rare diseases and, more recently, therapies and vaccines to fight the coronavirus pandemic.

The impact of this cutting-edge research has also spurred significant economic activity. The Canada Foundation for Innovation's $5-million investment in BMC has been leveraged at least tenfold by investments from other sources. BMC has also fostered more than five startup companies, which continue to invest in Canadian research and innovation.

BOOSTING CANADA'S INNOVATION CAPABILITIES

The coronavirus pandemic has brought attention to the need for increasing domestic manufacturing capabilities. That's where the BMC – which is currently helping to manufacture COVID-19 vaccines for clinical trials in collaboration with Canadian industry partners – can serve as an example, Dr. Stewart suggests.

"We are able to do the full end-to-end manufacturing," he says. "That includes fill finish: taking the final product and putting it into vials or other containers that can be delivered for direct use to the patient."

In addition to investments in infrastructure, Dr. Stewart sees a strong focus on nurturing talent as a key pillar for success. "We recognized early on that shiny new facilities aren't enough," he says. "What really makes things happen is the people who have this very specialized expertise."

With world-class biomanufacturing embedded within a teaching hospital, the BMC is "ideally positioned to train these highly skilled technicians and workers, as well as do the manufacturing," says Dr. Stewart.

The BMC also leads Canada's only hands-on training program in biomanufacturing, in partnership with Algonquin College, the University of Ottawa, Mitacs and BioCanRx.

Dr. Kekre is grateful to be to part of the endeavour. "BMC does awesome work," she says. "It is giving me, a junior investigator, the opportunity to try and improve the care of my cancer patients through building clinical trials that can potentially save lives."

Research advances in biotherapies also represent "important developments for Canada," notes Dr. Kekre. "Having domestic infrastructure and manufacturing capabilities is very important for ensuring that Canadian patients benefit from Canadian research."

More than anything, Dr. Kekre is hoping to improve the outlook for people diagnosed with cancer. "Unfortunately, even with chemo, radiation and standard therapies, patients still often hear that their cancer is not curable," she says.

"Hopefully, in my lifetime, we will see biotherapies not only alleviate suffering but also cure a lot of patients with different types of cancers as well as other diseases. The possibilities are endless."

Biologically based medicines and treatments must be made in highly specialized clean-room facilities, which are available at the Biotherapeutics Manufacturing Centre at The Ottawa Hospital. **SUPPLIED**

BY THE NUMBERS

The Ottawa Hospital Biotherapeutics Manufacturing Centre

- **15** years in operation
- **40** highly skilled staff
- **13** different kinds of cells and viruses produced
- **11** countries where BMC products have been used
- **8** production suites

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

PAUL DAVIDSON
PRESIDENT OF UNIVERSITIES CANADA

The world is facing some big challenges – global challenges that span sectors and borders. Finding solutions to these types of challenges requires diverse, interdisciplinary perspectives – perspectives that come from research collaboration and partnerships that extend beyond the conventional and that cross borders and boundaries.

Investments in innovation and research ... are critical to helping us build a strong and resilient future for everyone

We know that universities play an essential role in the development and translation of innovative thinking into knowledge and research that benefits all of society. As a result, for Canada to succeed, its universities must be strong.

Investments in innovation and research at Canada's post-secondary institutions are critical to helping us build a strong and resilient future for everyone.

The power of illumination

Canadian Light Source enabling research insights in range of fields

From the discovery of an enzyme able to turn any blood into a universal donor type to combating COVID-19 and identifying heat-tolerance traits in pea varieties, scientific advancements achieved at the Canadian Light Source (CLS) synchrotron at the University of Saskatchewan (USask) span various disciplines – and have the potential to change our way of life.

The CLS is a national research facility that produces light millions of times brighter than the sun, making it the go-to place for scientists looking to understand the structure of the matter they're studying, whether that is a protein in a virus or residues in mining operations.

For example, Joanne Lemieux is working to develop inhibitors of a protein that allows a virus to replicate. Clinically similar antiviral drugs are used to treat viruses, such as HIV and Hepatitis C, and now her research group at the University of Alberta has set its sights on COVID-19.

The protein crystallography facility at the CLS allows Dr. Lemieux to use X-rays to visualize how her target protein looks at the molecular level in three dimensions – and then see how her inhibitors work. And thanks to the CLS's remote research capabilities, her team was able to keep working through the pandemic, even when they could no longer travel.

"We ship our samples to the CLS and then use computers in Edmonton to get the robot at the CLS to put our protein crystals in the X-ray beam," says Dr. Lemieux. "We collect our data and interpret it – all remotely."

While drugs that slow viruses by inhibiting replication don't replace vaccination, they should dampen symptoms in people who get COVID-19 and may also shorten the duration of symptoms.

Dr. Lemieux is just one of almost 1,000 researchers across Canada – from academia, industry and government – who use the CLS and conduct thousands of experiments annually.

Gianluigi Botton, science director at the CLS, is proud of the discoveries the CLS has enabled, including new insight into planet formations using data from satellites. COVID-19 research is being conducted by scientists from across Canada, as is research on many other diseases, including cancer, heart disease, malaria and multiple sclerosis.

The Canadian Light Source synchrotron at the University of Saskatchewan is a world-leading resource that allows scientists from a range of fields to study the structure of matter. SUPPLIED

