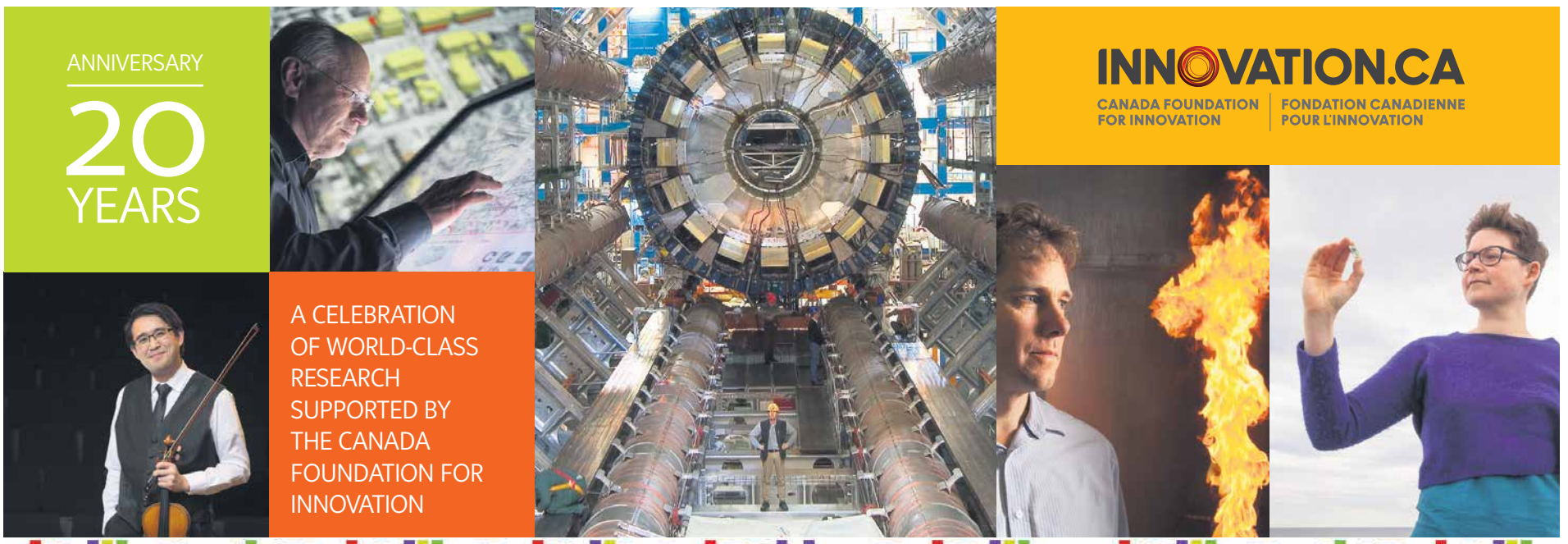
EXCELLENCE
IN RESEARCH AND INNOVATION

THE GLOBE AND MAIL TUESDAY, NOVEMBER 22, 2016 SECTION CFI



Research builds our communities

If you listen to Andrew Pelling, you'll believe your most creative and wild ideas are worth paying attention to. You may even feel compelled to submit them for further investigation in his lab, where biohacking and DIY science are par for the course. Dr. Pelling leads the Laboratory for Biophysical Manipulation at the University of Ottawa, described on its home page as "an openly curious and exploratory space where scientists, engineers and artists work in close quarters."

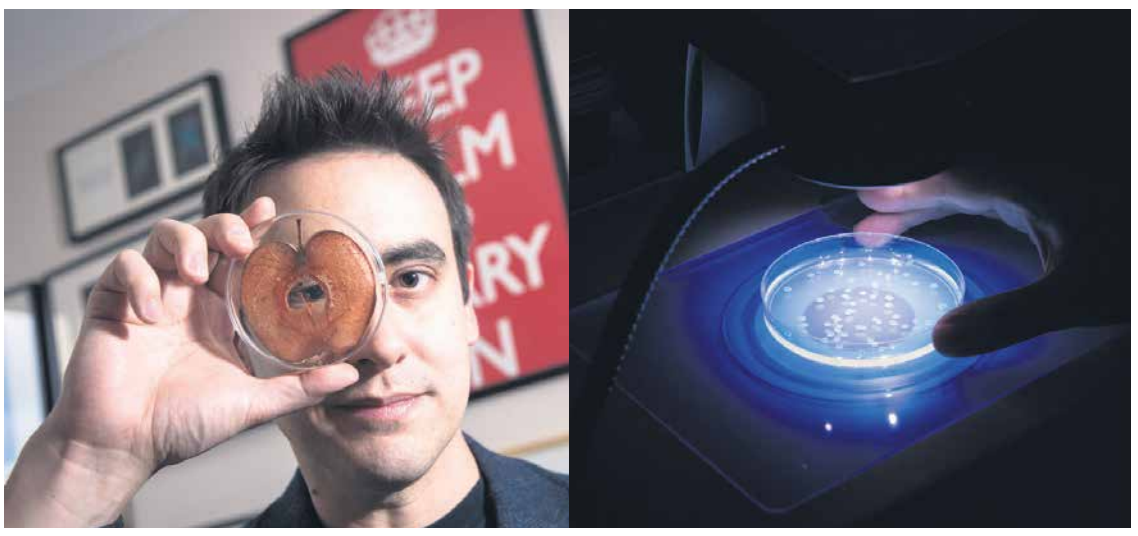
"My lab is about ideas," says Dr. Pelling, who is also Canada Research Chair in Experimental Cell Mechanics. "The best way to come up with really unconventional ideas is by getting a whole bunch of different perspectives in the same room and saying 'Ask questions! Be creative!'"

That kind of open-minded approach to research, especially when contrasted with a more conservative approach to research and innovation – where a problem is identified and research is done to find a solution – is a unique example of how intrinsically research and communities are linked. This might just be a missing piece of the research and innovation puzzle in Canada.

It's also what led Dr. Pelling to launch pHacktory, a small company that collects proposals from people with out-of-the-box ideas they want to test through "experiments in distributed and community-driven street-level research."

Only the most audacious ideas will be considered, says Dr. Pelling. "We want ideas that are 99 per cent certain to fail. We want to try them anyway, because failure can lead to some of the most profound discoveries. And if they were to work, they could be transformative."

The notion of making research a grassroots effort – and inviting everyone to participate – has earned Dr. Pelling a large fan base. His TED talk, where he explains the process of creating a human ear from an apple, has garnered well over a million views.



Dr. Andrew Pelling (left), who pioneered the process for turning an apple into a human ear, advocates the importance of taking creative and wild ideas towards intangible outcomes; the research at Calgary's Advancing Canadian Wastewater Assets facility (right) has a direct impact on the city's water quality. LEFT, PETER THORNTON; RIGHT, SUPPLIED

It's also a novel approach to feeding the innovation pipeline. "There seems to be this caveat that knowledge is only valuable if it leads to a billion-dollar enterprise," says Dr. Pelling. "But if we forget to generate new ideas and new knowledge, then eventually the pipeline runs dry."

With unapologetic curiosity as a guidepost, Dr. Pelling says his lab "generates ideas that just don't exist at the moment, but that may have a really disruptive effect down the road." He cites his ears-from-apples experiment as an example. Inspired by *Little Shop of Horrors*, the lab set out to create a man-eating plant, a "miserable failure" in Dr. Pelling's words. "But during that process we discovered we could use plants as a biomaterial, and all of a sudden we've got this biotechnology that's insanely cheap and solves many of the problems that come along with current biomaterial strategies."

Dr. Pelling's approach to discovering game-changing new technologies is more than great science-fiction-turned-fact. That's because finding mechanisms for boosting innovation is a pressing question to growing our economy, according to Christopher Ragan. He is a McGill University macro economist and a member of the Advisory Council on Economic Growth, which has been charged with pointing leaders and policy-makers to growth policies and actions that can address the slowing of Canada's economy.

Innovation is widely recognized as a key driver of productivity growth, which, in turn, is responsible for improving living standards over the long term, he explains. "If you want to know why we are better off on average than our great grandparents, productivity growth and innovation are at the heart of it," says Dr. Ragan.

Yet Canada's productivity growth is less than what it used to be, and less than that of our competitors, says Dr. Ragan. He adds that it's no secret that while Canadians excel in basic research and are good at inventing things, they often come up short in the next step: turning the idea or invention into a successful business – and scaling that business up. "Innovation is still a very tough nut to crack," says Dr. Ragan.

Even as economists and policy-makers work to answer the difficult questions around how to improve innovation, the impact that research and innovation have on Canadians' quality of life will be the ultimate measure of their success. In the broadest sense, innovation is the desire to make things better and to build our communities.

That's a tenet that Calgary Mayor Naheed Nenshi has embraced. He sees research and innovation as essential tools for serving the community and points to the Advancing Canadian Wastewater Assets (ACWA) facility, which is a research partnership between the city and the University of Calgary, as an example. ACWA includes 3.8 kilometres of naturalized, experimental streams that replicate real-life water situations and enable one-of-a-kind research into finding better ways to treat municipal wastewater for the benefit of human health and the environment.

"Every community along the Bow River is responsible for keeping [the water] healthy. That means being a good neighbour to everyone living downstream," Mr. Nenshi explains. Beyond their commercialization potential, the technologies developed at ACWA could have implications that go far beyond water quality in Calgary – they can potentially help to address the pressing global issue of access to clean drinking water, he says.

While the ACWA research partnership may appear radically different from Dr. Pelling's approach, the outcomes are strikingly similar: both are giving rise to valuable new technologies, and both are having an immediate impact on their communities. The only difference is the starting point. "What we're doing at pHacktory is creating the right conditions to bubble up innovators en masse, rather than waiting for them to randomly appear," says Dr. Pelling.

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INSIDE

RESEARCH AND INNOVATION

OPINION

A bold vision from 20 years ago is more relevant than ever

Dr. Gilles Patry is President and CEO of the Canada Foundation for Innovation

A yellow node containing a power source and Internet hub is loaded onto a ship in Victoria, B.C. The hub is part of Ocean Networks Canada, a system of hundreds of kilometres of cable attached to a raft of instruments and sensors laid along the ocean floor. The network uses the Internet to broadcast real-time data on marine life and earthquakes. OCEAN NETWORKS CANADA

The creation of the Canada Foundation for Innovation in 1997 stemmed from a bold vision to transform an ailing research system in this country. Twenty years later, the organization that turned dilapidated, makeshift labs into world-leading research facilities is more relevant than ever.

In the late 1990s, the problem was clear. Canadian research was in trouble because a history of under-investment in research infrastructure meant our best minds were prevented from querying the cutting-edge questions that would allow them to lead their fields.

Many looked elsewhere. Many left. "Brain drain" became a household phrase. At the time, I was dean of engineering at the University of Ottawa, and I witnessed an exodus of our brightest researchers. It was a problem that had all Canadian university presidents worried. The talent and reputation of their researchers was their biggest selling point. How could they compete when their key assets were heading for the door in droves?

A confluence of political will, fiscal opportunity and dire need brought to fruition the idea of an organization dedicated to funding research infrastructure – state-of-the-art equipment and facilities that researchers needed to think big, reach higher and help our country lead in the new knowledge era the 21st century promised.

The creation of the CFI by the Government of Canada was in itself an experiment to set Canadian research on a new path, and it worked! We're not playing catch-up anymore; we're setting the pace.

Look at the international scientists who flock to Dalhousie University's Ocean Tracking Network and the University of Victoria's underwater ocean network observatory to access unprecedented information about marine species and insights into pressing issues like climate change. Look also at the burgeoning Toronto-Waterloo corridor, where an incredible concentration of research and training institutions and tech companies have made this part of Ontario a hub of talent and discovery, and an excellent example of how clusters of capability and expertise can be engines of innovation.

The ultimate measure of our success, of course, is the difference our research endeavours have made in the quality of life of Canadians. That research builds communities is a simple truth we see reflected in our work every day, and which is brought into focus in this publication through the stories and images of Canadians whose communities have benefited in some way from research.

While some of our problems of two decades ago may have been solved, a slew of new challenges replace them. To name a couple: How can we support and position young researchers for success? And how can we turn our now world-leading research into innovation more efficiently and more consistently?

Sustaining our commitment to investing in world-leading research and research infrastructure is, without a doubt, part of the answer. Research infrastructure evolves rapidly. The machines of today quickly become obsolete; better, faster, more powerful research equipment lets researchers probe deeper, look further, ask trickier questions and get answers more quickly. Because, as any scientist will tell you, each new insight, development or innovation merely opens a door to the next most compelling question. Having the best equipment to answer the queries of the future is an ongoing effort.

More than that, the young researchers who will find answers to those questions are more globally minded, more connected and collaborative, and more mobile than ever. We learned our lesson at the end of the last millennium – if we don't provide the opportunities our research leaders seek, they will look abroad. With a new generation of researchers, this might be more of a risk than ever – all the more reason to continue to set our sights high and keep building our hard-won, world-class research enterprise.