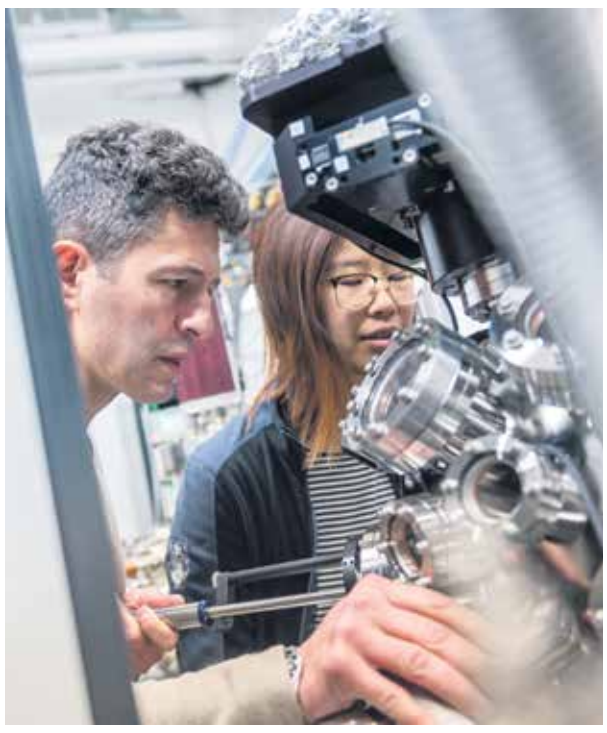
Other research teams are using the CLS to improve crop production, create the batteries of the future and combat climate change, he says. "The amazing thing about the CLS is that it's so diverse in terms of what we can analyze, from COVID-19 to bread and batteries and even plants and bones."

Dr. Botton says the CLS wouldn't exist without support from the Canada Foundation for Innovation, which was vital to its creation and funds 60 per cent of its operations. The Natural Sciences and Engineering Research Council, the Canadian Institutes of Health Research, Innovation Saskatchewan and USask are also core funders.

"The synchrotron's world-leading research enables discoveries that save and improve the lives of Canadians," says Dr. Botton. "These advancements will become even more necessary as we face global challenges such as climate change, food and water security, or the next pandemic."

From mRNA to superconductors

UBC pushing the boundaries of knowledge



Among the many scientists conducting groundbreaking work at UBC are Anna Blakney, assistant professor at UBC's Michael Smith Laboratories and School of Biomedical Engineering, and Andrea Damascelli, professor at UBC Department of Physics and Astronomy and scientific director of the Stewart Blusson Quantum Matter Institute. PAUL JOSEPH/UBC

From creating entirely new materials from single layers of atoms and instructing the body's own genetic machinery to fight disease, to honing the performance of instruments capable of detecting invisible objects thousands of light years away, scientists at the University of British Columbia (UBC) are leading the globe in key research areas that are helping to grow the Canadian economy and build a more sustainable and equitable society. And none of this work would be possible without UBC's cutting-edge labs, facilities and equipment, which have been supported by investments from the Canada Foundation for Innovation (CFI) over the last 25 years.

For example, while Anna Blakney's and Andrea Damascelli's fields of study might seem to have nothing in common, both researchers rely on highly specialized, sophisticated tools and infrastructure.

Dr. Blakney likes to say she was doing mRNA research "before it was cool." Before coming to UBC, she was on the U.K. team that developed a COVID vaccine. Drawn here by UBC's leadership in health and bio-innovation research – for which Vancouver has become a thriving hub due in part to UBC spinoff companies, Dr. Blakney says she has been able to equip her lab with the specific tools needed to make and formulate RNA thanks in part to investments from the CFI.

Dr. Blakney is working to learn "how the molecular design and formulations affect which cells and tissues RNA gets into." Her aim is to use this knowledge to help create the next generation of RNA vaccines and therapies. "There's really a whole wealth of diseases RNA technology could be applied to," she explains.

Take influenza, for example. Flu vaccines have traditionally been grown in eggs, and thus take many months to manufacture. And because the circulating virus can change over that time, flu shots are only 30 to 40 per cent effective. By contrast, because mRNA vaccines don't require cells, they can be made far more quickly and cheaply. The platform technology is almost "plug and play," and consequently, can turn out millions of doses of vaccine only weeks after a virus candidate is identified. This could make it possible to tailor vaccine formulations to match mutating strains of virus throughout flu season.

Another promising area relates to treatments that are capable of subduing a virus in the body within hours. For instance, "there are antibody treatments for COVID-19 – AbCellera here in Vancouver has developed one," Dr. Blakney says. While the resulting immunity is nowhere near as long-lasting as that induced by immunization, "there are outbreak situations, like Ebola, where it would be really useful to have a neutralizing antibody ready," she explains.

A third frontier: using RNA-based medications to coax the body to manufacture its own supply of powerful biologics like those used to treat diseases such as rheumatoid arthritis. Currently, "these drugs are life-changing, but inaccessible to a lot of the global population," Dr. Blakney notes, since most of them are administered by IV infusion, and they can cost up to $10,000 a dose. "If we could change the way we make these and encode it into RNA instead, we could make them a lot more accessible," she adds.

Research taking place at UBC's Stewart Blusson Quantum Matter Institute (QMI) has the potential to be equally transformational for other technologies, ranging from clean energy to quantum computing applications. Dr. Damascelli, scientific director of the Blusson QMI, studies quantum materials, which behave in ways that can't be explained by classical physics. Dr. Damascelli and his colleagues harness these unusual physical properties to "design, discover and make new materials that could be used for more efficient electronics and in completely new technologies," he explains.

For instance, in a world-first discovery, Dr. Damascelli and his team induced superconductivity in graphene (a single layer of carbon atoms that's both flexible and stronger than steel) in a new way – by coating it with lithium. Since electricity passes through superconductors with zero resistance, they have the potential to radically improve the efficiency of technologies such as quantum computers and sensors. The catch? Most superconductors discovered to date only work at prohibitively low temperatures.

However, another UBC researcher has widened that temperature window. Marcel Franz, deputy scientific director of UBC's Blusson QMI, recently proposed a path towards the creation of a high-temperature topological superconductor by stacking two atomically thin layers of a copper-oxide material atop one another at a specific angle. "This could be a revolutionary material for quantum computing," explains Dr. Damascelli. "Perhaps one of the most promising at this stage."

Yet institute researchers aren't only breaking ground on discoveries at the atomic level; they're also helping to expand our knowledge of the universe far beyond Earth. The Blusson QMI team, for instance, is improving the sensitivity of devices that detect gravitational waves, or "ripples" in space-time. Other institute scientists are collaborating with the Canadian Space Agency to develop devices to detect X-ray emission from black holes. "We have the technology to develop those detectors – and the infrastructure to make the materials needed to fabricate them," Dr. Damascelli explains. One example: a machine that creates nanoscale circuits essential in sensing tools, yet too small to be seen with an optical microscope.

According to Dr. Damascelli, ongoing support from the CFI and other funders "has led Canada to become a leader at the very forefront of the quantum technologies that are poised to transform many aspects of society."

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

CATHERINE GIRARD
PROFESSOR AT UNIVERSITÉ DU QUÉBEC À CHICOUTIMI

Canadians can be proud of the leadership our country has taken in climate change science. Research from Canadian universities and agencies has produced ground-breaking work on not only environmental – but also social and economic – impacts of climate change, especially in the North.

These outcomes are critical for Canada to meet its northern and global responsibilities in understanding the consequences of climate change. Due in part to investments from the Canada Foundation for Innovation (CFI), Canada is at the forefront of climate science on the global stage – and the research and innovation produced here will help us better adapt to future change. Examples of CFI-supported research infrastructure include the *CCGS Amundsen*, a dedicated research icebreaker that has pioneered monitoring projects in the North through ArcticNet, and the Centre for Northern Studies' network of Arctic observing stations that contribute to monitoring and research activities.

In climate science – as in all fields of research – better partnerships must be built with the First Peoples of Canada. Indeed, research has a role to play in reconciliation ...

In climate science – as in all fields of research – better partnerships must be built with the First Peoples of Canada. Indeed, research has a role to play in reconciliation: Canadian scientists must recognize the equal value of Euro-centric and Indigenous research methods, reflect on ways in which we share knowledge, and create meaningful relationships with Indigenous communities.

This must be done through collaboration and trust-building, through which we can uplift and amplify Indigenous voices in research. We must also reflect on how we can decolonize research and create spaces for Indigenous scholars in our system.

The diversity of perspectives in science directly correlates to the quality and innovation of research, and recognizing the existence of different ways of knowing and of measuring success can contribute to making research a safer and more welcoming space for Indigenous researchers, rights holders and community members.

These partnerships will deepen our understanding of climate change, strengthen our adaptive capabilities, and allow us to work hand in hand towards reconciliation.

Tom Gleeson, a President's Chair at the University of Victoria, works with communities, governments and organizations to secure water resources in Canada and globally. UVICPHOTOSERVICES

Solving water challenges

University of Victoria leading a quest to address one of the top five global threats

Most Canadians don't think twice about water – it's there when they turn on the tap or flush the toilet. But for many communities across the country, access to the clean water they need to survive and maintain their culture is a daily challenge.

It's not a uniquely Canadian problem, and it's not new. Pollution from industry, agriculture and resource extraction has degraded water sources since the Industrial Revolution. Climate change is making it worse.

With so many communities facing water crises, researchers in the Civil Engineering Department at the University of Victoria (UVic) in British Columbia are adopting a multidisciplinary approach to find solutions for what the World Economic Forum ranks as one of the top five global threats.

A leader in climate, environmental change and sustainability research aligning with the United Nations' Sustainable Development Goals, UVic prides itself on having the "greenest" civil engineering department in Canada. Scholars respond to global environmental challenges with practical design solutions such as managing, designing, constructing and maintaining the built and natural environments, using technologies and techniques that provide services to society while working within the carrying capacity of local ecosystems and the planet.

UVic researchers strive to achieve a key aspect of this mission – sustainable water on both a local and global scale – with the support of the Canada Foundation for Innovation and a common goal: sustainable and meaningful solutions supporting ecological and human health.

They are motivated in part by the knowledge that up to six million Indigenous and non-urban people in Canada face disproportionate exposure to contaminated water, and an estimated four billion people globally face water shortages.

Heather Buckley, who describes herself as a "green chemist and engineering professor," says she believes greener technologies are essential to improving human and environmental health.

She leads a research team developing green chemistry solutions to biological and chemical contamination in drinking water and environmental contexts. This ranges from sensors that easily detect trace contaminants to light-activated antimicrobials that prevent biological fouling of engineered marine and clinical surfaces.

"Having the tools for better environmental monitoring and adopting safe ways of cleaning contaminated surfaces empowers communities and industries to become environmental stewards, which in turn leads to better public health outcomes," says Dr. Buckley.

Her departmental colleague, Tom Gleeson, a UVic President's Chair, works with communities, governments and organizations to secure water resources in Canada and globally.

"Groundwater is a crucial, life-sustaining resource and the primary drinking source for over one million people in British Columbia alone," he says. "Unfortunately, the sustainability of groundwater resources is threatened by overuse or contamination in many areas."

Kristian Dubrawski, Canada Research Chair in Water Sustainability for Indigenous and Rural Communities (top), and chemistry and engineering professor Heather Buckley (bottom) are working to advance solutions to water challenges at UVic. ARMANDO TURA, UVIC PHOTO SERVICES

> "Adequate sanitation is considered a basic human right, but even in high-income countries such as Canada, many rural and remote communities lack adequate wastewater management systems.
>
> **Dr. Caetano Dorea**
> Associate Professor, Department of Civil Engineering, University of Victoria

Dr. Gleeson's special focus on groundwater is both global – shaping a United Nations report on the state of global groundwater – and local; he is supporting the co-governance of water by Cowichan Tribes First Nation on Vancouver Island, including citizens' participation to improve water management.

People in the Cowichan Valley near the City of Duncan depend on the Koksilah River for their water and salmon, but decades of decreasing summer flows are reducing available water and threatening salmon runs.

"The Koksilah is a threatened river because of low flows in summer driven by a range of factors, including climate change, irrigation and, possibly, logging," says Dr. Gleeson. "It's a great example of the challenge we face in water management."

Working through UVic's Community Water Innovation Lab, Kristian Dubrawski, Canada Research Chair in Water Sustainability for Indigenous and Rural Communities, focuses his research on the space where water quality and technology intersect with community and ecology. It includes the investigation of how communities can strengthen links between human and natural water systems – and it's important because 90 per cent of the world's wastewater is discharged untreated, causing pollution and disease.