In a recent blogpost, Bill Gates wrote "Science is the great giver – and we're just at the beginning of what it can give." The 20th anniversary of the CFI has provided us with an opportunity to look back at what we've built and to reflect on the resonance of that work with Canadians. When you consider where we started, it's impossible not to feel a great sense of accomplishment for how far our research community has come. But what is truly breathtaking is where we can go from here.

When you consider where we started, it's impossible not to feel a great sense of accomplishment for how far our research community has come. But what is truly breathtaking is where we can go from here.

RESEARCH BUILDS OUR COMMUNITIES

Featuring stories of how research enabled by CFI funding is touching Canadians and their communities.

CHRISTINNE MUSCHI

Jacqueline Mboko looks over the Thames River in London, Ont. She came to Canada from the Democratic Republic of the Congo with her family when she was 13 years old and now works as an interpreter for other Swahili- and French-speaking newcomers. Pathways to Prosperity, a research partnership led by nearby Western University, looks at ways of providing services to immigrant families like Mboko's that will help them more easily settle into their new home.

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RYERSON UNIVERSITY

Where research meets innovation and entrepreneurship

Dr. Ali Mazalek, Canada Research Chair in Digital Media and Innovation, is pictured at Ryerson University's Responsive Ecologies Lab. She uses a reconfigurable space that includes interactive tables and a large multi-touch wall that make it easier to explore and understand complex systems. WILL PEMULIS

Laboratory meets playhouse at Ryerson University's Responsive Ecologies Lab – a research centre investigating technological, cultural and social factors surrounding the emergent Internet of Things and housing physical fabrication tools such as 3D printers, a reconfigurable multi-touch wall and a host of electronic technologies for building interactive sensor-based systems.

This mix of technologies isn't the only thing that's diverse at the 20-month-old lab, referred to commonly as RE/Lab. The researchers who come to work here hail from a wide range of academic disciplines – from biomedical and computer engineering to business management and professional communication.

Even RE/Lab's co-founder and director, Jason Nolan, works in a discipline not typically associated with technological innovation – he is an associate professor at Ryerson's School of Early Childhood Studies. His research at RE/Lab focuses on applying technology to early childhood education and children with special needs through adaptive design.

"We work with faculty, students and postdoctoral fellows from different disciplines," says Ali Mazalek, Canada Research Chair in Digital Media and Innovation at Ryerson and co-founder and principal investigator of the RE/Lab. "Our integrated approach means that when everything is in one space, the various parts of complex technologies are not designed in isolation but rather all feed into each other."

The concept of the innovation hub isn't new to Ryerson. The school is already well known for the DMZ, one of the country's largest technology business incubators. Since its launch in 2010, the DMZ has incubated more than 260 startups, which have raised a total of $206-million in seed funding and created more than 2,400 jobs.

The DMZ, which is also open to entrepreneurs outside of Ryerson, is one of many innovation hubs or zones at the university. Each of these hubs feeds into a larger innovation ecosystem at Ryerson, says Dr. Mazalek, and all stand to benefit from each other's work and in turn help to support Canada's innovation ecosystem.

"As soon as something is emerging at our lab and ready to move to the real world, it can be moved to one of our innovation zones, and in turn if a startup in a zone is developing something they'll often partner with researchers at the lab to test or improve the technology," says Dr. Mazalek, who is also an associate professor at Ryerson's RTA School of Media. "There's a cycle back and forth with what happens on the research side and on the entrepreneurship side, so it's a nice loop."

Ryerson's innovation system extends well beyond the university and includes partnerships with business, community organizations and all levels of government. For instance, iBEST is a biomedical research and innovation partnership between Ryerson and St. Michael's Hospital that brings together the university's engineering and science researchers with biomedical researchers and clinicians at the hospital, located just a few blocks from the school. Ryerson also recently expanded part of its science faculty to the MaRS Discovery District, joining educators, researchers, social scientists, entrepreneurs and business experts under one roof.

Usha George, interim vice-president, research and innovation at Ryerson, says innovation has always been part of the school's DNA. But while this aspect of the university has grown organically over the years, today Ryerson is taking a more deliberate and strategic approach to innovation.

"Right now, we are making it more intentional and focused. We are becoming an innovation university for the 21st century," says Dr. George. "So what does this mean? It means that we are expanding our approach and definition of the university's innovation ecosystem to build on what we have today, and adapt in anticipation of tomorrow's needs."

With the goal of meeting societal needs, Ryerson's innovation ecosystem currently falls into three key areas: faculty-led research and invention, incubation of ideas, processes and products, and conscious effort to develop talent that can make an impact on society.

"Whether they're studying fashion design or chemical engineering, we want students to have an innovative and entrepreneurial experience," she says. "This is where interdisciplinary collaboration and our innovation hubs really play an important role. At Ryerson, we are defining and describing innovation in a way that includes all of us."

DID YOU KNOW?

SINCE IT BEGAN IN
1997
THE CANADA FOUNDATION FOR INNOVATION HAS FUNDED
9,415
PROJECTS AT
147
INSTITUTIONS, AND HAS AWARDED OVER
$6-billion
TO SUPPORT WORLD-CLASS RESEARCH

RESEARCH AND INNOVATION

DALHOUSIE UNIVERSITY

Diving into the evidence of a rapidly changing ocean

Humans may be creatures of the land – but we are increasingly dependent on the ocean. Oceans determine much of our weather and climate and are super-highways for trade. They have absorbed almost half of the carbon dioxide released since the Industrial Revolution, buffering the effects of climate change. More than half of Earth's oxygen production is due to oceanic phytoplankton. And as our population grows, pressure on the ocean's already depleted fish stocks will rise and aquaculture will continue its rapid expansion.

Yet we know alarmingly little about how oceans work, and even less about how climate change, coastal habitat destruction and pollution are changing this watery world.

Enter the Ocean Frontier Institute, a new partnership bringing together Dalhousie University, Memorial University and the University of Prince Edward Island, along with eight international research institutions and federal and industry researchers. The Dalhousie-led institute was launched in September with $94-million from the Canada First Research Excellence Fund, an initiative of the Social Sciences and Humanities Research Council, the Natural Sciences and Engineering Research Council (NSERC) and the Canadian Institutes of Health Research.

The institute's mandate, says Dalhousie vice-president of research Martha Crago, is to answer a deceptively simple question: How do we achieve sustainable use of a rapidly changing ocean?

"We will have two basic areas of focus – atmosphere-ocean interactions and shifting ecosystems," says Dr. Crago. "And we will look at solutions in sustainable fisheries and sustainable aquaculture, in marine safety, and in data and technology so we can make predictions about change."

The Ocean Frontier Institute will focus on the Northwest Atlantic and the adjacent Canadian Arctic Gateway, which includes the Labrador Sea and the eastern section of the straits of the Canadian Arctic Archipelago. This is because the region has an extremely productive ecosystem and may become home to southern marine species exploiting new opportunities in warming waters to the north. It is also a significant sink for carbon dioxide and affects Earth's climate through the Atlantic Meridional Overturning Circulation – a northward flow of warm, salty water in the upper layers of the Atlantic, and a southward flow of colder water in the deep Atlantic.

"The Northwest Atlantic is a sentinel ocean," says Dr. Crago. "What's happening there will be predictive of what will happen in other parts of the global ocean."

Some of that predictive work will come from Dalhousie's Ocean Tracking Network (OTN), funded primarily by the Canada Foundation for Innovation as well as NSERC, and which will support many of the Ocean Frontier Institute's programs. OTN's researchers track tagged marine animals such as sharks, sturgeon, eels and tuna, as well as other marine species including squid, sea turtles and marine mammals, in relation to changing ocean conditions. Their work is revealing where and when these animals migrate, feed and reproduce, allowing the fishing industry to avoid areas crucial to development and growth.

Technology like the SeaCycler, a new oceanographic mooring system with a large suite of sensors capable of collecting measurements near the surface, can help Dalhousie University researchers gain a better understanding of issues such as atmospheric gas exchange. SUPPLIED

Dalhousie biologist Sara Iverson is the OTN's scientific director. She says one current project will be especially important to the Ocean Frontier Institute's goal of sustainably managing a fast-changing ocean: gaining a deeper understanding of the apparent recovery of northern cod off the coast of Newfoundland.

"It's exciting, but we cannot just go out and start fishing again, otherwise we risk collapsing the population forever," says Dr. Iverson. "We are poised to look at the shifting ecosystems in the Northwest Atlantic, to look at how species may be moving with climate change, where their spawning grounds are and how to inform a plan for emerging and sustainable fisheries."

CANADIAN LIGHT SOURCE

Soil management research improving the livelihoods of West African farmers

Farmers in sub-Saharan Africa face high fertilizer costs, unstable rainfall patterns and poor soil quality. At the moment, crop production is growing by about one per cent per year while the local population is increasing by about three per cent. But University of Saskatchewan professor of environmental soil chemistry Derek Peak and an international research team are working to help bridge that perilous gap.

"Our research, funded by the International Development Research Centre's Canadian International Food Security Research Fund (CIFSRF), investigates using fertilizer microdosing," explains Dr. Peak. Microdosing, placing small amounts of fertilizer into the soil beside plants after they emerge, is proven to yield large improvements from small inputs.

However, the outsized benefits raised concerns that the process could accelerate land degradation. Through their research, Dr. Peak and his team were able to determine that microdosing had no more of an impact than other fertilization methods, encouraging news for farmers who can't afford traditional fertilizer costs.

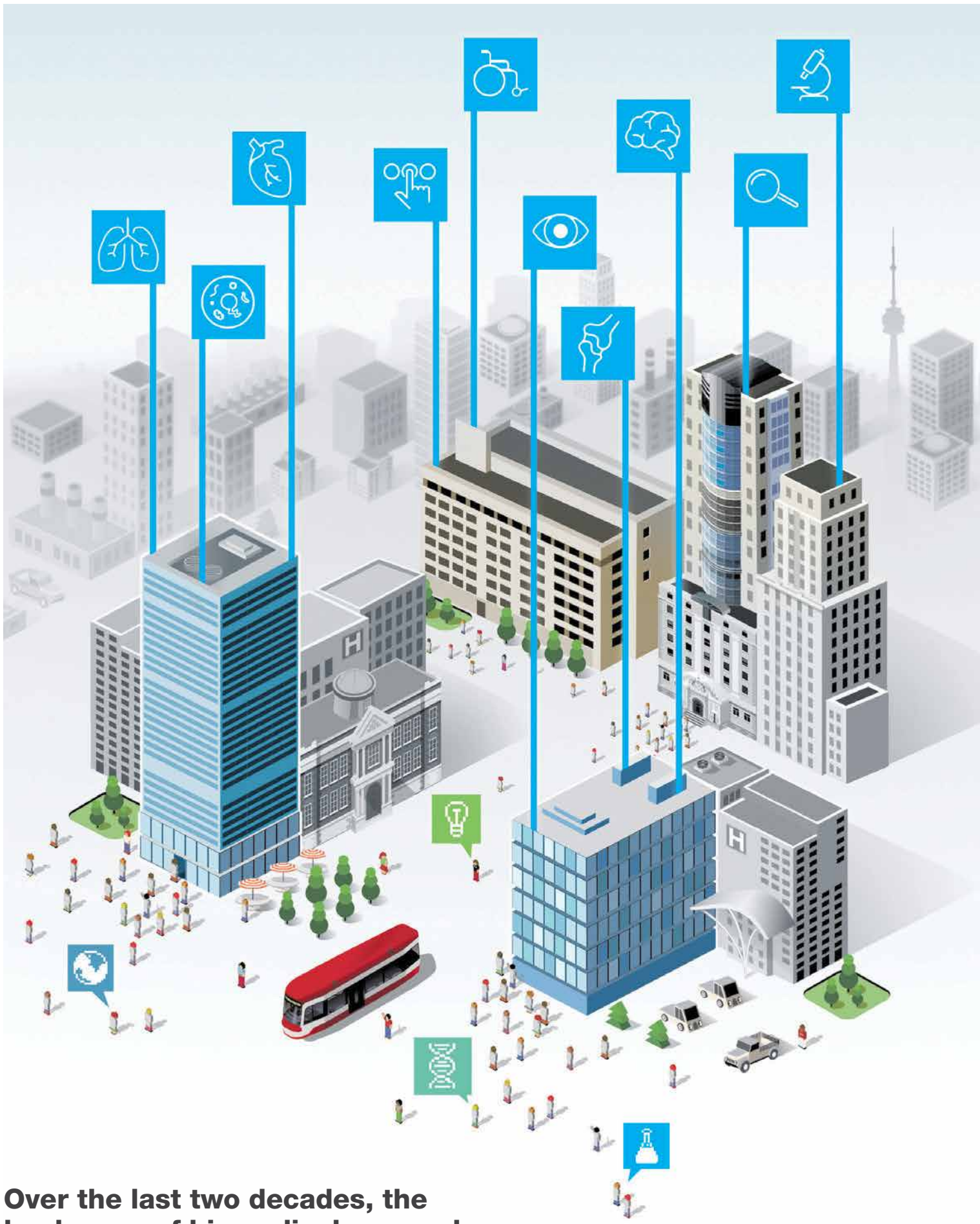
"We can now scale it up to an increasing number of farmers. Currently, we are applying this technique in Nigeria and Benin, and see a $4 to $5 return for every $1 of fertilizer. This is an enormous value proposition that will increase both farmers' profits and fertilizer demand in the region, which may drive improvement of other infrastructure," says Dr. Peak.