That needs to change, says Dr. Dubrawski, but addressing water needs is more than just finding a solution and imposing it.

"We need to co-develop the right tools, so the communities feel empowered to deal with the problem," he says. "We also need to recognize that some of the water challenges are the result of injustice, like when a First Nation is forced to close their shellfish beach because of polluted industrial run-off."

He says it's not uncommon for communities that notice pollution in their water sources to lack the scientific knowledge and resources to take any action, which is where UVic researchers can offer help.

Caetano Dorea designs and studies novel, effective and sustainable on-site sanitation systems to protect human health and the environment for the most vulnerable communities in Canada and elsewhere. He points out that about 15 per cent of Canadians don't have access to safely managed sanitation services, and nine per cent of wastewater systems in First Nations communities rely on on-site septic systems.

"Adequate sanitation is considered a basic human right, but even in high-income countries such as Canada, many rural and remote communities lack adequate wastewater management systems," says Dr. Dorea, adding that the global burden of this deficit can be measured by the annual loss of over 320 million working days, 272 million school days and $7-billion in health-care costs.

The work of the sustainable water group is energized by research from hydrologist Tara Troy, who studies the impact of climate and humans on water resources. It is also underpinned by UVic president Kevin Hall's special interest in water. As a civil engineer, his deep commitment to environmental sustainability is evidenced by work on water crisis solutions, including delivering low-cost, point-of-use water-treatment technologies to marginalized urban communities across southeast Asia.

From researchers to the president, UVic academics are thinking more than twice about water, and they're primed and poised to make an impact on water safety and supply for communities in Canada and around the world.

Our promising future is now

Rekindling the economy with innovation from research and synergies with industry

BY ROSEANN O'REILLY RUNTE, PRESIDENT AND CEO OF THE CANADA FOUNDATION FOR INNOVATION

It has been 25 years since the Canada Foundation for Innovation (CFI) opened its doors, filling an essential role in our country's research ecosystem. In supporting researchers by building the labs, providing the equipment and creating the environments they need to make discoveries and innovate, the CFI has always invested in the promise of a bright future.

More and more, we see that this future is now.

Take the COVID-19 pandemic. It has taught us many lessons, but none more important than the power of science and research. The solutions required to combat the virus and its variants were discovered by brilliant researchers. This achievement was the result of years of work that identified the genetic makeup of viruses. This information had to be translated into vaccines, which were then tested, mass-produced, packaged and distributed safely. This example of research and discovery matching industry and enterprise has inspired governments around the world to focus on the power of science and research to lead to social and economic recovery.

Reviving our economy and restoring a healthy state of normality in communities around the world are excellent goals that can be attained with special attention to the linkage between science and industry. One might call this the "idea supply chain," which goes from idea to research and discovery, and links directly to manufacturing and marketing.

While we focus on these immediate goals, we must not forget the longer term that involves not only the future of science but also the future of our world. Beyond the economy, we must think of the grand challenges we face such as access to clean drinking water, food security and climate change. We can take pride in the fine work of researchers like those at the Cégep de Sorel-Tracy where environmental industrial processes eliminate or recycle waste materials. Pure water supplies are being studied at Waterloo, Calgary and Carleton universities, and researchers at Lethbridge College are working to reduce waste from harvest to table by 20 per cent. Small and large research projects across the country will converge to make a significant difference in the environment and can combine with economic development projects to create a renewed and much greener economy.

By changing the way we do science, we will open doors to new discoveries and innovations. Creative models for teaching, learning and research like Nokom's House at the University of Guelph, which will incorporate Indigenous principles in land-based research, help to bring traditional knowledge to the fore. Partnerships across disciplines, institutions, regions and nations will provide the means to change perspectives and gain insights. When we reimagine research spaces and become more inclusive, we will broaden our horizons and potential for valuable immediate and long-term discoveries.

While we embrace new concepts, we must also think about possible impacts that may well change our lives and livelihoods. For example, if robotics enable rapid testing of greater numbers of samples in laboratories, we will need more data storage and experts in data analysis. The lab technicians who ran the tests may now have to prepare more samples and gain different but equally valuable skills. Similarly, many of us discovered how effectively we could study and work at a distance as the pandemic took hold. Now we are learning some of the side-effects of isolation and too many hours before a computer screen on the population. In labs the CFI has funded, researchers are currently refining and testing new discoveries and their impacts on the way we live and work.

Our legacy should not be a future filled only with problems for the next generation to solve. We must dream of the most extraordinary possibilities for science and open these doors to exploration. Whether it is researchers at York University who are exploring green manufacturing in outer space or a team in Victoria imagining the sequestration of carbon under the ocean floor, we must encourage curiosity-driven research that will identify the unknown and offer us new possibilities for future life.

Years of focused research are showing spectacular results. A year ago, Sir Michael Houghton was awarded a Nobel Prize in Physiology or Medicine for his contributions to discovering the hepatitis C virus in 1989, which enabled antibody testing, saving thousands of lives. His team has now developed a vaccine for the virus currently in preclinical testing. Other early projects supported by the CFI have laid the groundwork for rapidly evolving fields ranging from artificial intelligence to quantum computing.

CFI-funded facilities continue to welcome researchers, attract and retain young people and bring the best in the world to Canada. We have seen steady growth and extraordinary achievements and are confident that while we work together to rekindle the economy with innovation from research and synergies with industry, we can contribute to solving the challenges the world is facing. We can provide the sparks for the discoveries that will lead to a better future today.

Follow the CFI's 25th anniversary activities on social media through #PromisingFutureNow

SUPPLIED

> "Our legacy should not be a future filled only with problems for the next generation to solve. We must dream of the most extraordinary possibilities for science and open these doors to exploration.
>
> **Dr. Roseann O'Reilly Runte**
> President and CEO, Canada Foundation for Innovation

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

STEVEN N. LISS
VICE-PRESIDENT, RESEARCH AND INNOVATION, RYERSON UNIVERSITY

The pace of change – evident in rapid technological advancements and associated societal transformation – is accelerating, and post-secondary education has a key role in facilitating this shift in a way where no one is left behind.