> "Currently, we are applying this technique in Nigeria and Benin, and see a $4 to $5 return for every $1 of fertilizer. This is an enormous value proposition that will increase both farmers' profits and fertilizer demand in the region."
>
> **Dr. Derek Peak**
> is a professor of environmental soil chemistry at the University of Saskatchewan

The 1,000th peer-reviewed paper coming from data collected at the Canadian Light Source Synchrotron was published by University of Saskatchewan researchers Courtney Phillips (right) and Dr. Derek Peak (centre), along with the CLS Spherical Grating Monochromator (SGM) beamline scientist Dr. Tom Regier. SUPPLIED

This research wouldn't have been possible without the Spherical Grating Monochromator (SGM) beamline at the Canadian Light Source (CLS), a unique facility funded in part by the federal government through the Canada Foundation for Innovation. "For this project, the CLS staff were research partners in the truest sense," says Dr. Peak. "There was a lot of instrument development and software analysis required that we developed with the SGM beamline staff, particularly Dr. Tom Regier. I believe the SGM is still the only place in the world where we can make these measurements."

This confluence of research infrastructure and CIFSRF's unique research and development funding mandate made it possible to partner with research institutes and universities in West Africa to improve the livelihoods and household incomes of smallholder farmers, especially women farmers, says Dr. Peak.



Over the last two decades, the landscape of biomedical research across Canada has evolved dramatically.

This is perfectly exemplified in the evolution and impressive growth of our research community in downtown Toronto.

The Canada Foundation for Innovation is an important partner in driving this growth—with $283,833,122† of its support, we have leveraged another $328,722,864† with the help of our foundations, generous donors, private sector partners and the Province of Ontario.

The result is the creation of Canada's largest research hospital, expanded with two new research towers and packed with state-of-the-art expertise and infrastructure to support a broad spectrum of leading-edge research—from basic discovery to clinical translation. Our incredible growth, combined with that of the adjacent world-renowned University of Toronto and its affiliated hospitals, has transformed the area into one of the most research-intensive geographical corridors in the world, positioning Canada as a global leader in innovation in medicine.

Thank you 283,833,122 times.

UHN
Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
COURAGE LIVES HERE

†Funding awarded through Canada Foundation for Innovation programs, the Ontario Ministry of Research & Innovation Ontario Research Fund, and partner contributions from generous philanthropic donations, foundations and private sector partners. Figures accurate as of October 2016.

RESEARCH AND INNOVATION

UNIVERSITY OF WATERLOO

Keys to survival: advancing food and water security

There is an intrinsic link between water and food security – and both have been identified as pressing global concerns by the United Nations. Research is widely recognized as an important vehicle for finding solutions, and involving community partners – whether they are local, regional or global – can increase the potential for translating scientific findings into tangible outcomes, according to University of Waterloo researchers Philippe Van Cappellen and Heidi Swanson.

Dr. Swanson's expertise is in contaminant accumulation in aquatic food webs – a key issue for Canada's northern communities, where indigenous people have expressed concerns about the impact of climate change and resource development on the safety and security of their traditional food sources. Fish in Arctic lakes, for example, have been found to contain levels of contaminants, such as mercury, that can make them unsuitable for consumption.

Yet when Dr. Swanson travels to remote northern communities, her focus is not only on fish. "My role is doing chemical analyses – and I come from a hard science background – but the places where I work are on people's traditional homelands, so I see integrating a social and human dimension into my research as an ethical responsibility," she says. "The North is a very different environment, and cultural differences require us to build trust and understanding of each others' perspectives."

The fact that Dr. Swanson is usually invited by community representatives, prepares the ground for a highly collaborative approach, she says. Her work with the Kluane First Nation in the Yukon, for example, was based on a "two-way knowledge exchange" that included researcher visits to harvest camps, community feasts and meetings, and youth visits to the university.

Hosting community representatives – including indigenous youth – at the university campus was a personal highlight for Dr. Swanson. "Before the visit, the youth had worked with elders to decide where to fish. They had gone out on the boat with us to collect and process fish samples, and helped to generate the numbers for the age and mercury levels of the fish," she explains. "After spending time at the university with us, they really understood the research results and were able to present them to their own community after their return."

> "The North is a very different environment, and cultural differences require us to build trust and understanding of each others' perspectives."
>
> **Dr. Heidi Swanson**
> is a University of Waterloo researcher

Remarkably, the students were able to report low concentrations of contaminants in the Kluane Lake fish, she says. "They are healthier to eat than those in the other areas we've studied in the North."

But even in cases where her findings aren't so positive, she feels the research can help to "empower communities to make their own choices as to which are the healthiest sources of food and which actions to take."

Canada Excellence Research Chair Philippe Van Cappellen also sees the science-policy interface as a priority. "As humans, we're modifying the water cycle at an unprecedented scale. One example of this is the systematic damming of rivers and streams," he says. "While dams provide many services, from energy generation to flood control, they also have far-reaching consequences for water quality, freshwater biodiversity and the climate system."

By 2030, 90 per cent of all rivers and streams on Earth will be fragmented by dams, says Dr. Van Cappellen, who leads an interdisciplinary research team focusing on the processes – both natural and human-driven – that control water quality along the hydrological cycle.

"Dams create new habitats along rivers, they change water chemistry and they physically hold back sediments and nutrients from reaching coastal areas," says Dr. Van Cappellen, who looks at water as part of socio-ecological systems. "Large-scale retention of sediment by dams can cause river deltas to sink and limit the biological productivity of coastal ecosystems. Combined with rising sea levels, this creates enormous challenges for the very large populations living in, for example, the Mekong or the Ganges-Brahmaputra deltas."

At the same time, it's hard to ignore the benefits of dams. "In many parts of the world, dams are an important source of flood control, like the low-lying areas along the Yangtze River. Dams currently provide one of the most clean, affordable and reliable forms of electricity generation. We also see a surprising amount of adaptability of river ecology upstream of dams, with entirely new ecosystems evolving in the reservoirs."

Because of the global and often trans-boundary nature of the research and issues, Dr. Van Cappellen works closely with partners worldwide, including in Southeast Asia and Europe. "Ultimately, we want to produce the best possible science that is required to help communities and governments make informed decisions that minimize the trade-offs between the obvious benefits of dams and their environmental impacts at local, regional and global scales."

University of Waterloo researchers Dr. Philippe Van Cappellen and Dr. Heidi Swanson believe engaging communities in research efforts can lead to positive solutions, such as those emerging from Dr. Swanson's work with the Kluane First Nation in the Yukon. LEFT, MARTIN SCHWALBE; RIGHT (2), SUPPLIED

UNIVERSITY OF WINDSOR

DNA sequencing enables water monitoring of recreational beaches

Beach closures are common on hot summer days in the Windsor area, with water contamination levels keeping people out of Essex County's recreational waters on a regular basis. For Daniel Heath and Doug Haffner of the University of Windsor's Great Lakes Institute for Environmental Research (GLIER), more precise science could tell a different story.

They're among a team of researchers at the university who are using next-generation DNA sequencing to identify the presence and understand the source of pathogens in the water. The research could identify environmental factors that contribute to bacterial and algal outbreaks, as well as change how such testing is done in the future.

"It's such an obvious application of DNA technology," says Dr. Heath, a professor of conservation genetics who is executive director of GLIER. "We can more broadly screen for potential human health stressors in the water and do it faster," adds Dr. Haffner, Canada Research Chair in Great Lakes Research (Environmental Health) and a professor of aquatic ecology of large lakes.

Their research is being done in collaboration with regional, provincial and federal governments as well as private organizations, and earlier this year was given a more than $500,000 grant from the Natural Sciences and Engineering Research Council of Canada. Dr. Heath says it has significant implications for communities on the water looking for better testing methodologies to determine the health of their swimming and drinking water.

Together with research partners and with the help of volunteers (left), Dr. Daniel Heath (right) is using next-generation DNA sequencing to determine when beach-goers can safely enjoy water activities. SUPPLIED

> "We can more broadly screen for potential human health stressors in the water and do it faster."
>
> **Dr. Doug Haffner**
> is Canada Research Chair in Great Lakes Research

More accurate DNA testing "gives us a wide sweep of potential health hazards," Dr. Heath says, including additional bacteria types such as streptococcus, as well as algal blooms and other potentially harmful microbes. It can identify the danger level to human health that dictates beach closings. "We won't be guessing."

The team will compare DNA sequencing with current coliform testing, which identifies E. coli, a group of bacteria found in human waste. One problem is that E. coli itself isn't necessarily unsafe, although its presence can indicate the presence of human waste containing other pathogens.

The first round of data analysis from this past summer's water sampling should be available to the partners in a month. "There's a lot of interest in our results," he says, especially with extreme weather events brought about by climate change that can wash more contaminants into the water.

Dr. Haffner says the DNA sequencing will show if pathogens come from urban or agricultural sources or exist within the lake, for example in bird droppings. "If we identify the source of the contaminants, there can be proper targeted remediation."

Next-generation DNA sequencing can be expensive, he points out, but costs have fallen and it can detect myriad microbes in the water in as little as eight hours. This compares with doing scores of individual sample cultures, which add up and can take two days for results to be available.

He thinks more precise testing could show the region's beaches end up closed when they might safely remain open. It will also help find ways to reduce harmful microbes in the future, he adds. "This could keep the beaches open."

Dr. Dawn Keim (left), Global Water Futures program director Dr. Howard Wheater and Dr. Jay Sagin examine water from the South Saskatchewan River. SUPPLIED

UNIVERSITY OF SASKATCHEWAN

Research network tackling global water threats

Canada is seen as a land of great lakes and mighty rivers, but rapid rates of global warming and increasing human impacts on land and water are putting the country – and other cold regions of the world – at unprecedented risk for floods, droughts and other serious water security challenges.

That's why the University of Saskatchewan's $143-million Global Water Futures (GWF) project is so critical for Canada and beyond.

Awarded $77.8-million from the Canada First Research Excellence Fund (CFREF), GWF aims to transform the way communities, governments and industries in Canada and other cold regions of the world prepare for and manage increasing water-related threats in the face of climate change.

Led by the U of S Global Institute for Water Security and three key university partners – Waterloo, McMaster and Wilfrid Laurier – GWF is one of the largest research collaborations in the world, with 380 researchers in Canada alone and numerous industrial, academic and government partner organizations around the globe.

"No institution nationally or internationally has assembled such a large-scale and multidisciplinary water research initiative of this kind," says Howard Wheater, Canada Excellence Research Chair in Water Security and GWF program director.

The need for GWF is underscored by the increasing incidence of natural disasters related to water and climate such as the southern Ontario drought this summer, the Fort McMurray fires in May and both the Alberta and Toronto floods of 2013, to name a few.

"The costs of these disasters are extraordinarily high and could be reduced by improved forecasting, community planning and water management," says John Pomeroy, Canada Research Chair in Water Resources and Climate Change, and GWF associate program director.

He notes that half the world's water comes from cold regions. Yet as the climate warms, Canada's glaciers, frozen ground and snowpacks are diminishing, resulting in earlier and often smaller streamflows. "We simply have not properly looked after water, our most precious natural asset," Dr. Pomeroy says.

Water quality is also a serious issue in some areas. "The drinking water problems of many rural areas and especially First Nations communities are unacceptable," he adds.

GWF will provide new scientific information, prediction tools and community-based solutions to ensure water security. Specifically, GWF will dramatically improve understanding of water, weather, climate, aquatic ecosystems and how humans can sustain healthy water environments.

"We will use this world-leading science and unprecedented water data to develop new computer models to forecast flooding, droughts, water supply and water quality, and better manage water," says Dr. Pomeroy.

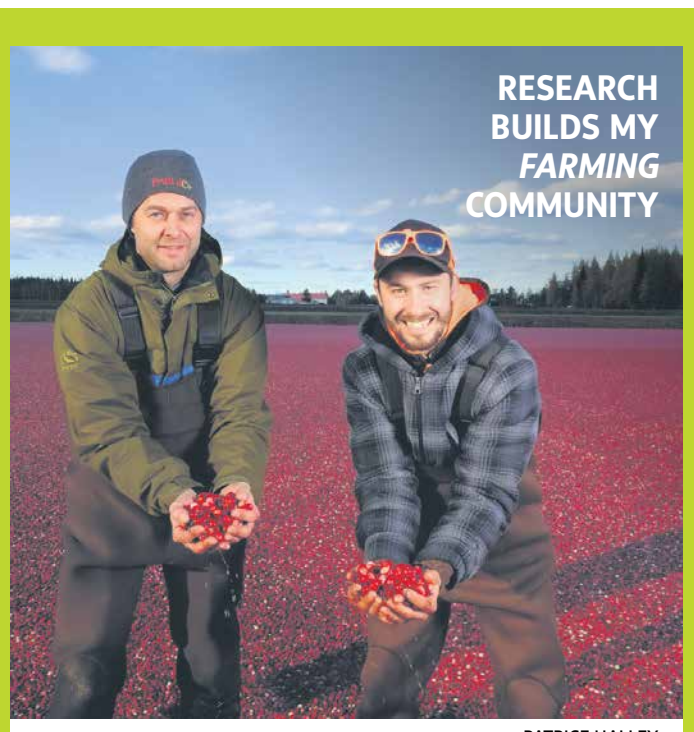
In particular, GWF will help initiate Canada's first national water disaster warning system through the creation of new forecasting tools and water-measurement technology.

"We will help make Canada a nation that has the capacity to sustainably manage its water, reduce its exposure to natural disasters and sustain a remarkably high quality of life, economic activity and ecosystem conservation," he says.

The program will also train hundreds of students, scientists and engineers in addressing water-related threats.

"Water security is one of the most pressing issues around the world," says Holly Annand, a U of S doctoral student studying the impact of changing climate and agricultural practices on prairie hydrology. "I see this project as a necessary step towards engaging people from multiple sectors to do their very best to preserve and protect water resources for the future – and not just for their own individual or immediate needs."

Ultimately, GWF will promote development of a national water policy "so that Canada better governs itself as a healthy water nation," says Dr. Pomeroy. "With GWF, Canada becomes a water solutions country that others will look to as an example of how to do it right and a source of answers for difficult water challenges."



PATRICE HALLEY

Crop scientist Simon Bonin and cranberry farmer Olivier Pilotte stand knee-deep in a flooded field in the rural municipality of Lourdes on the south shore of the St. Lawrence near Quebec City. It's the heartland of a cranberry-growing district that has expanded spectacularly in the last 15 years with research carried out at the Université Laval and the establishment of the Fruit d'Or processing company at Notre-Dame-de-Lourdes.

HISTORY HIGHLIGHTS

The Canada Foundation for Innovation's success is based on giving researchers the tools they need to think big and conduct world-class research.

1997
A bold vision

The CFI is established with a five-year mandate, $800-million and grand plans to reshape Canada's research landscape.

1999
Bringing scientists back

The CFI's first report on results points out the beginning of a brain drain reversal thanks to the attractive research facilities now available in Canada.

2001
A funding milestone

By March 2001, the CFI has invested $873-million in almost 1,200 projects.

2002
Online storytelling

The CFI launches an online magazine, Innovation Canada, in keeping with the times and to keep readers up to date with Canadian research.

2004
Tackling big health issues

The CFI launches a fund to support large-scale research hospital projects and to help conduct world-class health research.

2013
Cars of the future

Lighter, faster, safer cars are no longer a dream for the future thanks to a funding boost through Automotive Partnership Canada.

2015
Recognizing innovation

The CFI becomes a founding partner of the Governor General's Innovation Awards and responsible for managing the adjudication process.

2016
Gearing up for 20 years

Celebrations for the CFI's 20th anniversary begin with a fresh new website full of stories of how research builds communities across Canada.

RESEARCH AND INNOVATION

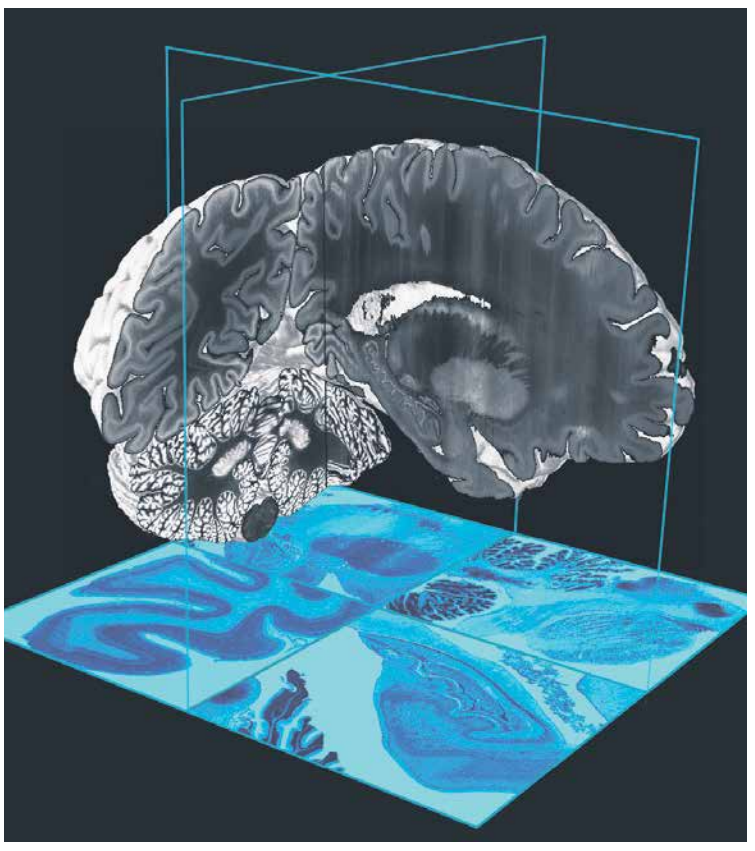
McGILL UNIVERSITY

Super computers are speeding up brain research

It takes more than scientific rigour and intellectual prowess to study the human brain at its deepest levels. These days, the pursuit of neuroscience also calls for computing power – a lot of it, way beyond what ordinary desk- and laptops can deliver.

"We're now at a point where neuroscience and information science have come together, with significant impact on how studies on the brain are conducted," says Alan Evans, professor of neurology, psychiatry and biomedical engineering at McGill University. "The problem is that you have these big supercomputers but most researchers cannot get at them.

> "The objective is to accelerate research and to facilitate the development of drugs. We're no longer in the days of Banting and Best where you work very hard on small-scale experiments that lead incrementally to discovery."
>
> **Dr. Guy Rouleau**
> is director of the Montreal Neurological Institute and Hospital



CBRAIN provides a way to combine data from DNA tests, brain imaging and other sources. An example of a resource that is available to the public is BigBrain, for which researchers stained sections of a preserved brain to detect cell bodies. After this step, the individual sections – numbering over 7,400 – were digitized to create a high-resolution 3D reference.
IMAGE COURTESY OF AMUNTS, ZILLES, EVANS ET AL.

In fact most really don't know how to approach the beast."

Today, thanks to a McGill-led project called CBRAIN, researchers can perform analyses on large datasets by connecting to high-performance computing facilities across Canada and in other countries. This open-source software platform, which is overlaid by an easy-to-use interface, provides access to neuroimaging and genetic analysis tools as well as 2D and 3D visualization of brain data.

For scientists trying to understand, and find a cure for, complex neurological diseases such as Alzheimer's, CBRAIN provides a way to combine huge amounts of data from DNA tests, brain imaging and other sources, and to collaborate with other researchers in the country and around the world.

"It is the default IT platform for neuroscience in the country," says Dr. Evans, a principal investigator in the McConnell Brain Imaging Centre at McGill University's Montreal Neurological Institute and Hospital. "There are very few equivalents in the world at this point."

CBRAIN is an important part of McGill University's Healthy Brains for Healthy Lives initiative, which brings together 270 scientists and clinicians, 350 graduate students and 255 post-doctoral fellows to study the brain. Dr. Evans says the initiative focuses on three key areas: brain development and development disorders, neurodegenerative diseases such as dementia and Alzheimer's, and normal brain cognition and plasticity.

In addition to CBRAIN, another thing that makes Healthy Brains for Healthy Lives unique is its adoption of open-science principles that share all research data with the world.

Guy Rouleau, director of the Montreal Neurological Institute and Hospital, says sharing resources can accelerate science by reducing or eliminating the duplication of work. This is why earlier this year the institute embraced an open-science approach that makes all of its published research results and data freely available.

"We also have an institutional biobank that contains both bio specimens and clinical data, and we are making all of that available as well," says Dr. Rouleau. "We are doing this within the constraints of ethics and patients will be asked for their approval before we share any information."

Dr. Rouleau says the institute will also not file for patents or licences – or anything that puts intellectual property restrictions – on any of its discoveries.

"The objective is to accelerate research and to facilitate the development of drugs," he says. "We're no longer in the days of Banting and Best where you work very hard on small-scale experiments that lead incrementally to discovery. Today, I'll send DNA samples to a lab and get back terabytes of data, some of which are of interest to me, and the rest, which are not, will end up buried in my lab.

"But if I make this data freely available, there are lots of smart people out there who can look at it and learn more things, far beyond what I'm looking at in my own research."

CHRISTINNE MUSCHI

Ewald Cheung, a graduate student of music at McGill University, started playing violin when he was four years old. A research partnership between McGill and Université de Montréal is developing new technologies for live performances – including in virtual environments – and studying how performers coordinate their actions in large ensembles and how listeners perceive the sounds of different instruments in orchestral works.

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UNIVERSITY HEALTH NETWORK

Two towers over two decades: the evolution of Toronto's biomedical research landscape

Over the last two decades, Canada's leadership in many aspects of biomedical research has progressed significantly, and the evolution is exemplified by the impressive growth of the University Health Network (UHN) research community in downtown Toronto.

Since its creation in 1997, UHN has worked in partnership with the Canada Foundation for Innovation (CFI), the Ontario government, and its foundations and donors to advance its medical research strengths. The organization has been ranked number one among Canada's top 40 research hospitals for several years. Additionally, many of its scientists are internationally recognized for advances across a spectrum of diseases and disciplines, including immunology, cancer, rehab medicine, cardiac science and brain research.

Two major milestones in UHN's growth include the design, construction and launch of two research towers that are equipped with the latest high-end laboratory facilities and research equipment.

In 2005, UHN opened the Princess Margaret Cancer Research Tower (PMCRT), a $400-million, 15-storey structure located in the heart of the Toronto Discovery District. PMCRT houses the Princess Margaret Cancer Centre over 10 research floors, one of the top-five cancer research centres in the world. The PMCRT also hosts the McEwen Centre for Regenerative Medicine and programs from the Toronto General Research Institute and Techna.

The Krembil Discovery Tower was launched in 2013. This $165-million, nine-storey extension of the Toronto Western Hospital is populated by research teams investigating new diagnostic tools and treatments in many of the major disease areas affecting the aging population, including stroke, dementia, arthritis and vision. Krembil researchers have many joint programs with UHN's fifth research institute, Toronto Rehabilitation Institute, which has also benefited from significant CFI funding.

The University Health Network's leading-edge research infrastructure enables world-class research, helps to attract and retain top talent, and enhances discovery and innovation. SUPPLIED

Together, the two towers have added over 550,000 square feet of state-of-the-art dedicated research space to UHN – equivalent to more than six-and-a-half FIFA-regulation soccer fields.

"When we sought funds to support these projects, we recognized that if we wanted to retain and recruit world-class scientists, we had to offer world-class facilities," says Robert Bell, who was CEO and president of UHN from 2005 to 2014, and is currently Ontario's deputy minister of health and long-term care.

For example, he points to the value of the more than $40-million in CFI grants for infrastructure and specialized equipment in the Krembil Discovery Tower.

"Those investments set us up to conduct modern neuroscience research and allowed us to attract top scientists with incredible visions of opportunity," Dr. Bell says. "Crucially, the researchers we have brought in to both towers are translational scientists – who want to work in centres attached to hospitals and see their discoveries translated into new treatments and improved patient care."

"Of the 130 scientists working in the two research towers, 68 of them were not at UHN before the towers were built," says Christopher Paige, who was UHN's executive vice-president of science and research from 1997 until earlier this year. He continues as a senior scientist in cancer research at UHN.

"These facilities have enabled us to attract superb scientists at the top of their fields, such as Don Weaver, who is making novel compounds for treatment of Alzheimer's disease, and Valerie Wallace, who is pushing the envelope on regenerative medicine for diseases of the retina," says Dr. Paige.

The leading-edge research infrastructure has also enabled UHN to retain its top scientists in the face of growing global competition for the "best and the brightest," he adds.

Among the state-of-the-art technology that has supported research advances is that of the STTARR Innovation Centre (cellular and preclinical imaging) and the Advanced Optical Microscopy Facility – the largest of its kind in Canada.

The PMCRT and Krembil Discovery Tower were also built using innovative approaches to lab benching, which promote flexibility and teamwork.

"Research changes over time, and our design allows us to take space configured for one kind of research and convert it easily to another kind," says Dr. Paige.

"We also have an open lab concept, instead of traditional enclosed lab spaces with small groups of people working in silos. When you have 30 or more scientists working in a space without walls, they can interact with each other more and that further enhances discovery and innovation."

YORK UNIVERSITY

Creating a community of research excellence

Ellen Bialystok is a superstar. The York University researcher studies the effects of experience on cognitive function and brain organization across the lifespan, with particular emphasis on bilingualism. Her findings point to a lifelong "bilingual advantage," which could offset or delay symptoms of age-related brain deterioration, such as dementia and Alzheimer's disease.

Dr. Bialystok's work has received wide attention from both within and beyond the research community, and this year, she was named an Officer of the Order of Canada.