Recent years have seen an increase in attention on the gaps and inequities that still exist in Canada, from the Truth and Reconciliation Commission's calls to action and the Black Lives Matter movement to youth climate action and studies documenting the disproportional impact of the coronavirus pandemic on female labour force participation. Speaking out about these issues is not only critical for creating a more just and sustainable society but also for advancing our nation's capacity to innovate.

Many studies have shown that diverse minds come up with better solutions, and that's why Ryerson is prioritizing a multi-pronged, collaborative approach that includes a dedication to empowering diverse voices. Examples are Ryerson's engagement with the Future Skills Centre and the Women Entrepreneurship Knowledge Hub, two key resources dedicated to overcoming hurdles to economic participation.

In addition to bringing under-represented populations to the table, Ryerson is also creating an ecosystem where perspectives from sciences, humanities, business and communities can be woven into one narrative for advancing a common vision: to leverage innovation as the path for inclusive growth.

Sea ice dynamics

University of Manitoba researchers look to the Churchill Marine Observatory for answers about a changing climate

The Churchill Marine Observatory (CMO) is located adjacent to Canada's only Arctic deep-water port, which will allow researchers access to marine and Arctic life like never before. SUPPLIED

Hudson Bay, considered a marginal sea of the Arctic Ocean, is changing rapidly. Local communities report that their traditional routes for travelling and hunting are disrupted due to the loss of sea ice, and that they encounter fish and marine mammals that are new to this habitat. Locals are also concerned about an increase in shipping and exploration.

A closer look at this ecosystem can provide valuable answers, not only for designing local interventions but also for understanding what a warming climate might mean for the planet, suggests David Barber, professor and Canada Research Chair (CRC) in Arctic-System Science at the Centre for Earth Observation Science (CEOS) at the University of Manitoba (UM).

Studying "the changing sea ice environment requires new and innovative facilities, techniques and approaches," says Dr. Barber, who leads a new facility, the Churchill Marine Observatory (CMO). "It's located adjacent to Canada's only Arctic deep-water port, which will allow researchers access to marine and Arctic life like never before. Our group is working to understand Canada's often overlooked third ocean. How do we manage it? How do we prepare for the changes happening there? How do we get our policies and procedures in place?"

Gary Stern, board co-chair of the CMO and lead of the GENICE project, studies the transport of contaminants through Arctic marine and freshwater ecosystems. "As we lose sea ice, there is more and more ship traffic," he says. "Local communities are concerned about this commercial activity, which brings challenges for the marine food web, such as ship noise and potential oil spills."

Mechanical oil recovery efforts, which may be effective in warmer climates, are hampered by the presence of sea ice, so Dr. Stern is looking at alternative approaches that take the seasonal change in temperature of the ice and the potential of microbial degradation into account.

"The idea is to study which microbes are present – and the types of ice where they are predominant – as well as under what conditions these microbes have a better chance of degrading the oil," he said.

Science will help to provide much-needed answers for authorities with regulatory responsibilities, shipping companies and local communities, believes Feiyue Wang, professor and CRC in Arctic Environmental Chemistry at CEOS.

"As the Arctic is getting more accessible, both in terms of marine transportation and resource development, we are facing imminent threats and opportunities," he says. "While communities are interested in developments that improve their socio-economic situation, change is happening so fast that many worry how this will affect their way of living."

The CMO's Ocean-Sea Ice Mesocosm (OSIM) will provide answers about the detection, fate, modelling and response techniques for crude oil and other transport-related contaminants, Dr. Wang says. "[OSIM] consists of two outdoor covered pools that can accommodate controlled experiments on various scenarios for marine and freshwater environments. We can pump water from surrounding sources into the tanks, and this allows us to emulate field experiments, albeit with greater control."

Researchers can gain insights on geophysical and biogeochemical processes across the ocean-sea ice-atmosphere interface and freshwater-marine coupling, and Dr. Wang envisions this to spur "development of new technologies that help to respond to some of the challenges."

In addition to OSIM, the CMO has an "Environmental Observing (EO) System, which consists of a series of automated instruments located across Hudson Bay," says Dr. Barber. "This provides us with real-time data for monitoring changes as they occur and to set conditions in our OSIM experiments."

Designed to operate for about 50 years, the EO will accumulate a significant amount of data about "the impacts of humans on the system, including what happens when hydrocarbons or other contaminants are spilled," he says. "It will also allow us to study extreme weather and climate change effects regionally and nationally."

As chief scientist of the EO, CJ Mundy emphasizes the importance of oceanographic research in Canada's North, which draws on data from the automated instruments as well as the *RV William Kennedy*, Canada's first research vessel dedicated exclusively to this region. It is operated – in partnership with the Arctic Research Foundation – during the summer months and has enabled a number of initiatives, including community-based projects around Hudson Bay.

A shift in focus – from deep water to the coastal areas – has revealed the region to be more productive than previously thought, says Dr. Mundy, who studies phytoplankton, ice algae and kelp. "There is a lot of production feeding marine life. The summer beluga whale population is estimated at more than 50,000 in southwestern Hudson Bay alone, and other marine mammals in the bay include polar bears, bowhead whales, seals and walruses."

Yet what does a changing climate mean for species adapted to cold water? Dr. Mundy believes they will face pressure from newcomers to the region, since increasing temperature and less sea ice could lead to a shift in seasonal production regimes at the detriment of highly adapted Arctic marine species. "New information can help us understand how this system works," he says, "and what is likely to happen as temperatures continue to change."

Implications of this kind of research go far beyond local communities in Hudson Bay, adds Dr. Barber. "The CMO is focused on climate change and how these changes, which are so obvious in the North, are connected to what is happening across the planet. Better understanding can help us inform the public and hopefully guide industry practices and policy toward better outcomes."

Whale watching

Ocean Tracking Network leveraging new technology to track whales and design interventions

When the North Atlantic right whale seemingly vanished from its spring/summer foraging grounds near the Gulf of Maine in 2010, scientists and conservation groups were alarmed and mystified.