At York, she holds the Walter Gordon York Research Chair of Lifespan Cognitive Development, an appointment conferred through the York Research Chairs program. These chairs, created exclusively for York University faculty members, acknowledge research excellence within the university community, says Mark Roseman, director of Strategic and Institutional Research Initiatives at York University.

Dr. Ellen Bialystok is part of the York Research Chairs program that acknowledges research excellence within the university community. SUPPLIED

York's vice-president, Research & Innovation Dr. Robert Hache adds "York's researchers are among some of the world's leading scholars and experts. We are proud to have established the York Research Chairs program, an initiative that will help to further build, support and intensify world-renowned research taking place at the university."

The program is modelled on the Canada Research Chairs (CRC) program, explains Dr. Roseman, and York recipients are on the same level as CRC chairholders. "We expect them to meet the same standards of excellence," he says. "And we have the same rigorous selection and peer review process. We also provide a comparable level of support and recognition."

The calibre of research conducted by chairholders like Dr. Bialystok and Nantel Bergeron, whose work furthers the understanding of complex algorithms in computer science and mathematics and provides insights into the super-symmetry of nature, speaks for itself. And receiving this high level of recognition from within the university raises the profile of the researchers. It can also help to attract talent and funding, says Dr. Roseman.

Yet the honour also comes with expectations. "We encourage our chairholders to undertake leadership activities to further accelerate their discipline," he explains. "They are expected to nurture up-and-coming researchers, for example, or lead collaborative efforts within their field."

In addition to celebrating research excellence, the program brings together experts from various faculties and disciplines – creating a "powerful multidisciplinary community of accomplished researchers," says Dr. Roseman. "They are all superstars.

RESEARCH AND INNOVATION

OPINION

Fostering a culture of innovation

By His Excellency the Right Honourable David Johnston, Governor General of Canada

The inaugural Governor General's Innovation Awards went to (clockwise from top right): Jeff Dahn, Kinova's Charles Deguire, Mark Torchia and Richard Tyc, Breanne Everett, Christi Belcourt and Robert Burrell. LEFT, TRUDIE LEE; TOP RIGHT, NICK PEARCE, DALHOUSIE UNIVERSITY; ALL OTHERS SUPPLIED

One of the true privileges of serving as governor general comes in having the chance to celebrate great Canadian successes in ceremonies at Rideau Hall and across the country. We do this to shine a light on remarkable achievements and individuals that make Canada and our world better places, and we do it to encourage others to attempt the same. This is especially important when it comes to innovation, a term that is often misunderstood despite its position at the heart of all human progress.

It's important to define what we mean by innovation. It's not invention. Innovation, rather, is an economic and social process, a means by which productivity is improved and better ways of organizing and operating are achieved as a society. It's about developing new ways of doing things and creating value – value that will stimulate positive social change, economic growth and higher standards of living for all. And that last point is critical, because recent history has shown us that in today's world, the only lasting progress is shared progress from which all people benefit.

The importance of innovation in today's rapidly changing, thoroughly interconnected world simply can't be overstated. If change is the new constant, innovation is the new imperative. In order to continue the work of building a Canada that maximizes both equality of opportunity and excellence in the global arena, we must sharpen our focus on innovation in our workplaces, our schools, our politics and our institutions. The spirit of creativity and problem-solving must permeate our entire society. That means creating a culture of appreciation and celebration for our leading innovators. Some of the world's best live among us, yet we don't highlight them or share their stories enough. We should do so widely and boldly.

It's important to define what we mean by innovation. It's not invention. Innovation, rather, is an economic and social process, a means by which productivity is improved and better ways of organizing and operating are achieved as a society.

This is one of the reasons why we presented the inaugural Governor General's Innovation Awards earlier this year at Rideau Hall. The awards went to six deserving recipients who come from cities and towns across Canada. They work in disparate fields but are united in their focus on improving lives and creating value. By honouring them and telling their stories, we aim to cultivate that culture of innovation and to nurture it. What we're trying to do is create a Canadian mindset that sees innovation as part of what makes us who we are. By recounting great innovation stories, we help people see what it means to innovate, how it can help us, and to say, "I can do that, too."

Speaking of celebration, let me add my thoughts on the 20th anniversary of the Canada Foundation for Innovation. It's a milestone worth celebrating. Over the past two decades, this organization has supported thousands of researchers in their important work. It has helped to tell their innovation stories and to build the case for creativity and ingenuity in Canada. It has been at the forefront in creating opportunities for Canadians, and it is leading us into 2017, the 150th anniversary of this great country, with a keen focus on this important challenge. May it continue to do so for many years to come, and may we make 2017 the year in which innovation emerges as central to what it means to be Canadian.

We have so much to celebrate when it comes to innovation in Canada. Let's share our successes widely and remind all Canadians that to innovate is to unlock the promise of a better future.

UNIVERSITÉ DE MONTRÉAL

Cancer research findings move from lab into clinics

Since cancer is the leading cause of mortality in Canada, and responsible for 30 per cent of all deaths, it is more than a distant threat for many Canadians who have faced its wrath directly or through a friend or family member.

That makes the work at the Institute for Research in Immunology and Cancer (IRIC) at Université de Montréal, the only facility taking anticancer drug development from start to finish, all the more critical. "We have assembled all the elements for early drug discovery," says Michel Bouvier, CEO of IRIC. "From target identification all the way to generating the chemistry and having early clinical trials – it's all integrated. There's no other place in Canada that has done that."

These capabilities enable IRIC to cultivate targeted therapies. "A lot of the therapies being used are very general," explains Dr. Bouvier. "They kill cancer cells, but they also kill normal cells with quite devastating side effects."

The institute's cutting-edge research can identify specific targets through genomics, systems biology and molecular diagnostics to control various individual cancers. "Cancer is not one disease," he says. "Even when we say breast cancer, leukemia or liver cancer, there are different types within each [category]. The idea is that we can identify these key targets to solve one type of the disease. Then we can target the therapy, and it will have much better efficiency without the detrimental side effects."

The combination of basic research to better understand cancer plus a rapid drug discovery chain enables faster results at the Institute for Research in Immunology and Cancer, says Dr. Michel Bouvier. SUPPLIED

The combination of basic research to better understand cancer plus a rapid drug discovery chain enables IRIC to deliver faster results. Over one decade, IRIC already has two drugs for leukemias in clinical trials – that's less than half the time it usually takes.

"For us to do this so fast is quite spectacular, by any account," says Dr. Bouvier. "We were able to assemble the right people and the right resources. By increasing the intensity of research, we are increasing the chance of getting more drugs more rapidly."

That's welcome news, especially since the incidence of cancer is expected to increase in light of Canada's aging population. "We're estimating that in three to five years, IRIC's work will have a real impact for people who have cancer now. It may happen during your lifetime, not just for your kids or grandkids," he affirms.

And for IRIC researchers, being able to see their work through from inception to completion is hugely gratifying. "There's nothing more rewarding than seeing the fruit of your research truly helping people."

RESEARCH AND INNOVATION

ALGONQUIN COLLEGE

Entrepreneurship models based on western and indigenous values

A renewed commitment to innovation at Algonquin College in Ottawa is meant to inspire students to acquire entrepreneurial skills and, in particular, to empower entrepreneurs among its aboriginal students.

Algonquin has announced the creation of a $44.9-million Innovation, Entrepreneurship and Learning Centre, part of the renovation and modernization of its library. It includes the Institute for Indigenous Entrepreneurship, the first of its kind on a college campus in Ontario, which will give aboriginal students, alumni and community partners access to tools, technologies and mentoring support based on indigenous as well as western business principles.

Marc Fares, vice-president of digital technologies and innovation for Algonquin College, says the facility, to be completed in 2018, will be a "hub for creative energies and a place to encourage the incubation and acceleration of ideas," as part of a broader mandate to embed entrepreneurship in all academic programming.

"This is more than just bricks-and-mortar," he says. "Our college is putting a renewed focus on innovation in all aspects of the applied learning experience."

Algonquin College's Institute for Indigenous Entrepreneurship, scheduled to open in 2018, will support innovation among the college's more than 1,100 Inuit, First Nations and Métis students. SUPPLIED

The new centre "will allow us to train more students for the innovative and highly specialized jobs of today and tomorrow," Mr. Fares says. Features include a multimedia production facility and space for students to experiment with digital technologies such as 3D printing and scanning. There will be mentoring programs, networking opportunities and competitions that promote business innovation.

As part of the centre, the Institute for Indigenous Entrepreneurship will support innovation among the more than 1,100 Inuit, First Nations and Métis learners at Algonquin, who represent 3.9 per cent of its 28,000 students.

Aboriginal youth are "a demographic cohort on the rise" in Canada, but they often "have been forced to follow a western model of entrepreneurship that values an aggressive, individual style in business practices," Mr. Fares says, while indigenous cultures emphasize family and community. "We need to find ways to help our indigenous students take their ideas and run with them."

He says the new centre is about "city building," reaching out to new partners and forming new collaborations. Algonquin is already a key part of Eastern Ontario's entrepreneurial and innovation ecosystem; its faculty, staff and students have participated in applied research projects that have helped some 400 companies create more than 200 jobs over the past five years.

"The goal is to dramatically increase Algonquin's capacity to accelerate innovation, support new business ventures, develop entrepreneurship within our students, alumni and all members of our community, and create jobs to stimulate economic growth," Mr. Fares adds.

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YORK UNIVERSITY

Researchers and entrepreneurs unite

Imagine monitoring a baby's vital signs through a fabric sensor technology that mimics a simple bed sheet, or curing toenail fungus with a low-cost, non-invasive treatment that's fast, safe and painless, and can be administered in the patient's home or in a clinic. These are among the startup ventures that are well on their way to becoming viable and scalable businesses with the help of Innovation York, York University's innovation office.

Innovation York provides pathways for taking ideas and early-stage ventures from the drawing board to the lab to the commercial marketplace. The startup ventures vary greatly – and include for-profit, social enterprise and non-profit ventures – yet they have one thing in common: the potential to have a positive impact on the global economy, while enhancing research capacity at the university, says director of Innovation York Sarah Howe.

> "At Innovation York, we are focused on translating research outcomes, whether they are technology, service or knowledge based."
>
> **Sarah Howe**
> is director of Innovation York

One program offered under the Innovation York umbrella is LaunchYU, which provides year-round support and mentoring to entrepreneurs both on campus (students, trainees and faculty members) and off campus – that is, community members. The LaunchYU Accelerator Program is an intensive 20-week program that supports 20 high-potential ventures, matching entrepreneurs with mentors and providing tailored support to facilitate sustainable growth.

"By encouraging industry-academic collaborations, we are helping these ventures grow, strengthening our research portfolio and often providing important research internship experience for our postdocs and graduate students," says Ms. Howe.

The fabric-sensor technology developed by Studio 1 Lab and the treatment for toenail fungus advanced by ToeFX are just two ventures now moving to the next stage, where they will benefit from collaborative research with the university community.

The university benefits, too, says York University's vice-president Research & Innovation Robert Haché. "These entrepreneurial engines at the university – Innovation York and LaunchYU – have become an integral part of York's culture. Their cross-functional support services encourage the collaboration between entrepreneurial and research communities, and will ultimately help pioneer novel innovations and maximize the economic, social and environmental benefits of our research."

Innovation York provides pathways that allow participants to take their ideas and early-stage ventures from the drawing board to the lab to the commercial marketplace. SUPPLIED

THOMAS FRICKE

Sheyenne Spence (left) is Métis and was a research assistant at the Indigenous Health Law Research Centre at Brandon University in Brandon, Man. The centre gathers traditional healing knowledge to inform better health policy for and with indigenous peoples in Canada. Grace Godmaire is an honorary elder within the Brandon community and with the Ojibwa/Cree Nation.

RESEARCH AND INNOVATION

UNIVERSITY OF BRITISH COLUMBIA

Making a modern world: transforming environmental liabilities into opportunities

With over 50 per cent of the world's population currently living in cities – and projections showing that number jumping to nearly 70 per cent by 2050 – the environmental performance of urban areas needs to feature prominently in climate change mitigation strategies.

As Ron Kellett sees it, that means improving the quality and impact of cities is a must for the planet. And, in fact, cities are rich with opportunity to address many of our world's diverse and urgent problems, such as rapid population growth, climate change, water quality, housing equity or human health and well-being.

"The United Nations' Habitat 3 in Quito that just concluded enabled an important global conversation around cities as agents and instruments of positive change," says Mr. Kellett, director of UBC's School of Architecture and Landscape Architecture. "This conversation has tipped significantly in the past decade. Cities, once perceived as environmental liabilities, are now seen as environmental opportunities – when they are planned, designed and engineered, built and managed right."

Mr. Kellett's school is part of UBC Applied Science, a mega-faculty on the front lines of shaping a smarter, more efficient, sustainable and livable built environment. It's no wonder municipalities reach out to Mr. Kellett and his colleagues as they tackle the complex challenge of designing cities and developing their infrastructure for sustainability.