"After 30 years of coming to the Bay of Fundy, they almost completely abandoned that habitat," says Kimberley Davies, an associate professor in the Department of Biological Sciences at the University of New Brunswick (UNB).

The slow-swimming mammals, measuring up to 52 feet, weighing 140,000 pounds and living up to 70 years, had been hunted almost to extinction. Even after industrial whaling ended in the early 1970s, their population continued to decline. Numbering in the low hundreds, they were considered a species at risk.

It took five years, says Dr. Davies, to track them down. A scientist who studies the North Atlantic right whale's foraging and prey, she had a hunch that the baleen whales had shifted their habitat in search of a new food supply.

By this time, Dr. Davies was working with the Ocean Tracking Network (OTN), a global aquatic animal tracking, data management and partnership platform headquartered at Dalhousie University. Supported since 2008 by the Canada Foundation for Innovation, OTN has pioneered the remote offloading of acoustic data using ocean-going marine autonomous vehicles called gliders.

As one of Canada's 16 national research facilities, says Sara Iverson, scientific director at OTN, "we've established the country's largest glider program." The underwater drones gather data, track ocean conditions and carry equipment that detects and monitors the movement of marine animals.

Fred Whoriskey, executive director of OTN, adds that the gliders are a cost-effective approach to monitoring large areas that present a "mass reduction of carbon footprint" compared to other surveillance methods.

"There's a huge increase in safety because they are unmanned and can function in any weather conditions," he says. "They can travel the open ocean 24/7 at any depth, at any time."

Deploying the gliders in Canadian waters, "we discovered the animals in the southern Gulf of St. Lawrence," says Dr. Davies. Further investigation determined that warming of the waters in the Gulf of Maine had led to declines in the whales' food source. They'd headed north where food is more abundant.

While this explained why the whales had left and where they went, the scientists were confronted by another dire problem, she says. "They started to be killed or injured by fishing gear entanglement and ship strikes in very high numbers."

In 2017, the death of 17 North Atlantic right whales shook both the scientific community and the public. It triggered governments and other agencies to accelerate research, monitoring and protection of the species, which had now been listed as critically endangered.

In 2021, OTN announced that it had extended its North Atlantic right whale monitoring project for five years in partnership with UNB and Transport Canada. The additional funding of $3.6-million allowed OTN to purchase a state-of-the-art G3 Slocum glider, supplementing the fleet of gliders operated and maintained by Dalhousie's Coastal Environmental Observation Technology and Research (CEOTR) group.

The Slocum glider, explains Dr. Iverson, features a hydrophone developed at the Woods Hole Oceanographic Institution in Massachusetts. "It is outfitted with a mobile transceiver that can detect animals with an acoustic tag. In the case of the right whales, we use 'passive acoustic' monitoring. Basically, these special hydrophones listen for whale calls," she says. "We can relay information of whale presence in real time or near real time to ships to basically alter their course, slow their speed or to create closures."

The addition of the new glider is critically important, says Dr. Whoriskey. "The more gliders we can add, the better job we can do covering areas of high probability of risk – in the fishing regions, in the shipping lanes – in order to avoid fatalities."

Hansen Johnson, a PhD student at Dalhousie University who studies baleen whale acoustic and habitat ecology, appreciates that the gliders are collecting "huge amounts of continuous information about whale presence and habitat." As part of his research, Mr. Johnson has developed an interactive map tracking right whale distribution.

The Wave Glider collects information on weather and sea-surface state, although its primary purpose is to remotely offload bottom moored tracking stations, which make up the majority of OTN's global tracking infrastructure. The Wave Glider derives electrical power from solar panels and is propelled by harvesting wave energy via a subsurface unit (top). The CEOTR team is ballasting gliders to ensure their neutral buoyancy on the surface of the water once they're deployed for research (bottom.) NICOLAS WINKLER

The gliders have "really expanded our observational capacity in a profound way," he says.

Dr. Davies is hopeful that through "continuous monitoring and mitigation of threats, by introducing new and better tools and technologies to alleviate risks, and with ongoing effort on all fronts, the North Atlantic right whale will soon be back on the road to recovery."

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

DENISE AMYOT
PRESIDENT AND CEO OF COLLEGES AND INSTITUTES CANADA

Enabling a future-ready Canada requires dedicated efforts for advancing an inclusive and sustainable economy. With over 95 per cent of Canadians living within 50 kilometres of a college or institute, these post-secondary institutions are ideally placed for supporting communities through the challenges ahead.

With extensive industry and community connections, Canadian colleges and institutes are a key element for taking innovation from idea to impact. In 2019-20, for example, they were involved in over 8,000 research partnerships, generating over 5,500 innovations, including new processes, products, prototypes and services, approximately 85 per cent of which were completed in less than one year. This kind of rapid innovation capacity will be more important than ever as businesses have to adapt to new circumstances.

For thousands of SMEs, colleges and institutes provide a gateway to the innovation ecosystem.

Colleges and institutes are sought-after partners for community stakeholders, and especially small and medium-sized enterprises (SMEs), which often lack the capacity, equipment and networks to undertake the kind of research and development that would help to drive their business forward. For thousands of SMEs, colleges and institutes provide a gateway to the innovation ecosystem.

By working together – in collaboration with industry, government, community and academia – we can unlock the powerful potential of research and innovation, and leverage it for the good of Canadian communities.

25 YEARS

A SOLID PAST, A BRIGHT FUTURE

Amplifying research impact

SFU unleashing economic growth through innovation

ALICE AIKEN
VICE-PRESIDENT, RESEARCH & INNOVATION, DALHOUSIE UNIVERSITY

When Canadian regions are able to develop world-class research infrastructure in their respective areas of strength, this benefits local economies by generating new knowledge and technologies that lead to economic growth through commercialization and employment.

Investments from the Canada Foundation for Innovation (CFI) have created a foundation on which Canada's top scientists can build their leading-edge research programs that address Canadian and global issues.

As the host of the Ocean Tracking Network (OTN), one of the CFI's Major Science Initiatives, we at Dalhousie University understand the regional, national and international impact of CFI funding. The OTN has united the finest marine scientists in the world in a comprehensive examination of marine life and ocean conditions using Canadian-made technology deployed in all of the world's five oceans.

The data being gathered is informing scientists and world leaders as they manage pressing global oceans issues in the face of climate change.

Science and innovation – and particularly science-based ventures – are important assets that can help to create economic value and high-quality jobs as well as meet community needs, including those emerging as a result of a global crisis.

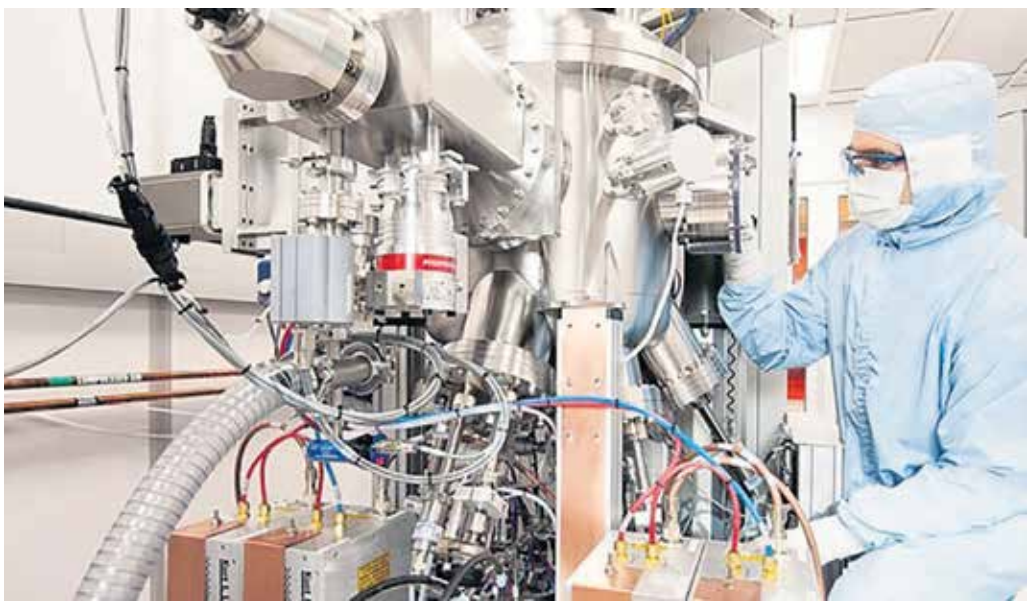
At Simon Fraser University (SFU) in British Columbia, the urgency of the coronavirus pandemic inspired quick action, says Dugan O'Neil, SFU's vice-president, research and international. Among the university's responses to COVID-19 were the development of coronavirus testing kits using SFU-invented RNA imaging technology, epidemiology modelling to forecast the possible spread of the virus, efforts to support global co-ordination of a coronavirus outbreak response and research on gender-related impacts of the pandemic.

What enabled SFU's timely response to the global pandemic is state-of-the-art research infrastructure that has in part been supported by the Canada Foundation for Innovation (CFI), says Dr. O'Neil. "The CFI has been pivotal to our success as an institution, and this impact is felt in every area of research and innovation."

An example of a world-leading institutional resource is Cedar, one of the largest academic supercomputers in Canada. "Cedar enables research in a range of disciplines, from chemistry and particle physics to big data and social science," he says. "In addition to fundamental science explorations, people are also conducting applied research; for example, engineering studies looking at combustion engines or artificial intelligence as answers to specific problems."

However, ushering research findings out of the lab and developing them to the point where they can make a difference in society is not without challenges, says Elicia Maine, special adviser on innovation to the VP, Research and International, who is advocating for a "build-for-scale strategy" for the science innovation ecosystem.

"Our research indicates that there are gaps in the system, and we could unleash more innovation – and associated economic growth – by making research facilities more accessible to researchers, nascent innovators and small and medium-sized enterprises looking to de-risk their technology inventions," proposes Dr. Maine, who is also the VanDusen Professor of Innovation & Entrepreneurship at SFU's Beedie School of Business.



Simon Fraser University's 4D LABS, an advanced materials research and development core facility funded by the CFI, provides researchers and industry partners with testing, fabrication and prototyping tools. SUPPLIED

> Congratulations to the CFI for 25 years of reshaping the Canadian research landscape, incentivizing partnerships between academic institutions, industry and government, and supporting the ambitions of the talented Canadians who want to make a positive impact on the world.
>
> **Dr. Dugan O'Neil**
> Vice-President, Research and International, Simon Fraser University

"When researchers have trouble commercializing an idea, we help them and their labs develop a commercialization strategy for their breakthrough research," she says. "We developed Invention to Innovation (I2I) in order to support research translation and to enable researchers to benefit from innovation skills training."

A key element bolstering the commercialization pipeline is SFU Innovates – the university's innovation strategy – which is built on four pillars: entrepreneurship; social innovation; incubation and acceleration; and industry and community research partnerships. And each pillar has its own support system. 4D LABS, an advanced materials research and development core facility funded by the CFI, for example, provides researchers and industry partners with testing, fabrication and prototyping tools, says Dr. O'Neil. "4D LABS lowers the barrier to innovation and has worked with hundreds of companies to advance their technologies."

These collective efforts have helped to elevate SFU's standing in the World's Universities with Real Impact Rankings, which measure how universities create value to society. SFU now ranks third in the world for entrepreneurial spirit – up from seventh – and 24th overall among innovative universities, the highest placed Canadian university and the only one to crack the top 100.

"We know that providing early-stage support for science innovation and spinoff ventures ends up yielding better returns for the region and the country," says Dr. Maine.

Yet while SFU has created a strong ecosystem for amplifying research impact, this would not be possible without a strong foundation, emphasizes Dr. O'Neil. "Congratulations to the CFI for 25 years of reshaping the Canadian research landscape, incentivizing partnerships between academic institutions, industry and government, and supporting the ambitions of the talented Canadians who want to make a positive impact on the world."