"What's been compelling to me about Applied Science is that it can tackle this very complex reframing of city-making to leverage cross-scale systems-based solutions that creatively integrate the best public policy, science, technology and design upon which excellent sustainable cities depend," Mr. Kellett says.

Getting cities and their infrastructure right is a huge challenge. Applied Science cuts across all aspects of that challenge.

"Our faculty includes planners, architects, landscape architects, engineers and health professionals," Mr. Kellett says. "If you think about the future of our world as dependent on a creative confluence of physical, technical, human and natural systems, this is what Applied Science can do better than other groups – we have smart and capable faculty and students, and academic programs that span that panorama."

For example, James Olson, a mechanical engineering professor and the associate dean for research and industrial partnerships, works on finding sustainable materials for a number of uses.

"If we're going to transform into climate-friendly economies, part of that is the transition from a fossil economy to a bio economy," Dr. Olson says. "I work to convert biomass into high-value materials and super-strong composites that can be used to improve a wide variety of products and create future products – everything from civil infrastructure materials to advanced wound dressings and ultra-efficient filters that can eliminate water- and air-borne disease."

Using those "high-value materials," which are made of advanced microfibres, his team is also building thermally insulated, renewable, recyclable packaging that could be used to deliver e-groceries, potentially by drone.

These materials – and much other work and consultation being undertaken at UBC Applied Science – are part of the bigger picture, says Mr. Kellett, who notes that the solutions needed to create better cities will be a confluence of technical, build, human and natural systems.

"How do you make the built environment a hybrid of the natural one?" he asks. "It has to be technically sound, people have to want it, it has to be environmentally sound and it has to be well integrated." That is indeed where he and his colleagues are concentrating their efforts.

Ron Kellett, director of UBC's School of Architecture and Landscape Architecture, and his teams tackle the challenge of getting cities and their infrastructure right. SUPPLIED

> "What's been compelling to me about Applied Science is that it can tackle this very complex reframing of city-making, to leverage cross-scale systems-based solutions that creatively integrate the best public policy, science, technology and design upon which excellent sustainable cities depend."
>
> **Ron Kellett**
> is director of UBC's School of Architecture and Landscape Architecture

KEITH LEVESQUE

Trevor Lucas, ashore here in Inuvik, Northwest Territories, has made nine voyages through Canadian Arctic waters as a marine wildlife observer aboard the Canadian research icebreaker CCGS Amundsen. His notes and photos of bowheads and belugas, of seals and polar bears and birds, are part of a wide range of activities carried out annually on the Amundsen, one of the best-equipped research vessels in the world.

WESTERN UNIVERSITY

Research strives to improve resilience and harness wind's power

What happens when a storm hits a city? How can the built environment – including buildings, structures and transmission lines – better withstand the onslaught of a strong gale? And how can wind power be harnessed for energy generation in an urban setting?

These are among the questions being explored at the Wind Engineering, Energy and Environment Research Institute (WindEEE RI) at Western University, says Horia Hangan, the institute's director.

The objectives of boosting sustainability while building resilience are at the heart of the research, he explains.

"With increasing extreme weather events, communities need to be more resilient and able to withstand high winds and storms, for example. But they can also benefit from enhanced opportunities to use wind as an energy source," says Dr. Hangan, who calls the approach "making the best of the weather."

WINDEE's facilities, which have been supported with more than $12-million from the Canada Foundation for Innovation and include the world's first 3D testing chamber, are capable of reproducing the dynamics of real wind systems at large scales and under controlled conditions. By using equipment that consists of a multitude of fans and louver systems, various wind patterns can be tested on a wide diversity of surface topographies over areas in the order of tens of square kilometres.

This kind of research attracts attention from a number of partners, among them the insurance industry, which has an interest not only in what happens in a storm but also how to prepare for extreme weather. "We look at the effect of climate change from a wind perspective, and come up with recommendations for building resiliency," explains Dr. Hangan. "Our role reaches from the macro level to very specific input on how specific structures will behave."

Feedback about how buildings, structures and materials perform under different weather conditions is also valuable to partners like the manufacturing, engineering and construction industries, says Dr. Hangan. "And we provide input for building codes and guidelines for regulators from both industry and government," he explains.

At the WindEEE Research Institute, subjecting model urban environments to a variety of wind conditions can provide answers about cities' resilience and potential to harness wind power, says the institute's director Dr. Horia Hangan (right). SUPPLIED

There is a strong additional focus on building the capacity of the wind energy sector through technology development, says Dr. Hangan, and WindEEE researchers have recently turned their attention to assessing wind resources in complex urban environments.

"We are exploring regional meteorological patterns and how they inform the behaviour of wind in cities," he says. "Evaluating the performance of buildings relative to wind can give us information about how to make them smarter and able to harness wind energy."

Since current wind turbines technology does not provide the best answer for urban environments, new evidence points to opportunities for using building envelopes – which can act as membranes between the outside climate and indoor environment – for capturing both solar and wind energy, he says. "We are trying to convince companies to explore this new approach of designing building envelopes that can extract energy."

Dr. Hangan adds that not all objects tested at the WindEEE Research Institute are stationary. "We also look at unmanned aerial vehicles, or drones, to see how they perform in difficult environments and under different weather conditions. We think they will play a vital role in the surveillance of infrastructure, among other things, so it's important that we improve the control of these machines."

The institute is also a place for conducting pure research – exploratory projects that advance scientific understanding. "We are truly multidisciplinary and international in reach," says Dr. Hangan, "and we touch both fundamental and applied research."

CARLETON UNIVERSITY

Evidence-based approach to boosting the energy sector's environmental performance

Global energy demand is growing and will continue to grow in step with development and industrialization. Currently, 81 per cent of global energy is derived from fossil fuels, and new energy sources coming online are still more likely to be fossil-fuel-based than renewable, says Matthew Johnson, who leads the Energy and Emissions Research Lab at Carleton University.

Dr. Johnson believes better methods of extracting fossil fuels can play an important role in addressing greenhouse gas emissions and enabling reduction strategies like the Clean Development Mechanism projects supported by the World Bank. And he sees quantifying emissions as an important first step.

"Any kind of policy decision needs to be based on evidence," explains Dr. Johnson, whose team is working on experimentally backed practical models for evaluating flare emissions from the oil and gas industry.

Dr. Matthew Johnson and his team at the Energy and Emissions Research Lab at Carleton University evaluate the impact of emissions from the oil and gas industry. SUPPLIED

Flaring, the process of burning off unwanted gas at refineries and oil and gas drilling sites, has been identified as a substantial source of emissions of carbon dioxide, black carbon and other pollutants. An estimated 140 billion cubic metres of gas are flared globally each year, and Dr. Johnson believes accurate measurements and pollutant inventories can pave the way toward effective mitigation strategies.

"The human eye is very unreliable when it comes to evaluating a flare," he says, adding that camera-based technology developed at Carleton measured a flare in Uzbekistan in 2011. "Our measurements suggested that emissions from that single flare equalled that of 500 diesel buses running 24/7."

Since then, the technology has been further refined, advancing the quantitative understanding of flare-generated emissions, according to Dr. Johnson.

While a number of countries, including Canada, have signed the Zero Routine Flaring by 2030 initiative, which was introduced by the World Bank and hopes to address routine flaring, Dr. Johnson says that "progress has been disappointingly slow."

Satellite images indicate discrepancies between actual and reported flaring in some countries, he states. The FlareNet Strategic Network – a new network supported by a number of industry and government partners, including the World Bank and the United Nations Climate and Clean Air Coalition – provides a platform for enabling the international community to work toward meeting climate goals.

In addition to evaluating flares, Dr. Johnson and his team are working on a range of measures for making the oil and gas industry more sustainable, including curbing methane emissions from unregulated leaks, valves, pumps and storage tanks. "Our goal is to translate information from the lab to the field," he says. "We need to invest in solutions that make a dent in climate change and air quality."

RESEARCH AND INNOVATION

SIMON FRASER UNIVERSITY

Turning 'incredible science' into real-life solutions

When it comes to solving humanity's most intractable problems – like climate change, economic inequality and food insecurity – scientific research is the single greatest source of optimism.

At Simon Fraser University (SFU) in B.C., research infrastructure funding from the Canada Foundation for Innovation (CFI) has exponentially increased the potential to meet these challenges, says Joy Johnson, SFU's vice-president research and international. "It has enabled us to get the tools needed into our researchers' hands to help them stay at the cutting edges of their fields, move their fields forward and develop incredible science."

"There is a real commitment to fundamental research here – and to harnessing this research to make a difference in the world through knowledge mobilization. None of that work would be possible without the engine that is CFI," says Dr. Johnson.

For example, at SFU's 4D LABS, a materials science facility focused on nanotechnology and developing new materials, the CFI-funded Prometheus Project enables researchers to partner with industry to solve key issues and create new materials in critical sectors such as solar energy and fuel cell technology. Chemistry professor Neil Branda, Canada Research Chair in Materials Science and 4D's co-founder, leads a team that includes more than 100 researchers from four B.C. universities working with about 30 partner companies. A partnership with Nanotech Security Corp. made it possible to translate SFU researchers' discovery of nanostructures that give the blue morpho butterfly its iridescent sheen to the production of high-security 3D nano-optic images on currency, documents and goods.

When Nanotech was chosen to produce a ticket that included their anti-counterfeiting technology for the Euro 2016 in France, they turned to 4D's Centre for Soft Materials, led by chemistry professor Byron Gates. Using the centre's nanofabrication, nano-imaging and photonics equipment, Nanotech created a hologram of the tournament's mascot Super Victor – one that was virtually impossible to counterfiet – for use in the manufacturing of the more than six million tickets needed for the games.

SFU is also the lead institution for a recent CFI investment of $30-million in Compute Canada, a national advanced research computing platform. In partnership with regional organizations ACENET, Calcul Québec, Compute Ontario and WestGrid, Compute Canada co-ordinates access to advanced computing, storage and software solutions to accelerate research and innovation. With access to massive pools of data, scientists will have an unprecedented ability to answer research questions, says Dr. Johnson.

In June of this year, SFU physics professor and Compute Canada's chief science officer Dugan O'Neil received Compute Canada's inaugural Trailblazer Award for bringing the power of advanced research computing to more than 10,000 scientists in engineering, natural sciences, health, social sciences and humanities. Beginning in 2003 as a beta tester of WestGrid, Dr. O'Neil and his group went on to use big data computing to make a breakthrough discovery about the behaviour of the Higgs boson particle in 2012.

Along with research potential, infrastructure investment expands learning opportunities for SFU's students, says Dr. Johnson. "Training on these tools and seeing the outcomes of this work inspires our students – and great research facilities attract great students and faculty, both nationally and internationally."

The SFU data storage hub (here under construction) is part of the infrastructure of advanced computing, storage and software solutions that accelerate research and innovation. SUPPLIED

> "There is a real commitment to fundamental research here – and to harnessing this research to make a difference in the world through knowledge mobilization."
>
> **Dr. Joy Johnson**
> is SFU's vice-president research and international

CHRIS BOLIN

Citizens of Calgary stand with their mayor, Naheed Nenshi, on the banks of the Bow River, the city's primary source of drinking water. Advancing Canadian Wastewater Assets, a partnership between the city and the University of Calgary, is researching wastewater treatment systems that could help make drinking water safer and protect the ecology of water bodies.

COMPUTE CANADA

Access to advanced research computing a must for modern-day innovation

In the not-so-distant past, access to advanced research computing (ARC) platforms capable of crunching big numbers and running complex simulations was a luxury confined to the few and the lucky, but in today's fast-paced world of research and discovery it is increasingly seen as a necessity. From climate change to the sudden emergence of virulent infectious diseases, researchers are facing a dizzying array of rapidly evolving challenges. Now, researchers have access to the kinds of computer tools they need to address these challenges, says Compute Canada president and CEO Mark Dietrich.

In partnership with regional organizations such as ACENET, Calcul Québec, Compute Ontario and WestGrid, Compute Canada, which is funded by the Canada Foundation for Innovation and allocates resources based on a merit-based annual exercise, is making ARC systems, including storage and software solutions, affordable and available to Canadian researchers and their collaborators in a wide range of academic and industrial sectors. And to facilitate success, users get assistance using the system from a team of more than 200 experts employed by 34 partner universities and research institutions across the country.

"This system allows researchers to run thousands and even millions of experiments virtually that it would have previously cost a fortune to do in a conventional lab setting, saving years, maybe decades of research time, which is crucial when facing the kinds of challenges confronting Canada and the global community," says Mr. Dietrich.

Currently, the national ARC platform is being used by as many as 10,000 researchers, including 2,500 faculty, working on a staggering array of projects. These include an oceanographer at Dalhousie University using the system to project what oceanic conditions will be like 50 or even 100 years in the future, and a computational scientist at McGill conducting virtual manufacturing studies. "You can test a theory in an afternoon that would have taken a month 15 years ago," says Axel Becke, a theoretical and computational chemist at Dalhousie. Engineers, astronomers, medical researchers, business people, social scientists and more are all breaking new ground using the system. And according to a recent study, Compute Canada-enabled publications are seen to be well above both the world and Canadian averages in terms of scientific impact.

"This kind of infrastructure is integral to modern-day innovation and competition," says Mr. Dietrich. "Nations and economic unions around the world are creating national strategies so they can use the power of supercomputing to drive their economies and compete globally, and Canada is leading the way, giving researchers who rely on these services and infrastructure the opportunity to make amazing discoveries and create revolutionary new products."

> "Nations and economic unions around the world are creating national strategies so they can use the power of supercomputing to drive their economies and compete globally, and Canada is leading the way."
>
> **Mark Dietrich**
> is president and CEO of Compute Canada

OPINION

Colleges and institutes collaborate with partners to advance research, seek solutions

Q+A with Denise Amyot, President and CEO of Colleges and Institutes Canada

Applied research enables innovation because it responds to the immediate needs and short-term opportunities identified by industry, small business owners, entrepreneurs and research users in both the public and not-for-profit sectors.

What is the place of colleges and institutes in Canada's innovation ecosystem?
Canada's colleges and institutes play an essential and growing role in our country's innovation ecosystem. First and foremost, they provide training to maintain an "innovation-ready" workforce that is inclusive of all Canadians. They are mandated to respond to the labour market, equipping students with the skills they'll need to maximize employment, self-employment and entrepreneurship opportunities.

Increasingly, this includes working with industry to provide, for example, the retraining people need to adapt to the changes that technology brings or move to new careers in emerging sectors that require a specialized workforce. It also includes offering skills training to indigenous communities and newcomers who need to tailor their experience and credentials to the Canadian market. Colleges and institutes have also seen a tremendous growth in applied research activity over the last decade or so and are directly contributing to Canadian innovation in many areas.

How does applied research help fuel innovation?
Applied research is about solving real-world problems through the practical application and commercialization of leading-edge knowledge, expertise, methods and techniques. It enables innovation because it responds to the immediate needs and short-term opportunities identified by industry, small business owners, entrepreneurs and research users in both the public and not-for-profit sectors. This allows them to produce new or improved products and processes that will have a real impact on Canadians – and that can help us tackle some of the big challenges of our time, such as energy efficiency and climate change.

How important is collaboration to the research generated at colleges and institutes?
Collaboration is at the heart of our approach to applied research. Projects are always done in collaboration with local partners looking for help in addressing a specific issue. In the case of small businesses that are part of a supply chain or local cluster, these research solutions often enable the success of much larger firms who rely on their partners' specialized expertise. In 2014-2015, Canadian colleges and institutes worked with over 5,500 private sector partners to develop new or adapted products, services, technology and processes. Eighty-six per cent of these partners were SMEs or micro-enterprises who would not otherwise have access to the facilities and expertise required to conduct this kind of research.

The federal government has hinted that its next budget will be an 'innovation budget.' What does that mean for colleges and institutes?
We're very pleased to see that the government is taking a broad and inclusive approach to innovation and we agree that it is crucial to invest now to ensure Canada's long-term prosperity. The links between innovation, productivity and long-term growth are abundantly clear. We recognize that Canada is faced with an aging population and increasing global competition. The government has already taken positive steps with its Post-Secondary Institutions Strategic Investment Fund, which will help colleges and institutes create the critical infrastructure required to fuel innovation. But there is still a lot to do. Increasing funding for applied research, which still represents a tiny fraction – just 2.5 per cent – of the overall federal research funding will certainly be key. So will developing and maintaining an innovation-ready workforce equipped to be competitive in our rapidly evolving and increasingly digital world.

DALE WILSON

Franziska Broell displays a wildlife tagging device she developed as a doctoral student while working with Dalhousie University's Ocean Tracking Network, a global research platform that tracks the movement of marine creatures through the world's oceans. Broell co-founded a company in Halifax to commercialize the device; the enterprise is one of many serving Atlantic Canada's vibrant oceanographic research community.

SHERIDAN COLLEGE

Lights! Camera! Research!

When the work you're doing in digital film research starts finding application in the work of acclaimed filmmakers such as Peter Jackson (*The Lord of the Rings*) and James Cameron (*Titanic* and *Terminator*) you know you're on the right track. That's certainly been the case with Sheridan College's Screen Industries Research and Training Centre (SIRT), fast emerging as a leading technology access centre for the film industry.

"Thanks in part to a significant grant from the Canada Foundation for Innovation we have been able to not only develop an industry-standard test and demonstration centre for digital cinema research here at Sheridan, but also attract the kind of expertise that allows us to work with industry partners on advanced technologies used in the rapidly evolving and highly competitive film, television and gaming sectors," says SIRT director, strategic partnerships, John Helliker. The research is done in open cooperation with other research institutions, including York University's Centre for Vision Research, and industry partners such as Christie Digital, which works with heavy hitters like Cameron and Jackson.

The Christie project, which is looking into increased frame-rate projection, is particularly intriguing, partly because of its current utility to the film industry, but also its potential for applications in other areas. Film is typically shot at the rate of 24 frames per second, but what if you bumped that up to 48 or even 60 frames per second? What kind of impact would that have on viewers? Quite a lot, it turns out. "It reduces motion blur and allows you to get considerably more information into a frame, enhancing the audience experience," says Mr. Helliker. The same technologies are finding application in 3D as well as virtual and augmented reality situations in vastly different fields. For example, Sheridan is also working with a major hospital on ways in which virtual reality can be used to enhance the patient experience, as well as a museum on making its exhibits and historical experiences come alive.

"We're working with companies at the forefront, companies that know what the challenges are," says Mr. Helliker. "They're coming to us to help them find the solutions because we are able to engage with them on research and innovation they have identified as important to them as international players."

It's also attracting the attention of students in other disciplines, adds Cindy Gillett, Sheridan's director, Office of Applied Research and Innovation, who says research findings are incorporated into the curriculum at Sheridan for all students to benefit from. "Students from other areas, including social sciences, computer programming, animation and gaming, realize that when they graduate they're going to be working not only with the kinds of companies we're working with here at SIRT, but also researchers and innovators," says Ms. Gillett. "Our programs and research centres prepare them to do just that."

The technology available at Sheridan College's Screen Industries Research and Training Centre finds application in the film industry, as well as virtual and augmented reality situations in vastly different fields. SUPPLIED

BY THE NUMBERS

Colleges and institutes

2,491
faculty and staff (e.g. industrial experts and technicians) engaged in applied research

107
have a dedicated applied research division

670
specialized research centres and labs were identified

1,083
areas of research specialization were reported in natural resources, energy, environment, health, information and communications technologies, manufacturing and social innovation

85%
have partnerships with universities

Source: Colleges and Institutes Canada

RESEARCH AND INNOVATION

UNIVERSITY OF MANITOBA

Under the microscope: powerful tools build better partnerships

Combine four powerful microscopes – which allow researchers to penetrate a wide range of materials to different levels and under various conditions – with world-class expertise and you've got a formidable hub that attracts interest from a wide range of partners.

That's the kind of momentum that has been building since the switch was turned on in January at the new facility of the Manitoba Institute for Materials (MIM), says Derek Oliver, the institute's director. "We had everything humming at the beginning of the calendar year and we haven't locked the door since then."

It has been a busy – and stimulating – period, and the facility's capabilities have made the MIM a go-to place not only for established industry and university partners, he says. "Obviously, we attract a number of partners whose work lends itself directly to this research, but for me, it is particularly interesting when people from different fields call us to explore how our instruments might help their work."

Among the samples that have been examined with the facility's microscopes are metal composites used in aerospace components, concrete and de-icing salt combinations, silicon micro-wires tested for their ability to generate hydrogen from water, and biological tissue indicative of fetal alcohol syndrome.

> "Rather than being tightly focused on a particular cluster of industries or companies, we're open to a highly interdisciplinary approach and we see a lot of potential in the breadth of partnerships we're creating. The great diversity of projects coming into the facility is really, really exciting."
>
> **Dr. Derek Oliver**
> is the director of the Manitoba Institute for Materials

"Rather than being tightly focused on a particular cluster of industries or companies, we're open to a highly interdisciplinary approach and we see a lot of potential in the breadth of partnerships we're creating," says Dr. Oliver. "The great diversity of projects coming into the facility is really, really exciting."

It had been the ongoing collective activity across five faculties – and a strong materials research presence on campus – that underpinned the case for turning the MIM, which was formed in 2009 as a virtual institute, into a physical facility, he explains. And three new top-line electron microscopes, plus a previously acquired x-ray photoelectron spectrometer (XPS instrument), have contributed much to making the launch a big success.

"These four major instruments are complementary," says Dr. Oliver. "Someone bringing a sample might use one, or two or three of them, and get slightly different information from each."

Of the two scanning electron microscopes, one is an environmental scanning electron microscope, which has a larger chamber and can be used for evaluating samples that are not conductive, such as biological or geological samples, he says. "Since you can vary the humidity in the chamber, you can look at salt recrystallization in a concrete crevice to help understand why concrete does or doesn't crack in winter."

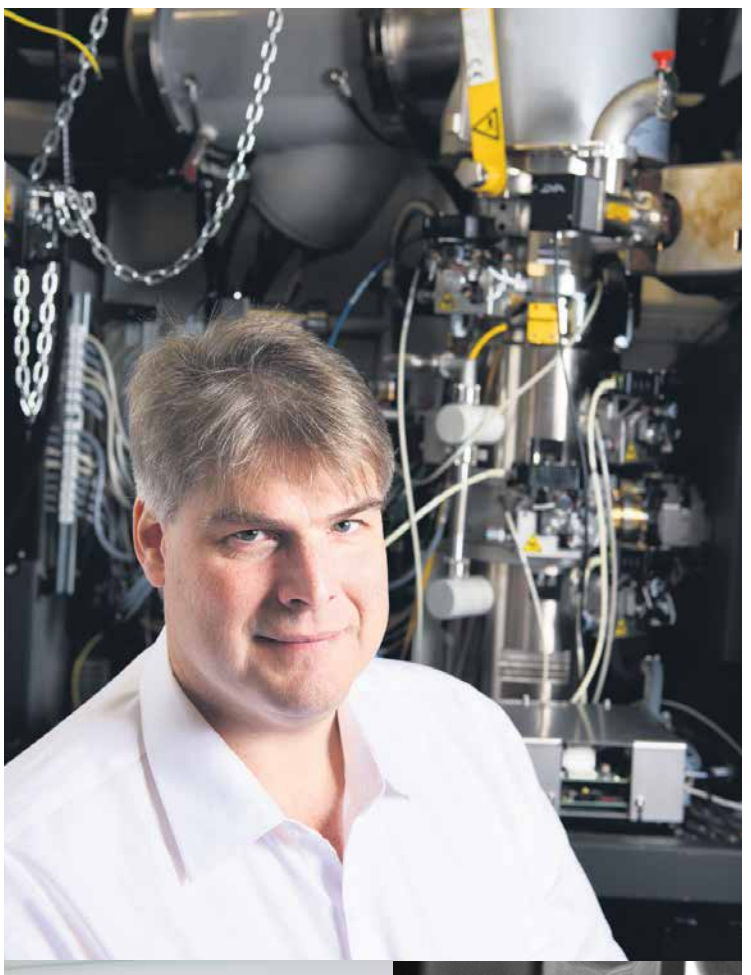
With the other scanning electron microscope – a high-resolution scanning electron microscope or NanoSEM – details the size of one-thousandth of the width of a human hair are visible, which is useful for shedding light on the intersection of two pieces of metal that are welded together, says Dr. Oliver. "For scientists and engineers, it is important to understand what goes on in the process of welding, what it looks like once it solidifies and what it tells us about the effectiveness of the weld."

With the third new instrument, a transmission electron microscope, a beam of electrons is passed through a sample, enabling the observation of individual atoms – and their arrangement – at a detailed level, says Dr. Oliver. He sees this top-line microscope, which is currently the only one in Canada, as an exciting resource for the region. In addition, the XPS instrument provides users with information about the surface chemistry of materials.

Operating these instruments requires training and expertise, says Dr. Oliver. "We have a commitment to run a course for undergraduate and graduate students, to give them hands-on experience with this sort of infrastructure as part of their learning."

The combination of tools and expertise provides fertile ground for research collaborations, bringing together partners from the Composites Innovation Centre, the university's faculty of agriculture and the department of biosystems engineering, for example. "Research in this field looks at utilizing what would otherwise be left behind on the fields after the harvest," says Dr. Oliver, adding that the idea of making composite materials with natural fibres is of great interest in a region with a large agricultural sector.

Interdisciplinary collaborations – and the MIM in general – do not only look for better and stronger materials, they also strengthen the research community and the region, says Dr. Oliver. "For a hub like Winnipeg, supporting and enhancing the capability of a range of sectors is essential for our long-term sustainability."



The combination of tools and expertise at the Manitoba Institute for Materials provides fertile ground for research collaborations, says Dr. Derek Oliver (top). SUPPLIED

RESEARCH BUILDS MY *HEALING* COMMUNITY

BEN NELMS

Breast cancer survivors and cherished friends (from left) Mary Chow-Humphries, Kara Horsman, Alana van Dam, Yvonne Eng, Julie Donegan, Ling Takara, Christine Gaio and Sharon Shum, became each other's support network after participating in a study on the effects of exercise on recovery from breast cancer. The research was conducted at the University of British Columbia.