Quantum leaps

UCalgary partnerships exploring how quantum research can help to address 'hard problems'

Five decades ago, nobody would have expected the extent to which computers would shape today's way of life. Quantum computing, while still at an early stage, promises to be similarly disruptive, says Barry Sanders, director of the Institute for Quantum Science and Technology at the University of Calgary (UCalgary) and lead investigator of the Alberta Major Innovation Fund Project on Quantum Technologies.

"We can't yet fathom everything quantum will impact, but we believe having computers that are based on a different form of logic can make hard problems – and especially problems of a bigger scale – easier to solve," says Dr. Sanders, who proposes three essential stages – "quantum aware, quantum ready and quantum active" – in order to unlock the potential of quantum.

"Quantum aware means that companies need to know that quantum computing is there – and that it could disrupt them. Quantum ready means that, with the possibility of using it on the horizon, they need team members who know about quantum computing, so it can be deployed," he says. "Quantum active would be applying it to solve practical problems."

Yet what could a real-world scenario look like? A quantum computer's potential to arrive at a solution with less data – compared to a traditional computer – can advance outcomes in areas like anomaly detection, Dr. Sanders suggests. Take a city's transportation system, for example, where trams are powered by overhead wires. A wire going down could pose significant hazards, and experts are turning to quantum science to explore the possibility of predicting – or even preventing – such events.

However, taking quantum research and development to the point of practical application requires efforts spanning multiple fields, such as fundamental quantum mechanics, information science, materials science, computer science and computer engineering, says William Ghali, vice-president (Research) at UCalgary, where "trans-disciplinary scholarship has become a signature brand."

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> "To advance quantum technologies, we need to support sector development, R&D and a purposeful talent strategy, and universities can play a key role.
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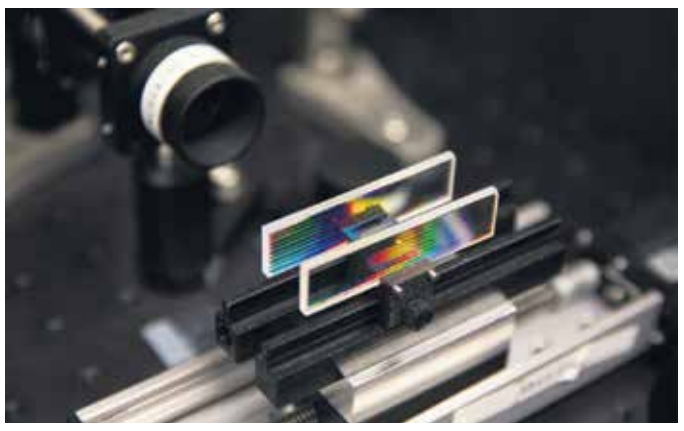

Quantum computers are based on a different form of logic – and experts at the University of Calgary believe that efforts to advance quantum technologies can bring significant benefits for the region. SUPPLIED

A decade-long effort to bring people "out of their faculty silos and engage in campus-wide research themes has led to interdisciplinary research excellence with examples in biomedical engineering, brain and mental health research, cybersecurity and more," says Dr. Ghali. "This has led to increased success in funding competitions, including support from the Canada Foundation for Innovation."

Beyond fostering cross-disciplinary connections, UCalgary is also dedicated to accelerating the adoption of real-world innovations through industry partnerships as well as entrepreneurship, he adds. "Our 'Eyes High' strategy, which started in 2011, envisioned two goals: to be one of Canada's leading research universities and to focus on entrepreneurship."

Statistics prove that both objectives have been accomplished. Last year, for example, UCalgary attracted $504-million in research revenue, which represents a 10 per cent increase over the previous year, says Dr. Ghali. "And we are number one in Canada in terms of startup companies. This trajectory is really important for us, and quantum is a central piece."

UCalgary is one of four universities – together with the University of Waterloo, Université de Sherbrooke and the University of British Columbia – advocating for a national quantum strategy, and Dr. Ghali welcomes the federal government's announcement of a $360-million investment to launch the strategy.

"To advance quantum technologies, we need to support sector development, R&D and a purposeful talent strategy, and universities can play a key role," he says, adding that efforts to strengthen the regional technology and innovation ecosystem have already helped to attract a number of companies to Calgary, with corporations such as RBC and Infosys having innovation hubs in the city.

Mphasis, an information technology solutions provider specializing in cloud and cognitive services, is yet another major corporation establishing an innovation hub in Calgary. In partnership with Mphasis and the Government of Alberta, UCalgary recently announced the launch of the Quantum City initiative that will build solutions for the commercial application of quantum computing for artificial intelligence and machine learning.

Beyond partnering with large corporations, Dr. Sanders emphasizes the need to "enable smaller companies to participate in exploring quantum solutions.

"Rather than quantum becoming this elite technology that average persons can't access, we want to build success across society – and for a range of businesses, including the mom-and-pop store next door," he says. "It's exciting to see more and more startups turning to quantum technology for real-world problems."

Dr. Ghali shares this excitement about quantum's potential to transform many sectors and dimensions of life. "There's no question that the impact will go beyond computing to encompass innovations spread across quantum information science, materials and technologies," he says. "Canada needs to move toward a knowledge economy, and we are helping to make this happen by facilitating growth in quantum as well as the digital economy more broadly."

SENTINELS

BE WHAT THE WORLD NEEDS

The Super Dual Auroral Radar Network (SuperDARN) is a global network of scientific radars monitoring conditions in the near-Earth space environment, studying activity in the upper atmosphere. The USask site, funded by the Canada Foundation for Innovation (CFI), was one of the first in a network that now includes 36 locations around the world. SuperDARN helps position Canada as a global leader in monitoring near-Earth space, with the data and expertise essential to mitigating damaging space weather effects.

Over its 25-year history, the CFI has funded more than 300 USask leading-edge research projects that help address global challenges — from new vaccines to the Canadian Light Source synchrotron, to sustainable food, water and energy security solutions. That's true innovation — with a uniquely Saskatchewan perspective.

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