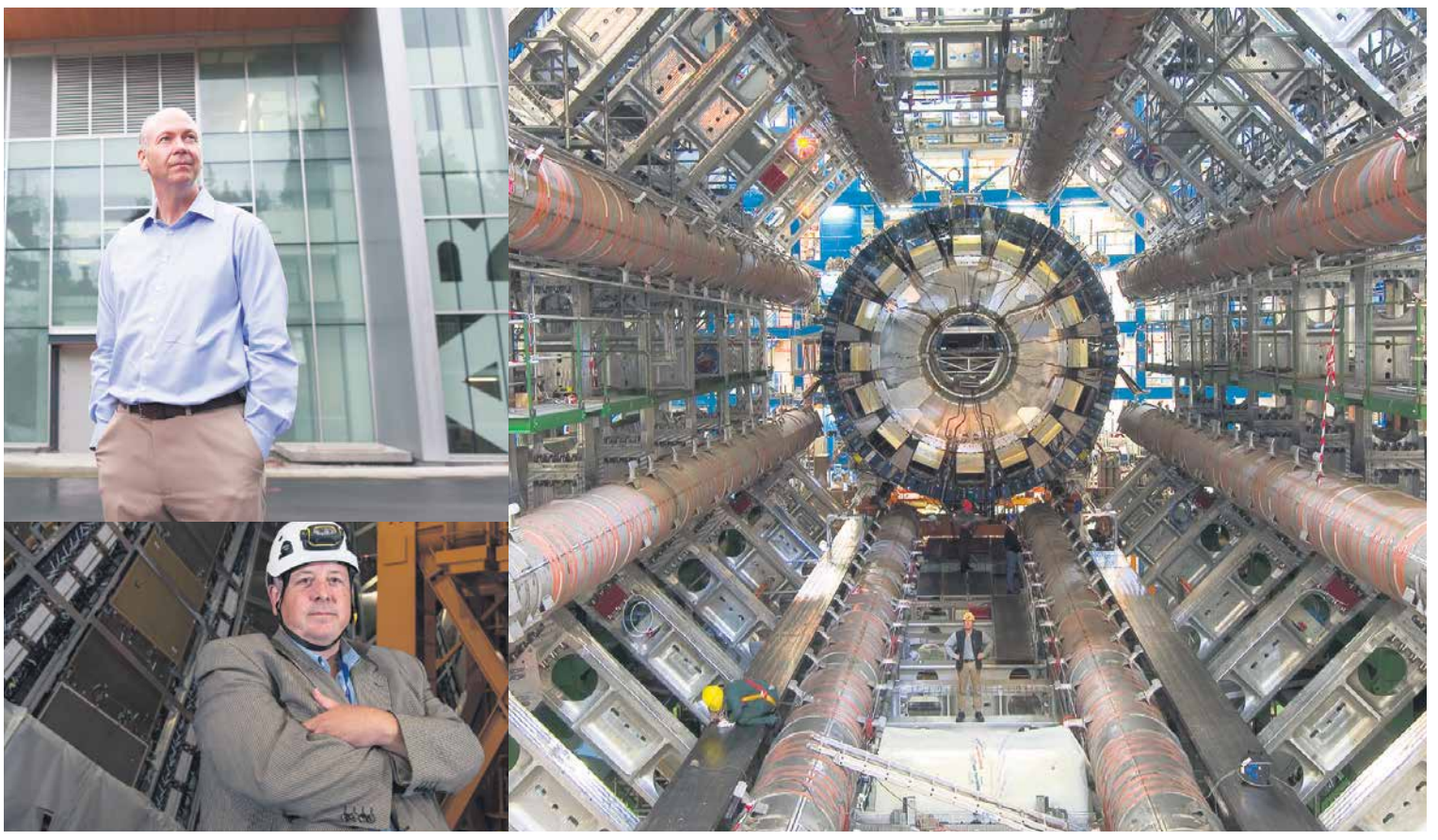
UNIVERSITY OF VICTORIA

Particle research aims to predict the universe's past and future

Researchers in nuclear and particle physics at the University of Victoria (UVic) are looking at the smallest of things so they can answer some of the biggest of questions about where the universe came from and where it might be going. Nuclear and particle physics research takes place on a global scale involving a multitude of international partners. Within that community, UVic is helping Canada build on its leadership role through the development of world-class research facilities and high-performance computing technologies used to store, access and analyze massive pools of data. These are the kinds of endeavours that attract some of the best and brightest.

UVic's Rob McPherson currently serves as deputy spokesperson for the ATLAS experiment at the CERN Large Hadron Collider (LHC) in Switzerland. Inside the LHC, two high-energy particle beams are made to travel towards each other at close to the speed of light before colliding. When they do, it opens a window into the past. "The kinds of things that happen are similar to what occurred just after the Big Bang, a time when everything was energy and there was no matter," says Dr. McPherson. "It's exciting because it allows us to explore this fundamental point in the history of the universe." To date, Canada has invested $135-million in the project and has also designed and built key components, including calorimeters that measure the direction and energy of particles produced in the collisions. UVic researchers are leaders in developing the cloud computing resources used to analyze the complex data the LHC produces.

Here in Canada, UVic's Dean Karlen is heading up ARIEL, an offshoot of TRIUMF, a national subatomic physics research laboratory located near the University of British Columbia. ARIEL will produce rare isotopes that can be used to study the nature of stars, where the elements come from and the way in which complex patterns arise from relatively simple building blocks. They also have a very practical side. Isotopes are used to develop sophisticated medical imaging tools that can better detect and treat disease. They're also used to selectively destroy cancerous tumours, leading to better patient outcomes. "It's fulfilling work because of the way it allows us to push the boundaries of knowledge and understanding, but also because of the people; doing this kind of work is transformative for those involved," says Dr. Karlen.



University of Victoria researchers Dr. Dean Karlen (top left, in front of the ARIEL building) and Dr. Rob McPherson (bottom left) are teaming up with international colleagues for particle research conducted at the ATLAS detector at the CERN Large Hadron Collider (right). LEFT, JEFF VINNICK; RIGHT, © CERN

> "Doing this kind of work is transformative for those involved."
>
> **Dr. Dean Karlen**
> is heading up ARIEL, an offshoot of TRIUMF, a national subatomic physics research laboratory located near the University of British Columbia

For Iris Dillman, being an astrophysicist was Plan B. "I originally wanted to be an astronaut," says the UVic adjunct professor who has been working at TRIUMF for three years. Nowadays, Dr. Dillman is using nuclear astrophysics to study the building blocks of the elements – the isotopes – that are produced in stars, including our own sun. She's investigating how long these isotopes live and how they decay, and how all this "star stuff" makes up anything and everything from the universe and planets to human beings and toaster ovens. "We're able to bring stars and star explosions into the lab," she explains.

"The contributions researchers like this are making to knowledge cannot be underestimated," says David Castle, UVic's vice-president research. "There is deep science involved that answers fundamental questions, and there are immediate applications for the rare isotopes being created that have an important role to play in medical and material science," he says. "We also believe there'll be considerable downstream potential in terms of commercial opportunities for those who work and study in the labs but go on to work in commercial and industrial sectors."

UVic has also been selected as one of four hub sites for the national advanced computing research network offering systems, storage and software solutions to researchers in a multitude of fields across Canada. "All of these initiatives are helping build global knowledge networks, accelerating the development and commercialization of new technology and materials, attracting and training young researchers, and helping Canada stay globally competitive," says Dr. Castle.

UNIVERSITY OF OTTAWA

Science of light transforms modern life

The international stature of the University of Ottawa's photonics research is illustrated by the establishment of the Max Planck-University of Ottawa Center for Extreme and Quantum Photonics.

In the scientific world, association with the German-based Max Planck Society is among the highest of honours.

"We are one of only three Max Planck centres in North America and it's a very prestigious designation," says Sylvain Charbonneau, associate vice-president, research, at the University of Ottawa. "And it's very exciting because it opens up new partnerships with the best researchers in the world."

Many of the world's best researchers in photonics – the science and engineering of light – are, in fact, based at the university's Centre for Research in Photonics (CRPuO). "We have developed into a globally recognized powerhouse in the field of photonics across a broad range of applications," says Dr. Charbonneau, who notes that the scientific team includes one Canada Excellence Research Chair, 13 Canada Research Chairs and four University Research Chairs.

At the University of Ottawa's Centre for Research in Photonics, Dr. Pierre Berini and Dr. Karin Hinzer are leading research efforts in areas including disease detection and solar energy. SUPPLIED

The CRPuO is housed at the Advanced Research Complex, a state-of-the-art facility that opened in 2014. With support from the Canada Foundation for Innovation and other partners, this research hub is equipped with the latest research technology, including Canada's only accelerator mass spectrometer, which is used to analyze radioisotopes.

Photonics applications are behind many current and evolving technologies touching virtually all aspects of modern life – from communications and entertainment systems to innovative uses in biology, medicine, quantum computing, energy generation and environmental sensing.

"People say that just as the 20th century was the century of electronics, this century will be the century of photonics," says Dr. Charbonneau.

Among the scientists pushing the envelope by harnessing the power of light is Pierre Berini, University Research Chair in Surface Plasmon Photonics and the director of the CRPuO. He is investigating using light to create biosensors capable of detecting specific diseases (for example, leukemia or HIV) in blood or other fluid samples from a patient.

"Biosensors hold much promise for enhancing health care," says Dr. Berini. "We're working on sensors that will allow quicker detection of disease, for example, at a patient's bedside. The goal is also to create biosensors that are much more sensitive than current lab techniques, so that we can diagnose and begin to treat cancer, for example, much earlier in the disease process."

Another exciting photonics research area is solar energy. Karin Hinzer leads the research team at SUNLAB, the University of Ottawa's solar research facility.

"Photonics has a huge role to play in Canada's ongoing energy leadership, now that we are moving towards a post-carbon economy," Dr. Hinzer says.

"We apply photonics to the development of new materials and new designs for the production of more efficient and lower-cost solar panels that can operate well as part of an electricity grid, in many different conditions and levels of sunlight."

RESEARCH AND INNOVATION

UNIVERSITIES CANADA

Why we need to invest in discovery research

More than any other activity that relies on government and private sector funding for its livelihood, research is the key to solving some of our biggest global challenges, from environmental degradation to food security – and yet, it's most vulnerable to cutbacks.

This is especially worrisome to people like Universities Canada president Paul Davidson: he has witnessed Canada rise from obscurity during the 1990s to become a globally recognized research leader – only to see this status steadily diminish as politicians and corporate leaders turn their attention to other matters.

"We're now ranked 24th in the world in terms of how much we spend on research compared to our gross domestic product," he says. "A far cry from being 12th in 2001 – which in itself was a struggle to achieve."

As the Canada Foundation for Innovation celebrates its 20th anniversary and a relatively new federal government settles in, Mr. Davidson cites several examples of how Canadian research is making an important impact.

The first is Queen's University professor emeritus Arthur McDonald, who discovered that neutrinos (subatomic particles) from the sun don't disappear on their way to Earth and instead change identities – meaning they have mass.

Dr. McDonald won the Nobel Prize in Physics in 2015 for his work, and the new understanding of neutrinos will reportedly tell us about the far reaches of the universe and even the inner workings of our own sun.

Another example is the Canadian Light Source facility at the University of Saskatchewan, which most recently developed a new way to make medical isotopes – which addresses the need for a reliable supply in hospitals.

Meanwhile, the University of Saskatchewan recently undertook research to create a global resource for farmers seeking to develop new crop varieties at unprecedented speed and scale.

> "Even in our diminished state, Canada represents only 0.5 per cent of the world's population but produces five per cent of the world's cited research. We can't let the advances we've made slide away."
>
> **Paul Davidson**
> is president of Universities Canada

Mr. Davidson notes that while the previous government supported research, "other countries invested much more, and faster, hence our current standing." However, he is hopeful the current leadership will take stock of the issue through a science review currently underway and to which Universities Canada has contributed.

"We need to invest in discovery research. We need a better circulation of ideas between public and private sectors," he says.

"Even in our diminished state, Canada represents only 0.5 per cent on the world's population but produces five per cent of the world's cited research. We can't let the advances we've made slide away."

SABRINA DANIEL

Samantha Knapp sits with her daughters Sienna and Saige. Sienna (right) has a rare genetic disorder that causes severe seizures in newborns and infants. Until recently, very little was known about this condition. With the help of research and many doctors, including at the Children's Hospital of Eastern Ontario Research Institute in Ottawa, the Knapp family was able to find the genetic root of the illness. It was the piece of information they needed to not only manage the disease, but also to find a community of support among parents going through similar situations.

One of the examples of Canadian research that has had a big global impact was the discovery by Dr. Arthur McDonald, particle physicist and professor emeritus at Queen's University, that neutrinos (subatomic particles) do have mass. Dr. McDonald won the Nobel Prize in Physics in 2015 for his work. BERNARD CLARK AND QUEEN'S UNIVERSITY